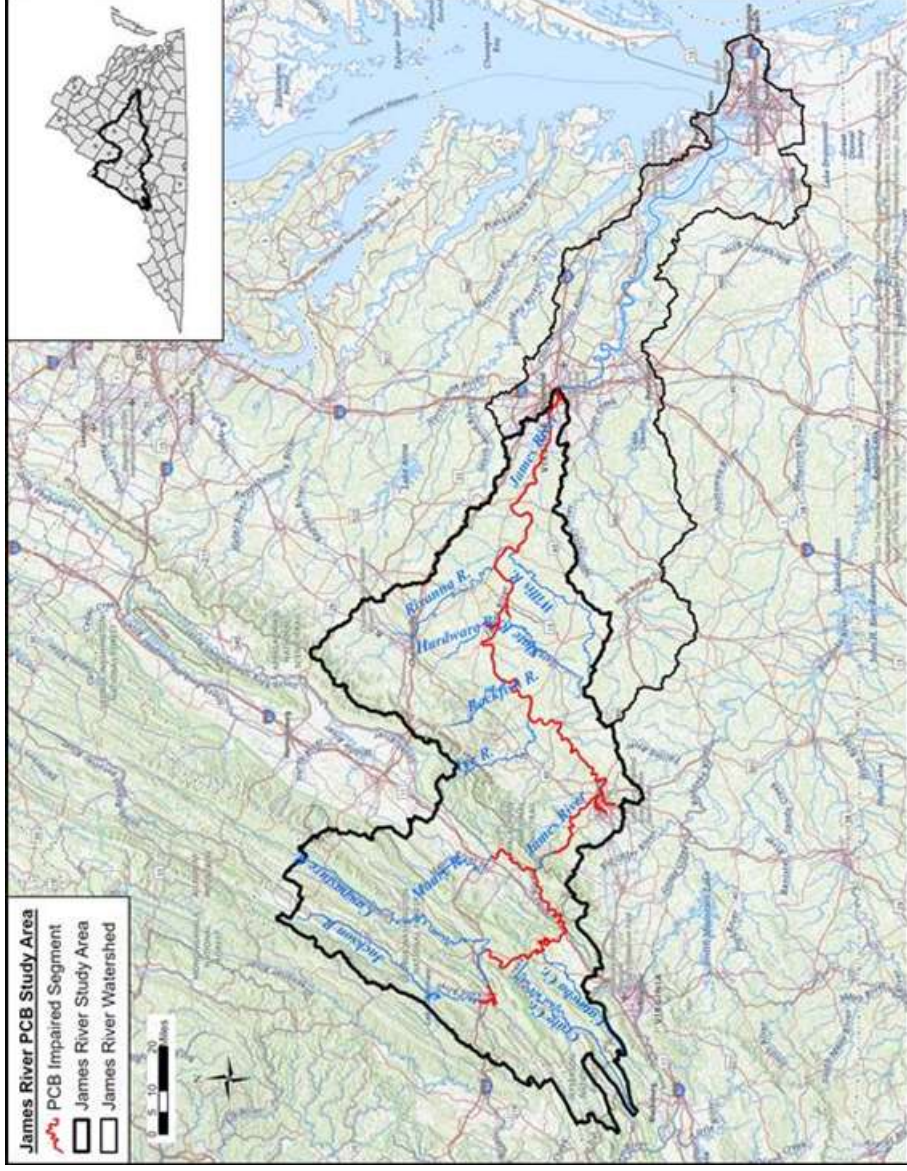


PCB Total Maximum Daily Load Development for the James River, Maury River, and Jackson River Watersheds



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Executive Summary

Background

Section 303(d) of the Clean Water Act (CWA) and the United States Environmental Protection Agency's Water Quality Planning and Management Regulations require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed applicable water quality standards (WQSs). TMDLs represent the total pollutant loading a waterbody can receive without exceeding applicable WQSs.

Multiple sections of the James River watershed, including Jackson River and Maury River were listed as impaired on Virginia's 2024 Section 303(d) List due to exceedances of the Virginia Department of Environmental Quality's (VADEQ) fish tissue screening value for polychlorinated biphenyls (PCBs). PCB Fish consumption advisories were also identified by the Virginia Department of Health (VDH) that include from the head of the James near Iron Gate (at the confluence of Jackson River and Cowpasture River) to Balcony Falls Dam downstream of Glasgow (near the Maury River), the Maury River from Buena Vista at Rt. 60 16 miles to the James River, and James River from Big Island Dam to the I-95 bridge in Richmond (VDH, 2022). Fish consumption advisories mean a TMDL is required. The DEQ impaired segments, descriptions of their extent, and initial listing year are provided in Table ES-1, and the VDH fish consumption advisories are listed in Table ES-2. Figure ES-1 maps the locations of the PCB impaired segments within the James River study area in Virginia and Figure ES-2 maps the watershed boundaries for each TMDL equation. The study area totals 4,342,969 acres (approximately 6,786 mi²), and consists of four TMDL watersheds: Jackson River, Maury River, Upper James River study area (from the head of the James near Iron Gate to Bent Creek confluence), and Lower James River study area (from Bent Creek confluence to I-95 James River Bridge in Richmond).

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

Table ES-1. Impaired segments from the 2024 303(d) list within each TMDL watershed addressed in this TMDL report (DEQ, 2024).

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Jackson River	Jackson River	VAW-I04R_JKS01A00	0.48	2008	extending from Westvaco main processing outfall downstream to Dunlap Creek confluence
Jackson River	Jackson River	VAW-I04R_JKS02A00	1.28	2008	extending from Covington water intake downstream to Westvaco main processing outfall
Jackson River	Jackson River	VAW-I09R_JKS04A00	5.92	2008	extending from Covington STP outfall downstream to just above Lowmoor community
Jackson River	Jackson River	VAW-I09R_JKS04B14	0.32	2008	extending from Potts Creek confluence downstream to Covington STP outfall
Jackson River	Jackson River	VAW-I09R_JKS05A00	3.01	2008	extending from downstream of Fudge's Bridge to Potts Creek confluence
Jackson River	Jackson River	VAW-I09R_JKS06A00	1.66	2008	extending from Dunlap Creek confluence downstream to just below Lexington Avenue Bridge
Maury River	Maury River	VAV-I37R_MRY01A00	5.11	2006	extending from Buffalo Creek confluence downstream to James River
Maury River	Maury River	VAV-I37R_MRY02A00	7.25	2006	extending from Indian Gap Run confluence downstream to Buffalo Creek confluence
Maury River	Maury River	VAV-I37R_MRY03A00	4.58	2004	extending from South River confluence downstream to Indian Gap Run confluence
Upper James River	James River	VAV-I28R_JMS01A00	6.73	2022	extending from Cedar Creek confluence downstream to Maury River confluence
Upper James River	James River	VAW-I18R_JMS01A00	7.77	2022	extending from Craig Creek confluence upstream to Stull Run confluence

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Upper James River	James River	VAW-I18R_JMS02A00	7.63	2022	extending from Stull Run confluence upstream to the confluence of the Jackson and Cowpasture Rivers
Upper James River	James River	VAW-I24R_JMS01A00	5.11	2022	extending from Craig Creek confluence downstream to Catawba Creek confluence
Upper James River	James River	VAW-I24R_JMS01A10	15.40	2022	extending from Catawba Creek confluence downstream to Looney Creek confluence
Upper James River	James River	VAW-I27R_JMS01A00	7.98	2020	extending from Jennings Creek confluence downstream to Big Hollow Branch confluence
Upper James River	James River	VAW-I27R_JMS02A14	7.15	2022	extending from Looney Creek confluence downstream to Jennings Creek confluence
Upper James River	James River	VAW-I28R_JMS01A08	1.55	2020	extending from Big Hollow Branch confluence downstream to Cedar Creek confluence
Upper James River	James River	VAW-H01R_JMS01A00	1.37	2006	extending from Wilderness Creek confluence downstream to Holcomb Rock Dam
Upper James River	James River	VAW-H01R_JMS01A04	0.70	2006	extending from upstream ending of the WQS PWS designation downstream to Wilderness Creek confluence
Upper James River	James River	VAW-H01R_JMS02A00	3.30	2006	extending from Georgia Pacific outfalls downstream to upstream ending of the WQS PWS designation
Upper James River	James River	VAW-H01R_JMS03A00	3.05	2006	extending from Peters Creek confluence downstream to Georgia Pacific outfalls
Upper James River	Blackwater Creek	VAW-H03R_BKW01A00	10.54	2024	extending from confluence of Tomahawk and Burton Creeks downstream to confluence on the James River

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Upper James River	Fishing Creek	VAW-H03R_FSG01A00	6.32	2020	extending from James River upstream to its headwaters
Upper James River	James River	VAW-H03R_JMS01A00	3.86	2004	extending from Business 29 bridge downstream to Williams Run confluence
Upper James River	James River	VAW-H03R_JMS04A02	4.22	2004	extending from Reusens dam downstream to Business 29 bridge
Upper James River	James River	VAW-H03R_JMS06A02	8.26	2006	extending from Holcomb Rock Dam downstream to Reusens Dam
Upper James River	James River	VAW-H05R_JMS01A00	6.27	2006	extending from Wreck Island Creek confluence downstream to Bent Creek confluence
Upper James River	James River	VAW-H05R_JMS02A00	6.78	2006	extending from Stonewall Creek confluence to Wreck Island Creek confluence
Upper James River	James River	VAW-H05R_JMS02B14	3.05	2014	extending from Beck Creek confluence to Stonewall Creek confluence
Upper James River	James River	VAW-H05R_JMS03A00	7.71	2006	extending from Archer Creek confluence downstream to Beck Creek confluence
Upper James River	James River	VAW-H05R_JMS04A00	2.68	2004	extending from Williams Run confluence downstream to Archer Creek confluence
Lower James River	James River	VAW-H08R_JMS01A00	9.68	2006	extending from Bent Creek confluence to Tye River confluence
Lower James River	James River	VAV-H14R_JMS01A18	13.49	2006	extending from Bishop Creek confluence downstream to Rockfish River confluence
Lower James River	James River	VAV-H14R_JMS02A18	5.09	2006	extending from Tye River confluence downstream to Bishop Creek confluence
Lower James River	James River	VAV-H17R_JMS01A18	8.13	2006	extending from Totier Creek confluence downstream to Hardware River confluence
Lower James River	James River	VAV-H17R_JMS02A18	4.82	2006	extending from Ballinger Creek confluence downstream to Totier Creek confluence

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Lower James River	James River	VAV-H17R_JMS03A18	5.74	2006	extending from Rockfish River confluence downstream to Ballinger Creek confluence
Lower James River	Hardware River	VAV-H19R_HRD01A00	7.00	2008	extending from Rt. 6 bridge downstream to James River
Lower James River	James River	VAV-H20R_JMS01A02	1.98	2006	extending from Hardware River confluence downstream to a point 5 miles above Fork Union Sanitary District raw water intake
Lower James River	James River	VAV-H20R_JMS02A02	2.94	2006	extending from a point 5 miles above Fork Union Sanitary District's raw water intake to Slate River confluence
Lower James River	Slate River	VAP-H22R_SLT03A02	1.00	2008	extending from Rt. 676 to a point 5 miles upstream of the Fork Union Sanitary District raw water intake to James River
Lower James River	Slate River	VAP-H22R_SLT03B20	2.90	2008	extending from a point 5 miles upstream of the Fork Union Sanitary District raw water intake to James River
Lower James River	James River	VAV-H20R_JMS02B18	2.16	2006	extending from Slate River confluence downstream to Fork Union Sanitary District's raw water intake
Lower James River	James River	VAV-H20R_JMS03A02	9.25	2006	extending from Fork Union Sanitary District's raw water intake downstream to Rivanna River confluence
Lower James River	James River	VAP-H33R_JMS01A98	6.30	2006	extending from Deep Creek confluence downstream to Big Lickinghole Creek confluence
Lower James River	James River	VAP-H33R_JMS01B24	16.79	2006	extending from Rivanna River confluence downstream to Deep Creek confluence
Lower James River	James River	VAP-H38R_JMS01A06	2.36	2006	extending from Big Lickinghole Creek confluence to start of PWS section

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Lower James River	James River	VAP-H38R_JMS02A04	3.75	2006	extending from Mohawk Creek confluence to rivermile 137.00
Lower James River	James River	VAP-H38R_JMS03A06	6.95	2006	extending from rivermile 137 to rivermile 130.14
Lower James River	James River	VAP-H38R_JMS04A06	0.52	2006	extending from start of PWS section downstream to Mohawk Creek confluence
Lower James River	James River	VAP-H39R_JMS01A98	7.45	2006	extending from Tuckahoe Creek confluence to William's Island dam
Lower James River	James River	VAP-H39R_JMS01B00	2.04	2006	extending from rivermile 130.14 to rivermile 128.14
Lower James River	James River	VAP-H39R_JMS02A98	3.36	2006	extending from William's Island dam to Boulevard Bridge
Lower James River	James River	VAP-H39R_JMS02B04	4.37	2006	extending from rivermile 128.14 to Tuckahoe Creek confluence
Lower James River	Reedy Creek	VAP-H39R_RDD01C10	1.09	2020	extending from Roanoke Street to James River
Lower James River	James River	VAP-H39R_JMS03A98	2.94	2006	extending from Boulevard Bridge to fall line at approximately railroad trestle above Mayos Bridge
Lower James River	James River – South Channel	VAP-H39R_JMS03B14	0.95	2006	extending from Belle Island dam to Brown's Island dam

Table ES-2. James River water bodies with PCB Fish Consumption Advisories from the Virginia Department of Health (VDH).

Water Body and Affected Boundaries	Affected Localities	Species	Advisories/Restriction
Maury River from Buena Vista at Rt. 60 16 miles to James River	Rockbridge County and Buena Vista City	Redbreast Sunfish Rock Bass Yellow Bullhead Catfish Carp	No More than Two Meals/Month

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

Water Body and Affected Boundaries	Affected Localities	Species	Advisories/Restriction
Upper James River from the head of the James near Iron Gate (at the confluence of Jackson River and Cowpasture River) to Balcony Falls Dam downstream of Glasgow (near the Maury River)	Botetourt and Rockbridge Counties	Carp	No More than Two Meals/Month
James River from Big Island Dam to I-95 James River Bridge in Richmond	Amherst, Bedford, Campbell, Appomattox, Nelson, Buckingham, Albemarle, Fluvanna, Cumberland, Goochland, Powhatan, Henrico, Chesterfield Counties, Lynchburg and Richmond Cities	Gizzard Shad Carp American Eel Flathead Catfish Quillback Carp sucker	No More than Two Meals/Month

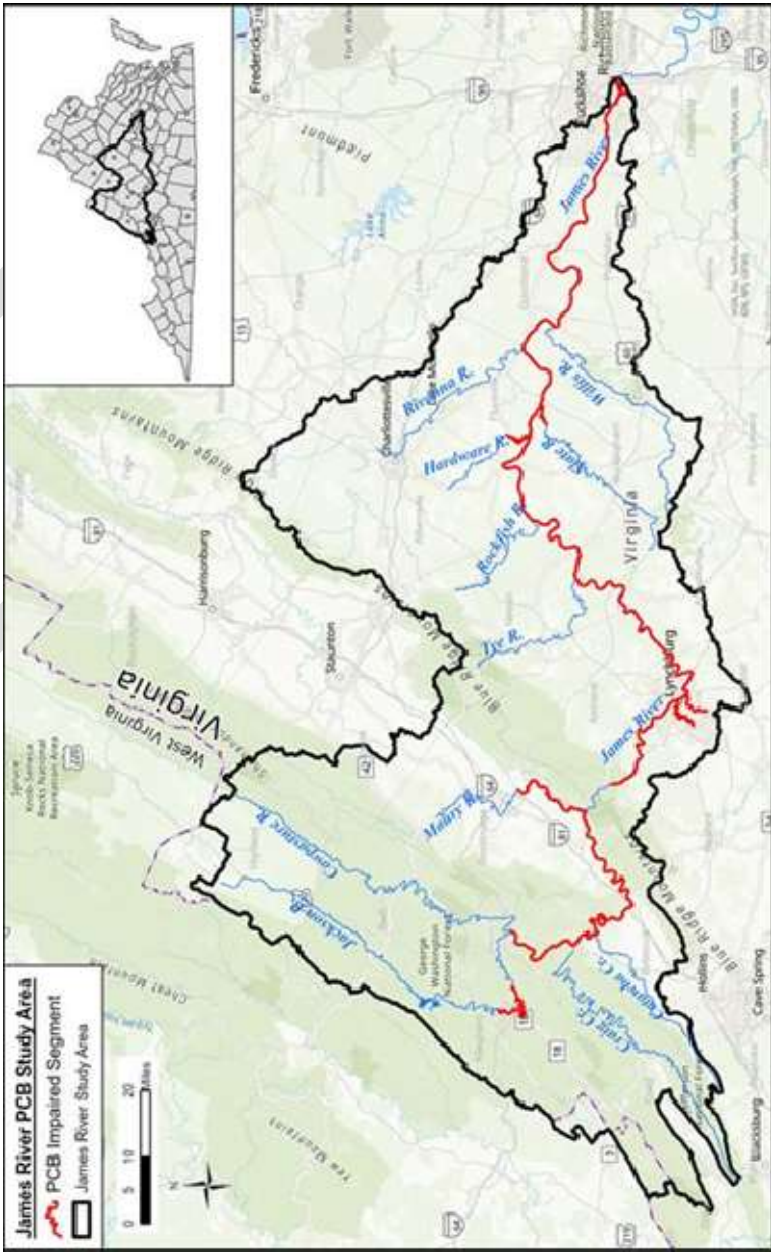


Figure ES-1. PCB impaired stream segments in the James River study area.

Modeling

The Hydrological Simulation Program–FORTRAN (HSPF) (Bicknell et al., 2005) was used to simulate the fate and transport of PCBs in the James River study area. HSPF is a continuous computational model that can represent fate and transport of pollutants on both the land surface and instream. The model simulated hydrology, and sediment and PCB fate and transport. A PCB load equation was developed for four TMDL watersheds: Jackson River, Maury River, Upper and Lower James River. These TMDL watersheds were further sub-divided into subwatersheds based on pollutant sources and various features that impacted the hydrology and pollutant fate and transport modeling. The hydrologic modeling established the foundation for the James River model. Since PCBs are hydrophobic and tend to associate with sediment, a sediment model component was built on the hydrologic model. The final model component simulated PCB fate and transport. The James River model was calibrated at each stage of model development, using a “weight-of-evidence” approach. Multiple analyses were used to ensure the simulated outputs adequately reflect the observed data, particularly during critical flow conditions.

Endpoints

The impaired segments of the James River study area do not support the fish consumption designated use due to exceedances of the Virginia Department of Health’s (VDH) PCB fish tissue threshold and/or the Virginia Department of Environmental Quality’s (VADEQ) total PCB (tPCBs) fish screening value and water quality criterion (WQC). Segment-specific PCB water quality endpoints were calculated using a Bioaccumulation Factor (BAF) approach. This method correlates the localized instream concentrations of PCBs to the concentration of PCBs found within a variety of fish species collected in the same area. As such, the maximum allowable water column tPCB concentration is calculated to ensure the fish tissue thresholds established by either the VDH, 100 ng/g, or the VADEQ, 18 ng/g will be attained. The water column tPCB endpoint for the Jackson River is the PCB WQC of 580 pg/L. Endpoints for the Maury, and Upper and Lower James were calculated using the BAF approach while the PCB WQC was used for the Jackson River segment because the calculated BAF was higher than the WQC (Table ES-3).

Table ES-3. PCB Endpoints for impaired segments of the James River study area

Impaired Segment	PCB Water Quality TMDL Endpoint (pg/L)
Jackson River	580
Maury River	400
Upper James River	120
Lower James River	52

PCB TMDLs

Various source reduction scenarios were evaluated to identify implementable scenarios that meet the TMDL endpoints for each calibration segment. Load reduction allocation scenarios were generated using meteorological data for the harmonic mean flow year (HMFY) for the James, Maury, and Jackson River segments (and tributaries) included in this TMDL report. The HMFY is the observed flow year whose harmonic mean flow best corresponds to the harmonic mean flow of the entire period of observed flow data at a given gage. The modeled PCB loads correspond to anticipated and permitted future conditions. The TMDL model(s) is used to simulate hourly, instream PCB concentrations for the HMFY. The upper 95% confidence limit of the median of the simulated, daily average instream PCB concentrations, for the applicable HMFY, is compared to the TMDL endpoint to determine if a given PCB pollutant allocation scenario reduces PCB loads sufficiently to meet the TMDL endpoint. Equation ES-1 was used to calculate the loadings shown in Table ES-4. To be consistent with WQS, the annual loads and WLAs are presented using two significant figures.

$$TMDL = WLA_{Total} + LA + MOS$$

Eq. ES-1

Where:

WLA_{Total} = waste load allocation (point source contributions, future conditions which account for point source facilities inadvertently excluded from TMDL);
 LA = load allocation (nonpoint source contributions); and
 MOS = margin of safety.

Margin of Safety

In order to account for the uncertainty of the relationship between the pollutant loads and the quality of the receiving waters, a margin of safety (MOS) was implemented, an explicit MOS of 5% was included. Additional conservative modeling precautions resulted in an implicit additional MOS.

Table ES-4. Annual and daily PCB loadings for the TMDLs.

Impaired Segment (Harmonic Mean Flow Year)	Units	WLA _{Total} ¹	LA ²	MOS ³	TMDL ⁴
Jackson River	mg/yr	170,000	110,000	15,000	300,000
(HMFY: 2010)	mg/day	1,100	670	89	1,900
Maury River	mg/yr	4,100	440,000	23,000	470,000
(HMFY: 2011)	mg/day	24	2,300	120	2,400
Upper James River	mg/yr	190,000	340,000	28,000	560,000
(HMFY: 2010)	mg/day	1,000	1,900	160	3,100
Lower James River	mg/yr	160,000	270,000	22,000	450,000
(HMFY: 2002)	mg/day	1,000	1,700	140	2,800

¹ WLA_{Total} includes future conditions.

² The LA is the remaining loading allowed after the MOS and WLA_{Total} are subtracted from the TMDL as determined for the downstream end/outlet of the impaired segment.

³ Explicit MOS (5%).

⁴ Expressed as two significant figures.

Allocation Scenarios

The proposed TMDL allocation scenarios require load reductions from point and nonpoint sources of PCBs. The difference between the TMDL and the existing annual load represents the necessary level of PCB reduction. The recommended reduction scenarios to meet the segment-specific TMDL endpoints are shown in Table ES-5.

Table ES-5. PCB allocation scenarios showing percent load reduction from existing conditions to meet segment-specific TMDL endpoints.

PCB Load Source Category	Required PCB Load Reductions to Meet the TMDL Endpoint (%)			
	Jackson River	Maury River	Upper James River	Lower James River
Upstream Sources	–	–	10	8
Known Contaminated Sites	99	99	99	99
Streambed Sediment	0	0	0	0
Atmospheric Deposition	0	0	0	0
Spills	100	100	100	100
Combined Sewer Systems (CSO)	–	–	68	92
Surface Load, Unspecified	15	0	0	0
Surface Load, Regulated	–	–	10	10
Permitted	<1%	99	88	97

Table ES-6 summarizes the existing loads, WLAs, LAs, and percent reduction by TMDL segment and source category. The LAs and existing loads for the nonpoint sources are the average annual loads based on the source contribution to instream PCB concentration at the outlets of the impaired segments. The WLA is calculated at the outlets of the permitted areas. Existing loads for nonpoint sources are back calculated from the final TMDL. The rows for WLA

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

Future Conditions in Table ES-6 account for point source PCB dischargers that may have been inadvertently excluded from the TMDL and are equal to 0.10% of the TMDL.

Table ES-6. Average annual tPCB loads for James River impaired segments by source category.

Source Category	Existing Load (mg/yr)	WLA (mg/yr)	LA (mg/yr)	Reduction (%)
Jackson River				
Upstream Sources				
Known Contaminated Sites	83		1	99
Streambed Sediment	11,795		11,795	0
Atmospheric Deposition	11		11	0
Spills	<1		0	100
Combined Sewer Systems (CSO)				
Surface Load, Unspecified ²	116,781		99,264	15
Surface Load, Regulated				
Permitted	164,727	173,028		-5
WLA Future Conditions ¹		296		
TOTAL	293,397	173,324	111,071	3
Maury River				
Upstream Sources				
Known Contaminated Sites	110		1	99
Streambed Sediment	1		1	0
Atmospheric Deposition	42		42	0
Spills	<1		0	100
Combined Sewer Systems (CSO)				
Surface Load, Unspecified ²	439,139		439,139	0
Surface Load, Regulated				
Permitted	355,762	3,645		99
WLA Future Conditions ¹		467		
TOTAL	795,054	4,112	439,183	44
Upper James River				
Upstream Sources				
Known Contaminated Sites	73,216		65,895 ³	10
Streambed Sediment	1,255		13	99
Atmospheric Deposition	181		181	0
Spills	832		832	0
Combined Sewer Systems (CSO)				
Surface Load, Unspecified ²	3,104		993	68
Surface Load, Regulated	277,574		277,574	0
Permitted	200,306	180,275		10
WLA Future Conditions ¹	83,452	9,880		88
TOTAL	639,920	190,719	345,488	16
Lower James River				
Upstream Sources				
Contaminated Sites	265,825		244,559 ⁴	8
Streambed Sediment	720		7	99
Atmospheric Deposition	1,367		1,367	0
Spills	1,562		1,562	0
Combined Sewer Systems (CSO)				
Surface Load, Unspecified ²	<1		0	100
Surface Load, Regulated	<1		<1	92
Permitted	18,293		18,293	0
WLA Future Conditions ¹	169,327	152,394		10
TOTAL	272,789	8,995		97
	729,883	161,837	265,788	42

¹ WLA Future Conditions account for permitted facilities that may come on-line in the future and are equal to 0.10% of the TMDL.

² Unspecified surface load is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not explicitly specified in the model, stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

³ The LA accounts for the upstream TMDLs (i.e. Jackson River, Maury River).

⁴ The LA accounts for the upstream TMDLs (i.e. Jackson River, Maury River, Upper James River).

Implementation

The goal of the TMDL program is to establish a three-step path that will lead to reasonable assurance that attainment of the applicable WQSSs will be achieved. The first step in the process is to develop TMDLs that will meet targeted water quality goals. This report represents the culmination of that effort for the PCB impairments in the James River, Maury River and Jackson River watersheds. The second step is to develop a TMDL implementation plan, which can include the use of available PCB data to “fingerprint” source areas, perform additional investigation of unspecified surface loads which includes uncharacterized nonpoint sources, and to recommend the implementation of best management practices (BMPs) where practical or remediate hot spots. The final step is to initiate recommendations outlined in the TMDL implementation plan, and to monitor stream water quality to determine if fish tissue thresholds and WQSSs are being attained. Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan in the future. Implementation plan development will be supported by DEQ’s regional and local offices and other cooperating agencies.

Public Participation

Public participation was elicited at every stage of the TMDL development in order to receive inputs from stakeholders and to apprise the stakeholders of the progress made. A series of three Technical Advisory Committee meetings and two public meetings during development of the TMDL. TAC participants included representatives from the City of Lynchburg, Albemarle County, Environmental Standards Inc., Dutoy Creek WWTP, Virginia Department of Transportation, Henrico County MS4, Dominion Energy, Chesterfield County, Falls of the James Scenic Advisory Committee, Virginia Association of Municipal Wastewater Agencies, Roanoke Valley-Alleghany Regional Commission, WestRock, City of Richmond, Bontex, Inc., Virginia Manufacturers Association, One Environmental Group, Ivy Materials Utilization Center, Sonoco Recycling, Inc., Griffin Pipe Products Co LLC, James River Association, Modine Manufacturing, AquaLaw, BWXT Nuclear Operations, Rockbridge Area

Conservation Council, University of Virginia, Jackson River Preservation Association, Chesapeake Bay Foundation, Waste Management, CHA Companies, Hampton Roads Sanitation District, New River Geographics, Vaught Landscaping, Appalachian Bronzeback Adventures, Riverside Outfitters, Central Virginia Planning District Commission, Natural Bridge Soil and Water Conservation District, M&M Service and Salvage Yard, Van der Linde Recycling, Blueridge Resource Authority, Roanoke Cement Company, Rutledge Creek WWTP, Amherst County Service Authority, Hanwha Azdel, Greif Packaging-Riverville Mill, Lexington-Rockbridge Regional Water Quality Control Facility.

The first Public Meeting was held on Tuesday, January 12, 2021, and held virtually through a webinar platform (76 attendees). The meeting, hosted by DEQ staff, included background information on PCBs and related human health concerns, long term PCB monitoring data from the study area, and an overview of the TMDL process was used in this project. Representatives from Virginia Tech's Biological Systems Engineering Department discussed the modeling process and tools that were used to predict PCB fate and transport. The comment period for the first public meeting ended February 11, 2021. Five public comments were received. The comments received and DEQ's response to those comments are documented in Appendix G:.

The first Technical Advisory Committee (TAC) meeting was held on February 24, 2021, and was conducted virtually through an online webinar platform due to the Covid-19 State of Emergency. Presentations included an overview of the James River (Upper and Lower), Maury River, and Jackson River PCB TMDL project including problem identification, PCB monitoring results and prospective sources. The meeting was attended by 54 people.

The second and third TAC meetings were held on August 2nd, 2022 (14 people attending) and November 2nd, 2022 (11 people attending), respectively. The primary focus of these meetings was to discuss changes in the WQC and to review draft PCB source allocation scenarios.

The second and final Public Meeting to present the draft PCB TMDL report for the James River study area was held on February 15, 2024, and more than 30 people attended the meeting. The public comment period for the second public meeting ended March 18, 2024. Seven public comments were received. The comments received and DEQ's response to those comments are documented in Appendix G:.

DEQ revised the draft PCB TMDL report for the James River study area in response to public comments after the final public meeting. Another 30-day public comment was offered from December 2, 2024 – January 6, 2025, to invite feedback on the changes made to the PCB

baseline loads and Waste Load Allocations. No comments were received during the public comment period.

DRAFT

Chapter 1: Introduction

1.1 Background

1.1.1 TMDL Definition and Regulatory Information

Section 303(d) of the Federal Clean Water Act and the U.S. Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130 and 131) require states to identify water bodies that violate state water quality standards (WQSS) and to develop Total Maximum Daily Loads (TMDLs) that are established at levels necessary to attain narrative and numerical WQSS. A TMDL reflects the total pollutant loading a water body can receive and still attain and maintain the applicable numerical criterion. 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.

1.1.2 PCB Impairment Listing

Multiple sections of the James River watershed, including the Jackson River and the Maury River were listed as impaired on Virginia's 2022 Section 303(d) list due to exceedances of the Virginia Department of Environmental Quality's (DEQ) fish tissue screening value for polychlorinated biphenyls (PCBs). PCB Fish consumption advisories were also identified by the Virginia Department of Health (VDH) that begins at the head of the James near Iron Gate (at the confluence of Jackson River and Cowpasture River) to Balcony Falls Dam downstream of Glasgow (near the Maury River), the Maury River from Buena Vista at Rt. 60 16 miles to the James River, and James River from Big Island Dam to the I-95 bridge in Richmond (VDH, 2022). Fish consumption advisories issued by VDH are also considered impaired by DEQ and require the development of a TMDL. The impaired segments, descriptions of their extent, and initial listing year are provided in Table 1-1 and the fish consumption advisories listed in Table 1-2. Figure 1-1 maps the locations of the PCB impaired segments within the James River study area in Virginia.

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

Table 1-1. Impaired segments from the 2024 303(d) list within each TMDL watershed addressed in this TMDL report (DEQ, 2024).

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Jackson River	Jackson River	VAW-I04R_JKS01A00	0.48	2008	extending from Westvaco main processing outfall downstream to Dunlap Creek confluence
Jackson River	Jackson River	VAW-I04R_JKS02A00	1.28	2008	extending from Covington water intake downstream to Westvaco main processing outfall
Jackson River	Jackson River	VAW-I09R_JKS04A00	5.92	2008	extending from Covington STP outfall downstream to just above Lowmoor community
Jackson River	Jackson River	VAW-I09R_JKS04B14	0.32	2008	extending from Potts Creek confluence downstream to Covington STP outfall
Jackson River	Jackson River	VAW-I09R_JKS05A00	3.01	2008	extending from downstream of Fudge's Bridge to Potts Creek confluence
Jackson River	Jackson River	VAW-I09R_JKS06A00	1.66	2008	extending from Dunlap Creek confluence downstream to just below Lexington Avenue Bridge
Maury River	Maury River	VAV-I37R_MRY01A00	5.11	2006	extending from Buffalo Creek confluence downstream to James River
Maury River	Maury River	VAV-I37R_MRY02A00	7.25	2006	extending from Indian Gap Run confluence downstream to Buffalo Creek confluence
Maury River	Maury River	VAV-I37R_MRY03A00	4.58	2004	extending from South River confluence downstream to Indian Gap Run confluence
Upper James River	James River	VAV-I28R_JMS01A00	6.73	2022	extending from Cedar Creek confluence downstream to Maury River confluence
Upper James River	James River	VAW-I18R_JMS01A00	7.77	2022	extending from Craig Creek confluence upstream to Stull Run confluence

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Upper James River	James River	VAW-I18R_JMS02A00	7.63	2022	extending from Stull Run confluence upstream to the confluence of the Jackson and Cowpasture Rivers
Upper James River	James River	VAW-I24R_JMS01A00	5.11	2022	extending from Craig Creek confluence downstream to Catawba Creek confluence
Upper James River	James River	VAW-I24R_JMS01A10	15.40	2022	extending from Catawba Creek confluence downstream to Looney Creek confluence
Upper James River	James River	VAW-I27R_JMS01A00	7.98	2020	extending from Jennings Creek confluence downstream to Big Hollow Branch confluence
Upper James River	James River	VAW-I27R_JMS02A14	7.15	2022	extending from Looney Creek confluence downstream to Jennings Creek confluence
Upper James River	James River	VAW-I28R_JMS01A08	1.55	2020	extending from Big Hollow Branch confluence downstream to Cedar Creek confluence
Upper James River	James River	VAW-H01R_JMS01A00	1.37	2006	extending from Wilderness Creek confluence downstream to Holcomb Rock Dam
Upper James River	James River	VAW-H01R_JMS01A04	0.70	2006	extending from upstream ending of the WQS PWS designation downstream to Wilderness Creek confluence
Upper James River	James River	VAW-H01R_JMS02A00	3.30	2006	extending from Georgia Pacific outfalls downstream to upstream ending of the WQS PWS designation
Upper James River	James River	VAW-H01R_JMS03A00	3.05	2006	extending from Peters Creek confluence downstream to Georgia Pacific outfalls
Upper James River	Blackwater Creek	VAW-H03R_BKW01A00	10.54	2024	extending from confluence of Tomahawk and Burton Creeks downstream to confluence on the James River

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Upper James River	Fishing Creek	VAW-H03R_FSG01A00	6.32	2020	extending from James River upstream to its headwaters
Upper James River	James River	VAW-H03R_JMS01A00	3.86	2004	extending from Business 29 bridge downstream to Williams Run confluence
Upper James River	James River	VAW-H03R_JMS04A02	4.22	2004	extending from Reusens dam downstream to Business 29 bridge
Upper James River	James River	VAW-H03R_JMS06A02	8.26	2006	extending from Holcomb Rock Dam downstream to Reusens Dam
Upper James River	James River	VAW-H05R_JMS01A00	6.27	2006	extending from Wreck Island Creek confluence downstream to Bent Creek confluence
Upper James River	James River	VAW-H05R_JMS02A00	6.78	2006	extending from Stonewall Creek confluence to Wreck Island Creek confluence
Upper James River	James River	VAW-H05R_JMS02B14	3.05	2014	extending from Beck Creek confluence to Stonewall Creek confluence
Upper James River	James River	VAW-H05R_JMS03A00	7.71	2006	extending from Archer Creek confluence downstream to Beck Creek confluence
Upper James River	James River	VAW-H05R_JMS04A00	2.68	2004	extending from Williams Run confluence downstream to Archer Creek confluence
Lower James River	James River	VAW-H08R_JMS01A00	9.68	2006	extending from Bent Creek confluence to Tye River confluence
Lower James River	James River	VAV-H14R_JMS01A18	13.49	2006	extending from Bishop Creek confluence downstream to Rockfish River confluence
Lower James River	James River	VAV-H14R_JMS02A18	5.09	2006	extending from Tye River confluence downstream to Bishop Creek confluence
Lower James River	James River	VAV-H17R_JMS01A18	8.13	2006	extending from Totier Creek confluence downstream to Hardware River confluence
Lower James River	James River	VAV-H17R_JMS02A18	4.82	2006	extending from Ballinger Creek confluence downstream to Totier Creek confluence

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Lower James River	James River	VAV-H17R_JMS03A18	5.74	2006	extending from Rockfish River confluence downstream to Ballinger Creek confluence
Lower James River	Hardware River	VAV-H19R_HRD01A00	7.00	2008	extending from Rt. 6 bridge downstream to James River
Lower James River	James River	VAV-H20R_JMS01A02	1.98	2006	extending from Hardware River confluence downstream to a point 5 miles above Fork Union Sanitary District raw water intake
Lower James River	James River	VAV-H20R_JMS02A02	2.94	2006	extending from a point 5 miles above Fork Union Sanitary District's raw water intake to Slate River confluence
Lower James River	Slate River	VAP-H22R_SLT03A02	1.00	2008	extending from Rt. 676 to a point 5 miles upstream of the Fork Union Sanitary District raw water intake to James River
Lower James River	Slate River	VAP-H22R_SLT03B20	2.90	2008	extending from a point 5 miles upstream of the Fork Union Sanitary District raw water intake to James River
Lower James River	James River	VAV-H20R_JMS02B18	2.16	2006	extending from Slate River confluence downstream to Fork Union Sanitary District's raw water intake
Lower James River	James River	VAV-H20R_JMS03A02	9.25	2006	extending from Fork Union Sanitary District's raw water intake downstream to Rivanna River confluence
Lower James River	James River	VAP-H33R_JMS01A98	6.30	2006	extending from Deep Creek confluence downstream to Big Lickinghole Creek confluence
Lower James River	James River	VAP-H33R_JMS01B24	16.79	2006	extending from Rivanna River confluence downstream to Deep Creek confluence
Lower James River	James River	VAP-H38R_JMS01A06	2.36	2006	extending from Big Lickinghole Creek confluence to start of PWS section

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

TMDL Watershed	Impaired Segment	305b Segment ID	Segment Length (miles)	Initial Listing Year	Description
Lower James River	James River	VAP-H38R_JMS02A04	3.75	2006	extending from Mohawk Creek confluence to rivermile 137.00
Lower James River	James River	VAP-H38R_JMS03A06	6.95	2006	extending from rivermile 137 to rivermile 130.14
Lower James River	James River	VAP-H38R_JMS04A06	0.52	2006	extending from start of PWS section downstream to Mohawk Creek confluence
Lower James River	James River	VAP-H39R_JMS01A98	7.45	2006	extending from Tuckahoe Creek confluence to William's Island dam
Lower James River	James River	VAP-H39R_JMS01B00	2.04	2006	extending from rivermile 130.14 to rivermile 128.14
Lower James River	James River	VAP-H39R_JMS02A98	3.36	2006	extending from William's Island dam to Boulevard Bridge
Lower James River	James River	VAP-H39R_JMS02B04	4.37	2006	extending from rivermile 128.14 to Tuckahoe Creek confluence
Lower James River	Reedy Creek	VAP-H39R_RDD01C10	1.09	2020	extending from Roanoke Street to James River
Lower James River	James River	VAP-H39R_JMS03A98	2.94	2006	extending from Boulevard Bridge to fall line at approximately railroad trestle above Mayos Bridge
Lower James River	James River – South Channel	VAP-H39R_JMS03B14	0.95	2006	extending from Belle Island dam to Brown's Island dam

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

Table 1-2. James River water bodies with PCB Fish Consumption Advisories from the VDH

Water Body and Affected Boundaries	Affected Localities	Species	Advisories/Restriction
Maury River from Buena Vista at Rt. 60 16 miles to James River	Rockbridge County and Buena Vista City	Redbreast Sunfish Rock Bass Yellow Bullhead Catfish Carp	No More than Two Meals/Month
Upper James River from the head of the James near Iron Gate (at the confluence of Jackson River and Cowpasture River) to Balcony Falls Dam downstream of Glasgow (near the Maury River)	Botetourt and Rockbridge Counties	Carp	No More than Two Meals/Month
James River from Big Island Dam to I-95 James River Bridge in Richmond	Amherst, Bedford, Campbell, Appomattox, Nelson, Buckingham, Albemarle, Fluvanna, Cumberland, Goochland, Powhatan, Henrico, Chesterfield Counties, Lynchburg and Richmond Cities	Gizzard Shad Carp American Eel Flathead Catfish Quillback Carp sucker	No More than Two Meals/Month

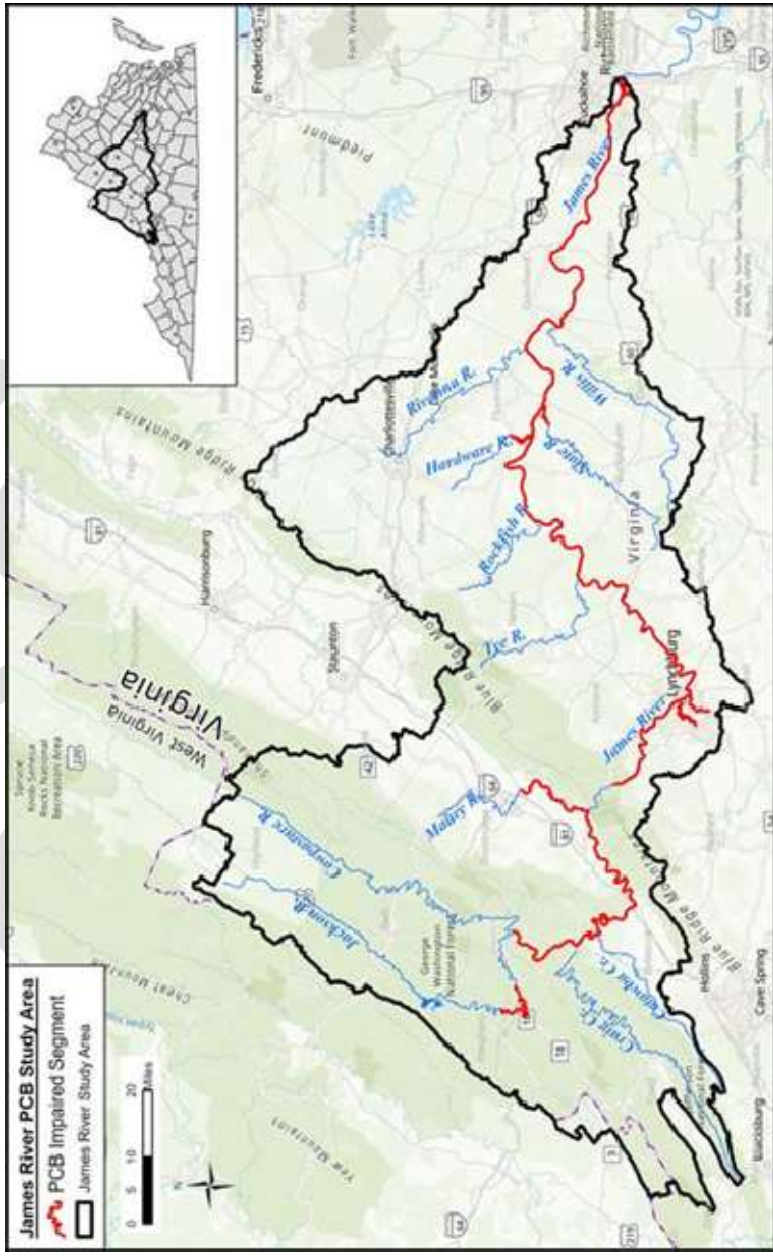


Figure 1-1. PCB impaired stream segments in the James River watershed.

1.1.3 Study Area Location and Description

The James River study area spans 27 counties and includes six city jurisdictions (Figure 1-2). The headwaters start near the West Virginia border, with the confluence of Jackson and Cowpasture Rivers forming the James River. From this point the James River flows eastward roughly 239 miles before it reaches the city of Richmond. The study area totals 4,342,969 acres (approximately 6,786 mi²), and consists of four TMDL watersheds: Jackson River (Figure 1-3), Maury River (Figure 1-4), Upper James River (Figure 1-5) and Lower James River (Figure 1-6). The James River study area spans steep mountainous slopes in the west, low rolling ridges and hills to the east of the Blue Ridge, and relatively low relief plains in the east. The fall line (roughly parallel to the I-95 corridor) defines the eastern-most extent of the freshwater (non-tidal) James River PCB TMDL study area.

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

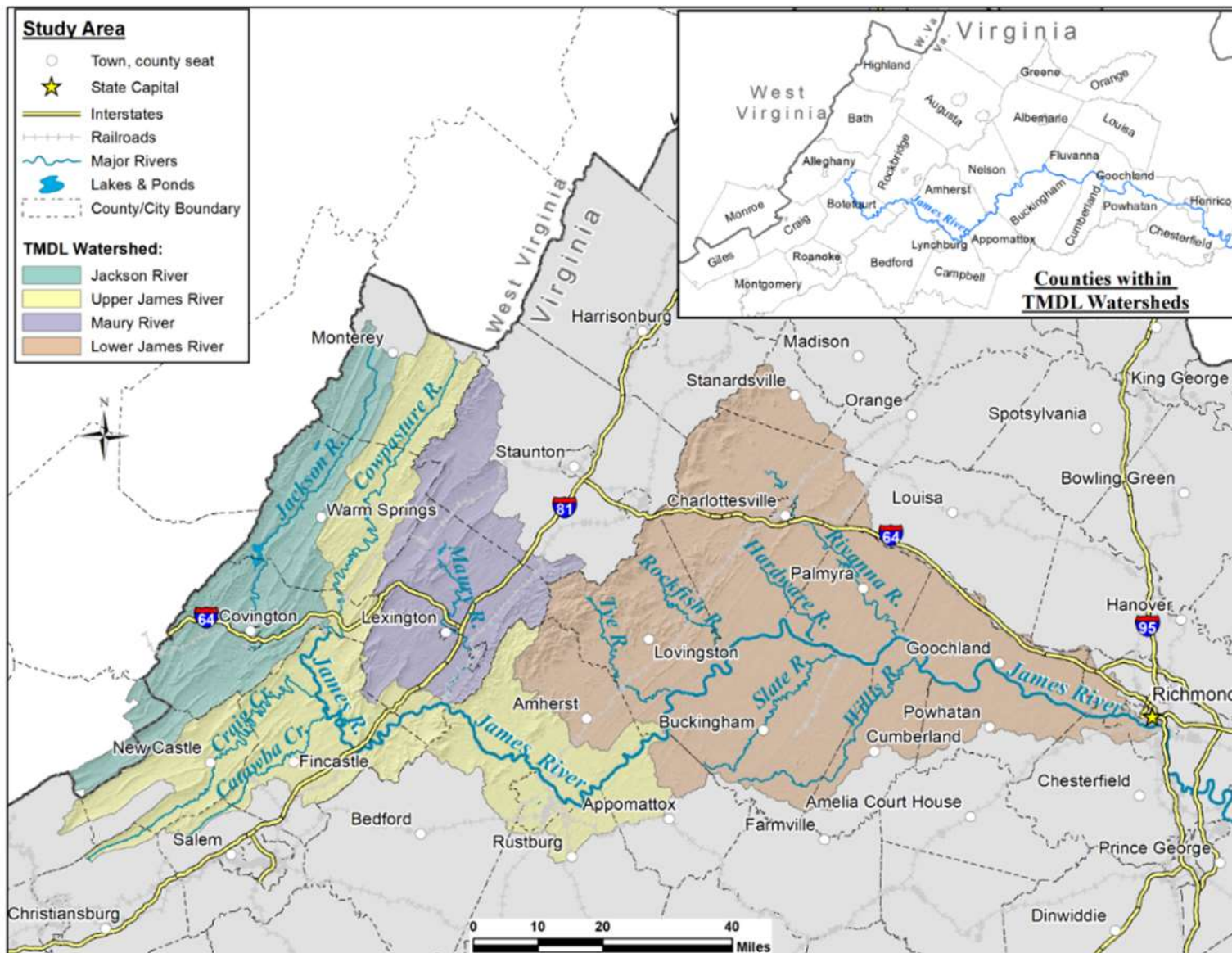


Figure 1-2. TMDL watersheds located within the James River study area.

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

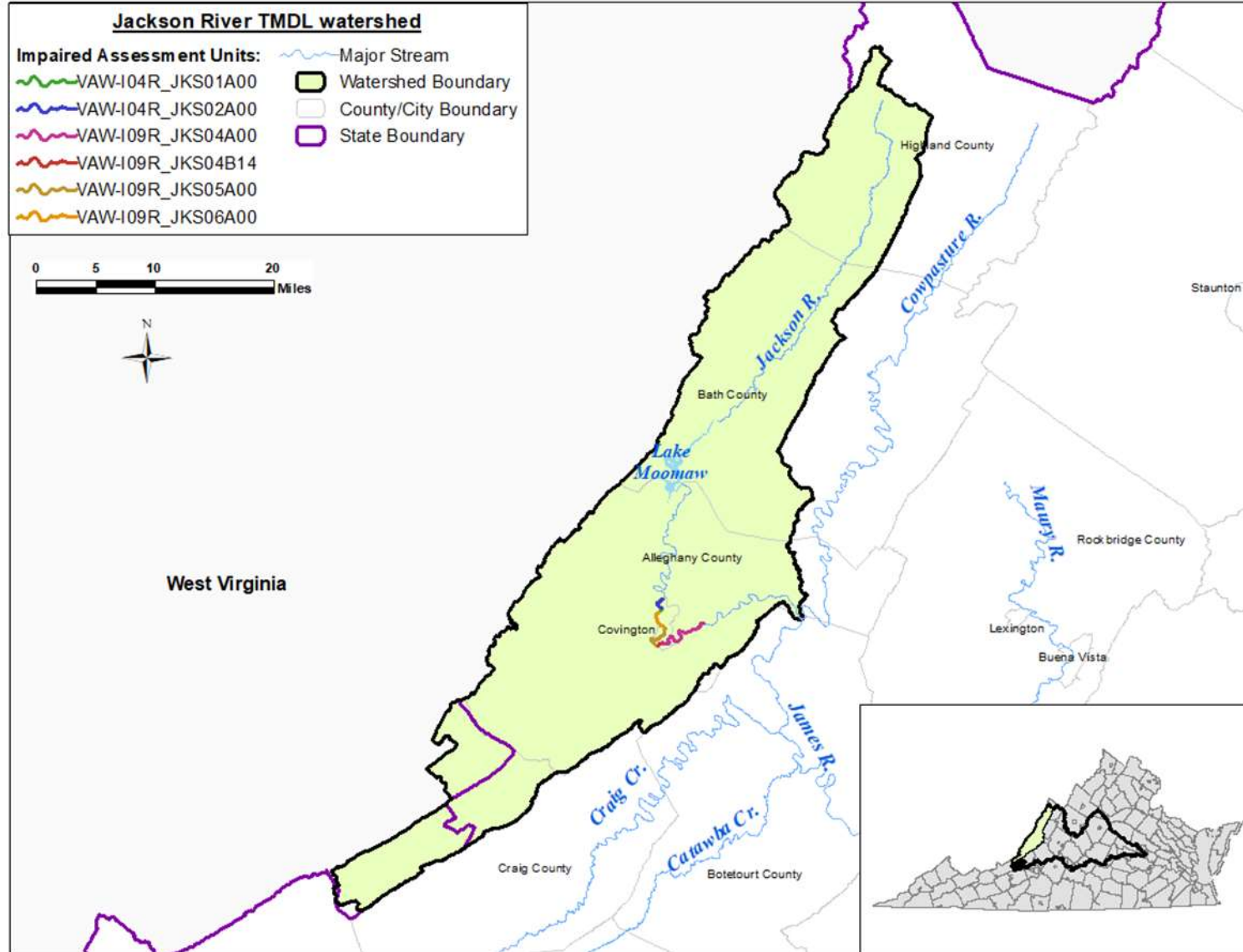


Figure 1-3. PCB impaired segments in the Jackson River watershed.

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

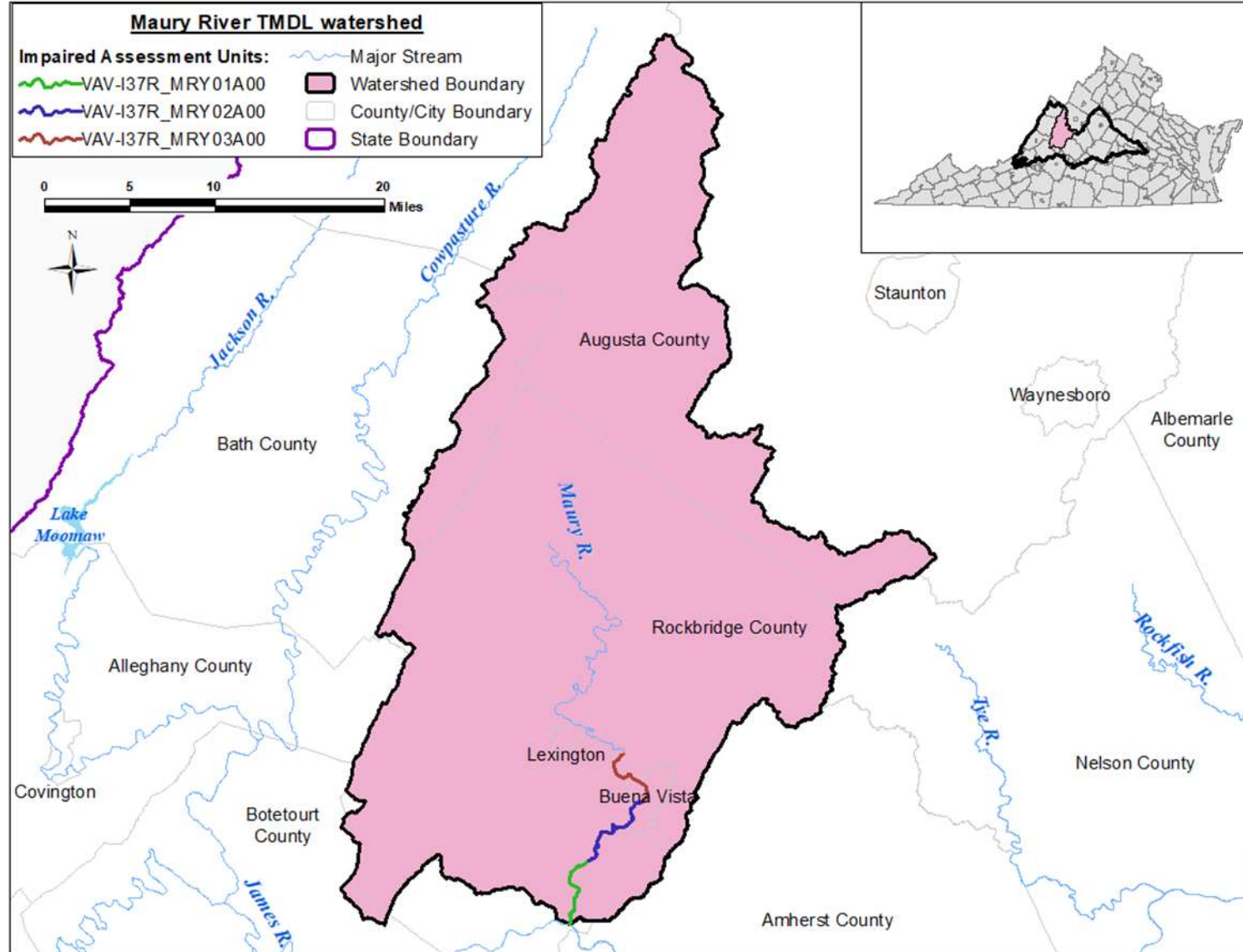


Figure 1-4. PCB impaired segments in the Maury River watershed.

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

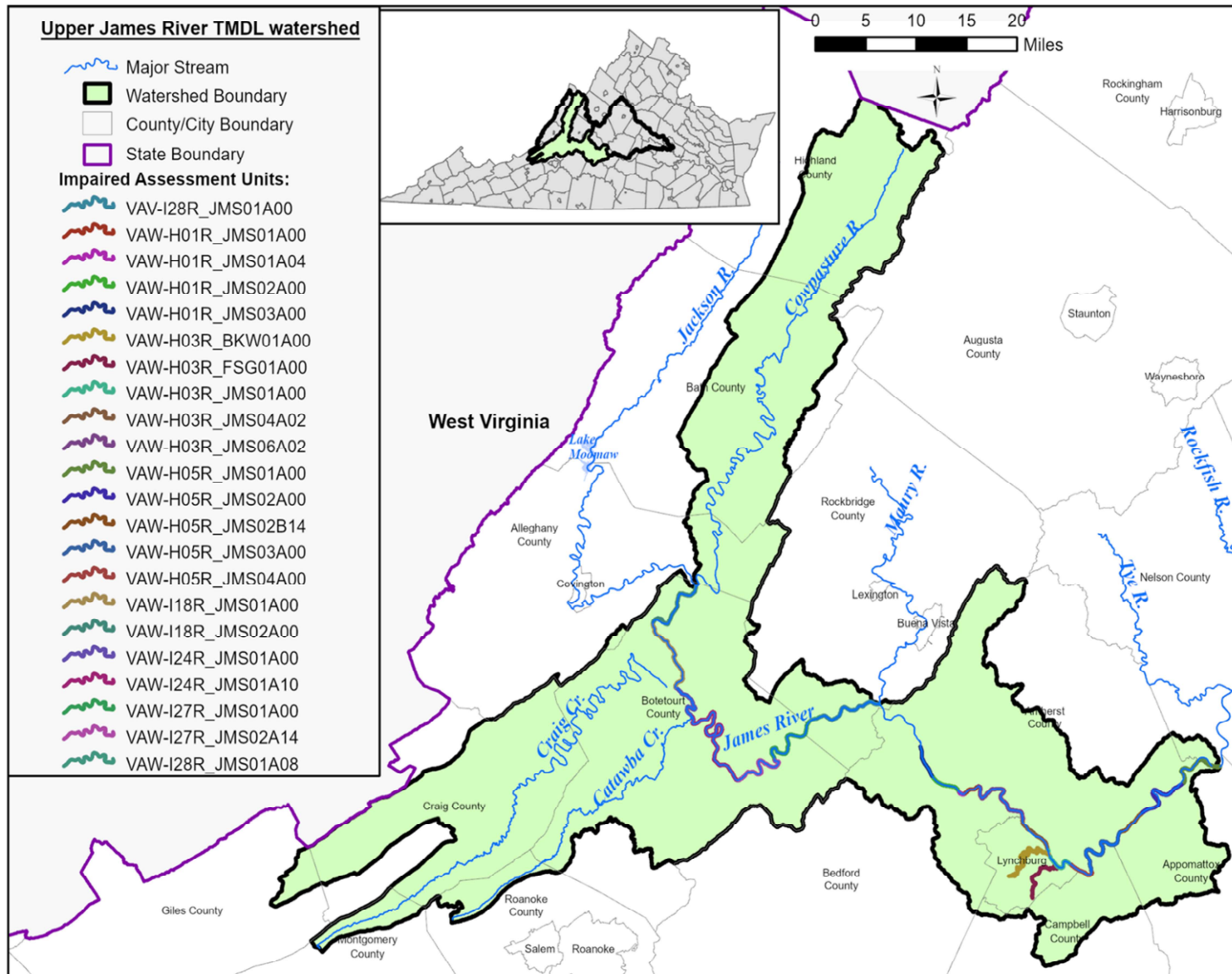


Figure 1-5. PCB impaired segments in the Upper James River watershed.

PCB TMDL for the James River, Maury River, and Jackson River Watersheds

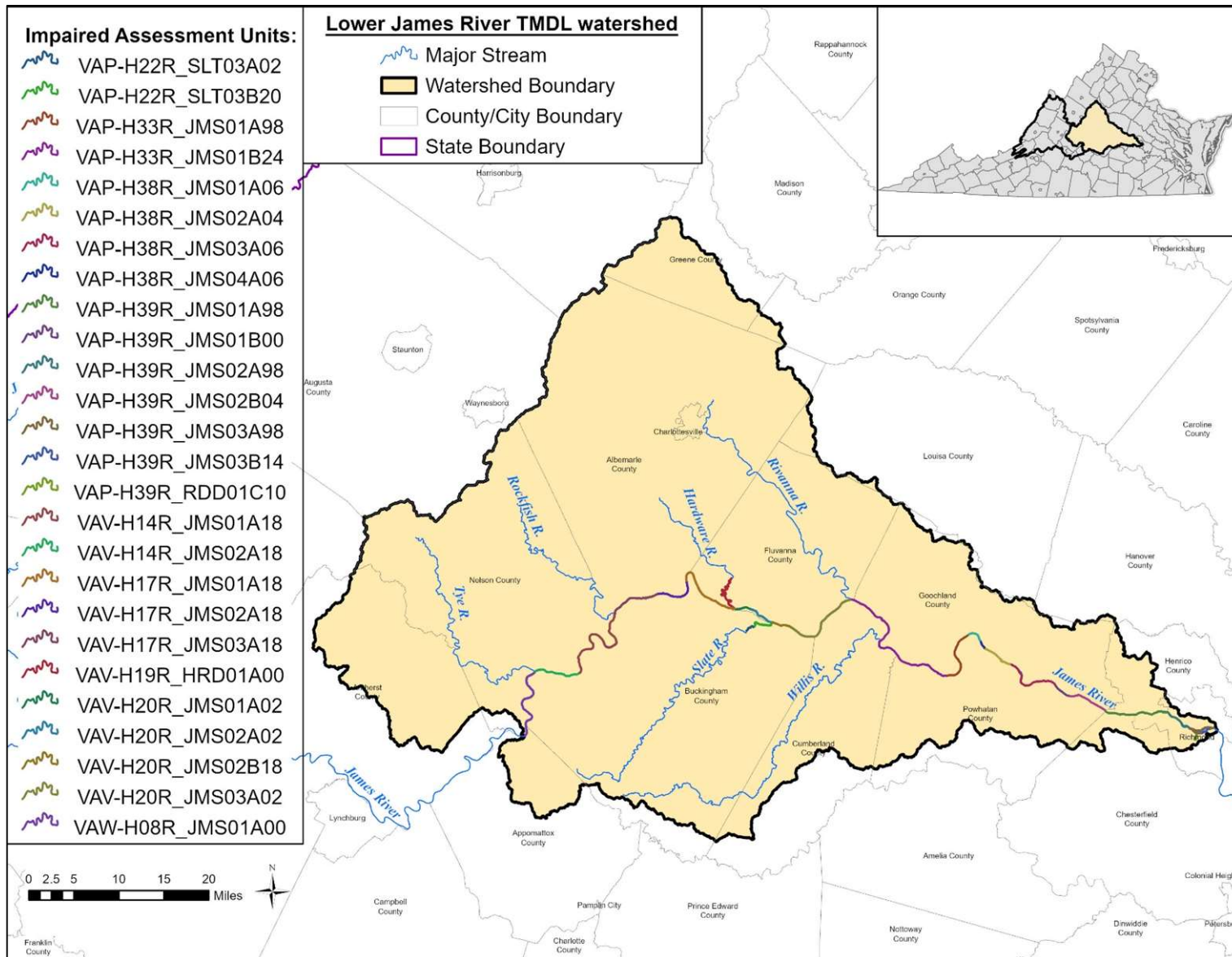


Figure 1-6. PCB impaired segments in the Lower James River watershed.

1.1.4 Pollutant of Concern

The TMDL pollutant of concern is polychlorinated biphenyl (PCB) contamination. PCBs are synthetic compounds that were commonly manufactured in the first half of the 20th century. The chemical structure consists of two bonded phenyl rings with at least one chlorine atom bonded to one of ten positions on the perimeter of the rings (Figure 1-7). There are 209 individual PCB combinations, or congeners, of which chlorine atom(s) are substituted at different positions on the rings. Congeners are grouped by the number of chlorine atoms, irrespective of position, into ten homologs (e.g. monochlorobiphenyl, di-, tri-, ...deca-). The molecular composition of PCBs enables them to be very resistant to degradation. They are relatively insoluble in water, dielectric, and flame-resistant. As a result, they were commonly used in industrial processes and were often found in oils used in machinery such as transformers. The anti-degradation properties that made them valuable to industrial and manufacturing processes also made them an environmental hazard. When introduced into the environment through volatilization, landfill dumps, or wastewater outflows from municipal or industrial sources, PCBs can persist for many decades.

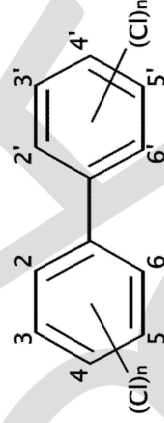


Figure 1-7. Chemical structure of polychlorinated biphenyls (PCBs) (Wikimedia, 2006)

PCB production and usage were banned in the late 1970's. However, PCBs may still be found in legacy machinery that fall under the exceptions to EPA regulations, such as train locomotives. The chemical properties of PCBs mean they are still commonly found in the atmosphere, in the water column and sediment of streams and lakes, and in the soils of contaminated sites. Their tendency to bioaccumulate in fish at low concentrations and their known high toxicity and risk to human health mean that even in small quantities their presence is a concern. The common units used in this report to denote concentrations and loads of PCBs are listed in Table 1-3.

Table 1-3. Common PCB concentration and load units used in this report.

Media	Units	Parts-per
Fish Tissue	nanograms per gram, ng/g	parts-per-billion, ppb
Sediment	nanograms per gram, ng/g	parts-per- billion, ppb
Water Column (PCB Concentration)	picograms per liter, pg/L	parts-per-quadrillion, ppq
Annual PCB Load	milligrams per year, mg/yr	

The primary human health exposure pathway of concern is through consumption of contaminated food. When PCBs enter a water body, they may contaminate fish tissue at very low levels through bioaccumulation. Fish are exposed to PCBs via different pathways such as uptake through the gills and/or skin, exposure can be affected by different feeding strategies and are known to increase in concentration through trophic transfer within a food chain (i.e., biomagnification). Humans that consume fish contaminated with PCBs may contract a multitude of chronic ailments. PCB exposure can result in endocrine system disruption and weakened immune systems. Acute symptoms include fatigue, headaches, coughs, and rashes. The children of women exposed to PCB concentration levels even slightly higher than the general population during or before pregnancy have been found with compromised immune systems and intellectual impairment (Jacobson and Jacobson, 1996). Some commercial PCB mixtures have been characterized as probably carcinogenic to humans. Although food is the major cause of PCB exposure, it can also occur by breathing contaminated air and skin contact.

1.2 Designated Uses and Applicable Water Quality Standards

1.2.1 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, 2010).

Portions of the Maury River and the James River do not support the Fish Consumption use as VDH made the determination for restrictions on fish consumption to protect human health from PCB contamination. In its 1999 Final Rule: Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants; States’ Compliance-Revision of Polychlorinated Biphenyls (PCBs) Criteria (USEPA 1999), the EPA determined that the major pathway of human exposure to PCBs is fish consumption.

1.2.2 Applicable Water Quality Standards

The VDH and DEQ have PCB fish tissue thresholds, and DEQ has a water quality criterion (WQC) designed to be protective of the “fishable” use (Table 1-4). VDH provides alerts on unsafe fish consumption when contaminants like PCBs are detected in fish tissue and their quantity in the sampled tissue exceeds the level of concern. In 2012, VDH revised the threshold level from 50 ng/g (ppb) to 100 ng/g (ppb) (VDH, 2012). DEQ’s WQC for total PCBs (tPCB), as listed in 9 VAC-25-260-140, was derived by following EPA’s guidelines to protect human health from toxic effects through drinking water and the consumption of fish. The WQC, adopted by the Virginia State Water Control Board in January 2010, was derived using a risk-based approach whereby 1) a bioconcentration factor (BCF) was used as the denominator of the risk-based equation to translate the value into an acceptable concentration in water (e.g., WQC), and then 2) an acceptable fish tissue threshold concentration was determined by removing the BCF from the equation. DEQ’s criterion-based fish screening threshold was originally 54 ng/g (ppb), but with the application of updated risk-based assumptions, the threshold was decreased to 20 ng/g (ppb) in 2010 (DEQ, 2010), and then again in 2021 to 18 ng/g (ppb) (DEQ, 2021a). The VDH’s revised value and DEQ’s fish tissue value (TV) are different because they serve different purposes. VDH consumption advisories seek to mitigate human health risks once a waterbody has become contaminated. DEQ’s fish screening value is designed to mitigate the risk of excess contamination in all of Virginia’s waters.

Table 1-4. Applicable Fish Tissue Thresholds and Water Quality Criterion for PCBs

Agency	Fish Tissue Threshold (ng/g, ppb)	Water Quality Criterion (pg/L, ppq)
Virginia Department of Health (VDH)	100 (Fish Consumption Advisory)	–
Virginia Department of Environmental Quality (DEQ)	18 (Fish Tissue Value)	580

Because fish have different exposure pathways to very low levels of PCBs, the use of DEQ’s fish TV and a segment-specific Bioaccumulation Factor (BAF) adds additional assurance to the prospects of restoring the “fishable” use. The benefit to using a segment-specific BAF approach was established during the development of the multi-jurisdictional PCB TMDL for the Potomac River (ICPRB, 2007) the Roanoke River PCB TMDL (DEQ, 2009), and the more recent New River PCB TMDL (DEQ, 2018). By adhering to the guidelines from the aforementioned studies, a PCB water quality target for the Jackson, Maury, and Upper and

Lower James Rivers were determined through the derivation of segment-specific endpoints using local fish tissue/river water monitoring data.

A BAF quantifies the ratio between the pollutant concentrations in a stream to the pollutant concentration found within fish. This methodology improves upon the BCF approach as it accounts for multiple pathways of exposure in fish including uptake from water, food, and sediment. For each TMDL watershed, the final BAF value uses DEQ's fish tissue screening value of 18 ppb to derive the water quality endpoints. Of note, the fish TV is an equivalent concentration to the water based WQC and is consistent with the most up-to-date threshold level as described in VADEQ's applicable Water Quality Assessment Guidance Manual (DEQ, 2023).

1.2.3 Targeted Water Quality Goals

After the water quality endpoint was derived from the final BAF, it was compared against the WQC (580 pg/L) for each impaired segment. Appendix A details the process of calculating and selecting the TMDL endpoints. Provided in the appendix is an explanation of the BAF calculation, how the fish tissue thresholds were used, and the conditions for selecting a suitable endpoint. Segment specific water quality endpoints were determined for each TMDL watershed of the James River study area (Table 1-5). Specific endpoints were used for each TMDL watershed to account for differences in the degree of PCB contamination in each watershed and the magnitude of PCB sources. The TMDL endpoints for the James, Maury and Jackson Rivers were developed according to a PCB WQS that establishes compliance with the "human health" criteria by relying on the assumption of (an) "average amount of exposure on a long-term basis".

Table 1-5. PCB Water Quality Targets/TMDL Endpoints for each impaired segment

Impaired Segment	PCB Water Quality TMDL	
		Endpoint (pg/L)
Jackson River		580
Maury River		400
Upper James River		120
Lower James River		52

Chapter 2: Watershed Characterization

2.1 Selection of Subwatersheds

The James River study area spans 27 counties, including some or all of: Albemarle, Alleghany, Amherst, Appomattox, Augusta, Bath, Bedford, Botetourt, Buckingham, Campbell, Chesterfield, Craig, Cumberland, Fluvanna, Giles, Goochland, Greene, Henrico, Highland, Louisa, Montgomery, Nelson, Orange, Powhatan, Roanoke, and Rockbridge counties of Virginia, and Monroe County of West Virginia. The study area includes six city jurisdictions: Buena Vista, Charlottesville, Covington, Lexington, Lynchburg, and City of Richmond. The headwaters start near the West Virginia border, with the confluence of Jackson and Cowpasture Rivers forming the James River. From this point the James River flows eastward roughly 239 miles before it reaches the city of Richmond. The study area totals 4,342,969 acres (approximately 6,786 mi²), and consists of four TMDL watersheds: Jackson River, Maury River, Upper and Lower James River (Figure 1-2).

Portions of the James River study area exceed water quality criteria due to PCB contaminants found in fish tissue. The study area was divided into four TMDL watersheds based on major tributary junctions and the location of the PCB impaired segments. The TMDL watersheds were subdivided into a total of 265 subwatersheds (Figure 2-1). Subwatersheds were delineated based on several factors including location of PCB impaired segment, proximity to water quality monitoring stations, stream network continuity, and land use distribution. The length of the PCB impaired stream segments within the study area totals approximately 229 miles. There are approximately 13 miles of PCB impaired stream along the Jackson River, 17 miles on the Maury River, and the Upper James River watershed includes 51 miles of PCB impaired stream. The Lower James River TMDL watershed includes a 7-mile-long impaired segment (on Hardware River), 4 miles (on Slate River), and 121 miles along the James River ending in Richmond. Table 2-1 lists the number of subwatersheds and their total acreage within each TMDL watershed.

The stream network used to help define the subwatersheds was obtained from the National Hydrography Dataset (NHD) (USGS, 2019). It was preferable to have a subwatershed outlet at or near a monitoring station location, so that simulated outputs could be more readily calibrated to observed data (discussed further in Chapter 5). Due to the large size of the James River study area, subwatersheds were further divided among major tributaries within the Upper and Lower James River TMDL watersheds. Major tributaries and segments organized within the Upper James River TMDL watershed include: Cowpasture River, Craig Creek, Catawba Creek,

PCB TMDL for Jackson River, Maury River, Upper and Lower James River Watersheds

and James River. The Lower James River TMDL watershed includes: Tye River, Rockfish River, Hardware River, Slate River, Rivanna River, Willis River, and James River.

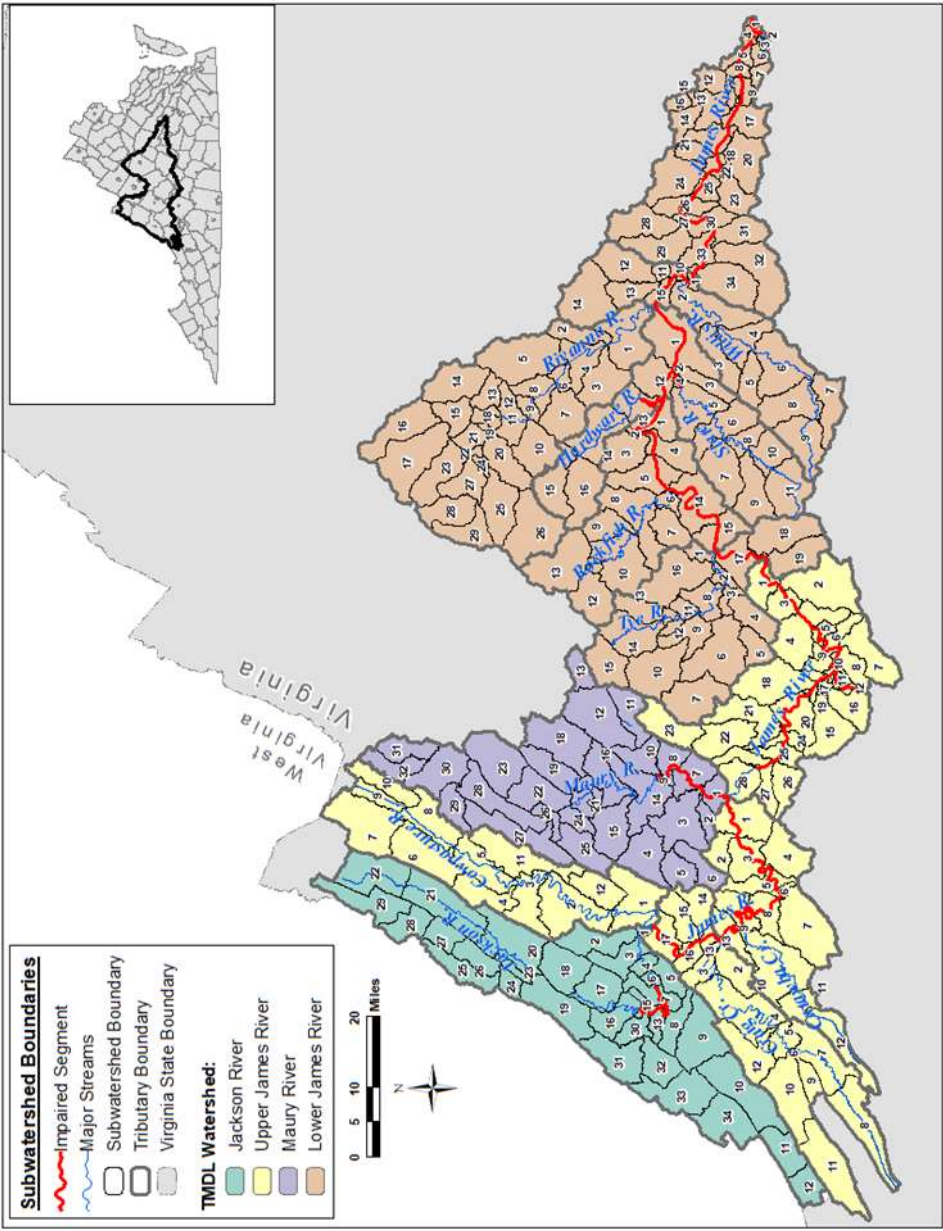


Figure 2-1. Subwatershed boundaries used in the James River study area. Note, subwatersheds were further refined by major tributary within the Upper and Lower James River TMDL watersheds.

Table 2-1. TMDL watershed, number of subwatersheds, and area.

TMDL Watershed	No. Subwatersheds	Total Area (acres)
Jackson River	34	577,798
Maury River	32	536,445
Upper James River	70	1,220,570
Lower James River	129	2,008,156
TOTAL	265	4,342,969

2.2.3 Soils

The Soil Survey Geographic (SSURGO) dataset was used for the purpose of characterizing the soils and hydrologic modeling of the James River study area. Hydrologic soil groups were the primary soil property used during watershed characterization. Soil groups provide a basis for estimating infiltration rates and surface runoff. For example, soils in hydrologic group “A” pass a larger proportion of rainfall through to groundwater than soils in hydrologic group “B.” Conversely, soils in hydrologic group “D” inhibit infiltration such that a large proportion of rainfall contributes to surface runoff and therefore a more direct path to stream channels. These processes have consequences for the washoff rate of pollutants from the land surface (USDA-NRCS, 2019). Figure 2-4 shows the distribution of the hydrologic soil groups within the James River study area. Hydrologic group “B” soils dominate the watershed with 52% of the entire study area. Hydrologic groups “A”, “D”, and “C” cover 16%, 15%, and 13% of the study area, respectively. A low proportion of the study area contain hydrologic groups “B/D” (2% of the study area), “C/D” (2%), and “A/D” (< 1%).

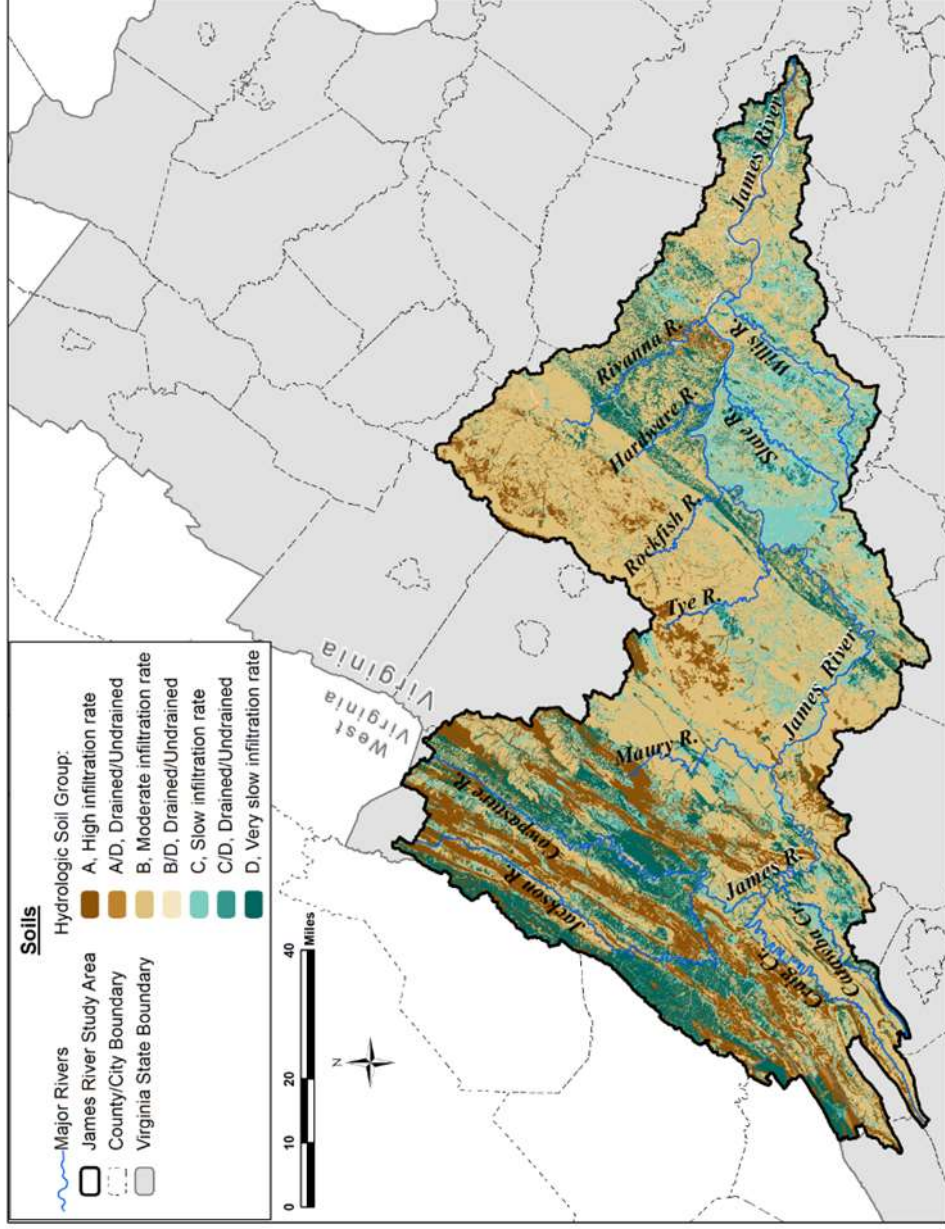


Figure 2-4. Distribution of soil types by hydrologic soil group in the James River study area.

2.2.4 Climate

The climate of the James River study area was characterized using meteorological observations acquired at weather stations from the National Centers for Environmental Information (NCEI) located within or near the watershed (NCEI, 2019; Table 2-2). A map of meteorological station locations is shown in Figure 2-5. These stations were selected based on proximity to the TMDL watersheds, proximity to flow gage stations, orographic influences, and available data with a complete period of record.

Table 2-2 shows the NCEI stations used to collect the main meteorological data for model input: precipitation, minimum and maximum temperature. These nine stations were situated within, and close to, the study area, and together were used to compile a complete dataset for modeling purposes. Most data consisted of daily observations obtained from Global Historical Climatology Network – Daily (GHCN-Daily) meteorological stations.

Below the line break in Table 2-2 is the station used to collect other meteorological data including percent sun, dew point temperature, and average wind speed. These constituents are less commonly recorded, and the nearest station with a complete dataset was the Lynchburg Regional Airport. Past experience from developing TMDLs had revealed that water quality models are not sensitive to these weather inputs. Using best professional judgment, it was determined that a station as distant as Lynchburg is justified.

Table 2-2. Meteorological stations and the parameter data used from each station.

Meteorological Station Locations	Station ID	Meteorological Parameters
Appomattox, VA	USC00440243	Precipitation Minimum Daily Temperature Maximum Daily Temperature
Charlottesville 2 W, VA	USC00441593	
Covington Filter Plant, VA	USC00442044	
Crozier, VA	USC00442142	
Gathright Dam, VA	USC00443310	
Glasgow 1 SE, VA	USC00443375	
Hot Springs, VA	USC00444128	
Lexington, VA	USC00444876	
Pedlar Dam, VA	USC00446593	
Roanoke Regional Airport	724110 13741	Dew Point Temperature
Richmond International Airport	724010 13740	Average Wind Speed
Lynchburg Regional Airport	724100 13733	Percent Sun

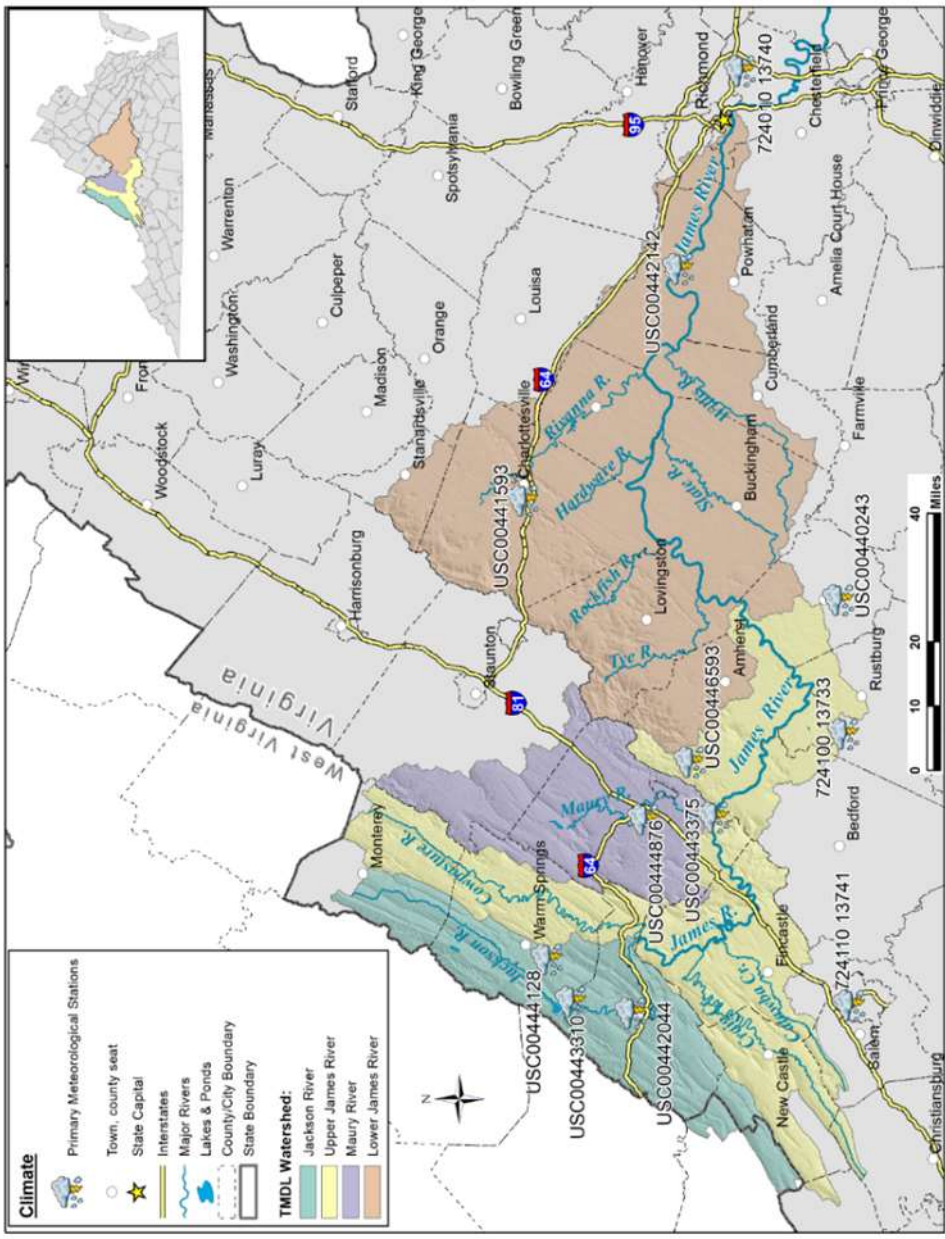


Figure 2-5. Meteorological stations used for the James River study area.

2.2.5 Topography

Topography governs stream gradients and influences weather patterns that drive hydrological behavior. Within the James River study area, elevation data is available as a 10-meter resolution Digital Elevation Model (DEM), which is a detailed topographic dataset derived from the United States Geological Survey (USGS) 3D Elevation Program (USGS, 2019). DEMs were used to delineate subwatersheds and calculate average land surface slopes. Figure 2-6 illustrates the topography in the study area. The James River study area extends from the mountainous slopes along the West Virginia border, where the James River originates and flows eastward through the Blue Ridge Mountains, to the rolling hills of the Piedmont, eventually reaching the fall line that defines the edge of the low-relief Coastal Plain. The changing terrain from west to east is significant, with elevations in the James River study area ranging from 1,382 to 0.4 meters (approximately 4,534 to 1 feet) above mean sea level.

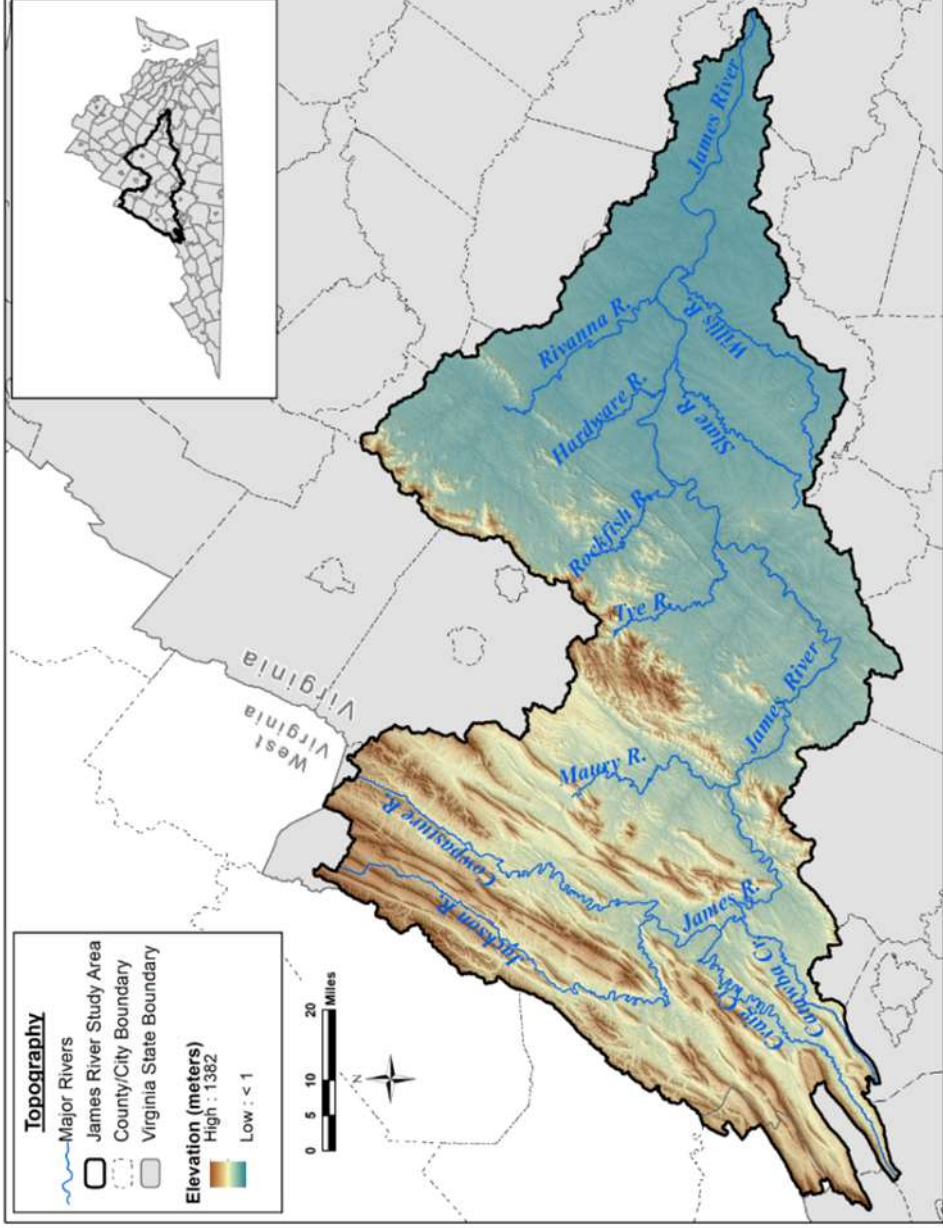


Figure 2-6. Topography of the James River study area. Elevation is in meters.

2.2.6 Land Use

Land use within the James River study area was characterized using two GIS land cover datasets. The Virginia Land Cover Dataset (VLCD), completed in 2016 from the Virginia Geographic Information Network, was used to characterize land use in most of the study area that is located within the state of Virginia (VGIN, 2017). The VLCD consists of 1-meter resolution digital land classes derived from base map aerial imagery. A portion of the study area located within West Virginia (within the Jackson River TMDL watershed), was characterized using the 30-meter resolution 2016 National Land Cover Dataset (NLCD) completed in 2019 (MRLC, 2019).

The VLCD and NLCD land cover classes in the James River study area were grouped into six major land use categories based on similarities in hydrologic features and runoff potential (Table 2-3). Pervious and impervious percentages were assigned to the land use categories for use in the watershed model. VLCD land features classified as 'Impervious' tend to represent constructed landscape that includes buildings, paved lots, roads, and railroad

corridors (VITA 2016, VGIN 2017). Land cover with VLCD impervious classifications were reclassified as either 'Residential' or 'Commercial'. Areas dominated by high concentrations of impervious features were identified, and these land features were assigned to the 'Commercial' category. The modeled land use categories for the James River study area summarized by TMDL watershed in Table 2-4 and are illustrated in Figure 2-7.

Table 2-3. Land use category aggregation.

TMDL Land Use Categories	Pervious/Impervious (Percentage)	VLCD Land Use Classes (Gridcode)	NLCD ¹ Land Use Classes (Gridcode)
Cropland	Pervious (100%)	Cropland (82)	--
Pasture	Pervious (100%)	Pasture (81)	Pasture/Hay (81)
	Pervious (100%)	Turfgrass (71)	--
Residential	Pervious (90%); Impervious (10%)	--	Developed, Open Space (21)
	Pervious (65%); Impervious (35%)	--	Developed, Low Intensity (22)
	Pervious (35%); Impervious (65%)	Impervious-extracted (21) Impervious-local datasets (22)	Developed/Medium Intensity (23)
	Pervious (10%); Impervious (90%)	Impervious-extracted (21) Impervious-local datasets (22)	Developed/High Intensity (24)
		Barren (31) Forest (41) Tree (42) Scrub/Shrub (51) Harvested/Disturbed (61) National Wetland Inventory/Other (91) Hydro (11)	Barren (31) Deciduous Forest (41) Evergreen Forest (42) Mixed Forest (43) Shrubland (52) Grassland Herbaceous (71) Woody Wetlands (90) Herbaceous Wetlands (95) Open Water (11)
Forest	Pervious (100%)		
Water	Pervious (100%)		

¹ NLCD categories only apply to portions of Jackson TMDL subwatersheds 11, 12, and 34.

Table 2-4. Land use areas in the James River study area (acres).

TMDL Watershed	Forest	Cropland	Pasture	Residential	Commercial	Water	Total
Jackson River	516,365	1,955	40,190	14,300	515	4,473	577,798
Maury River	414,233	6,513	89,223	24,124	387	1,965	536,445
Upper James River	1,022,869	9,626	117,320	60,543	1,751	8,461	1,220,570
Lower James River	1,575,911	32,837	234,849	139,320	5,466	19,773	2,008,156
Total Acres	3,529,378	50,931	481,582	238,287	8,119	34,672	4,342,969
% of Total	81%	1%	11%	5%	<1%	1%	100%

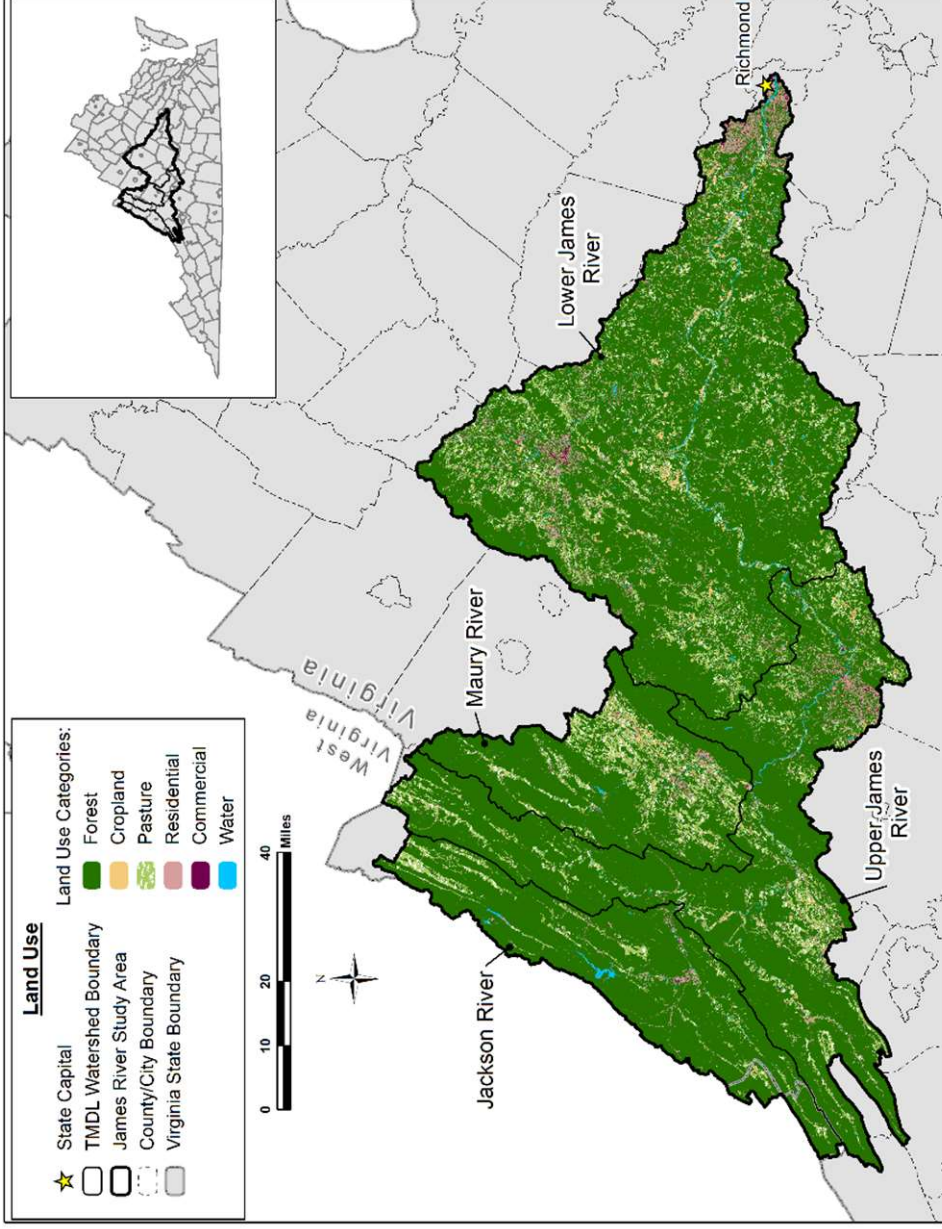


Figure 2-7. Land use distribution in the James River study area.

2.3 Stream Flow Monitoring Data

When developing the hydrologic component of a watershed model, observed flow data collected by the United States Geological Survey (USGS) is typically used. The USGS operates numerous flow gages throughout the United States that continuously measure the height of the water level (stage) in the stream. The stream stage is then converted into a discharge volume per unit time using a stage-discharge relationship. The stage-discharge relationship is unique for each gaging station. The USGS reports flow rates as daily averages in units of cubic feet per second (cfs).

Utilizing observed flow data is important for model calibration and verification. Because of the importance of flow data for model calibration, only active gages with complete datasets are used. Stream flow monitoring data from USGS gage stations across the James River study area were used to calibrate and verify the watershed model, Figure 2-8.

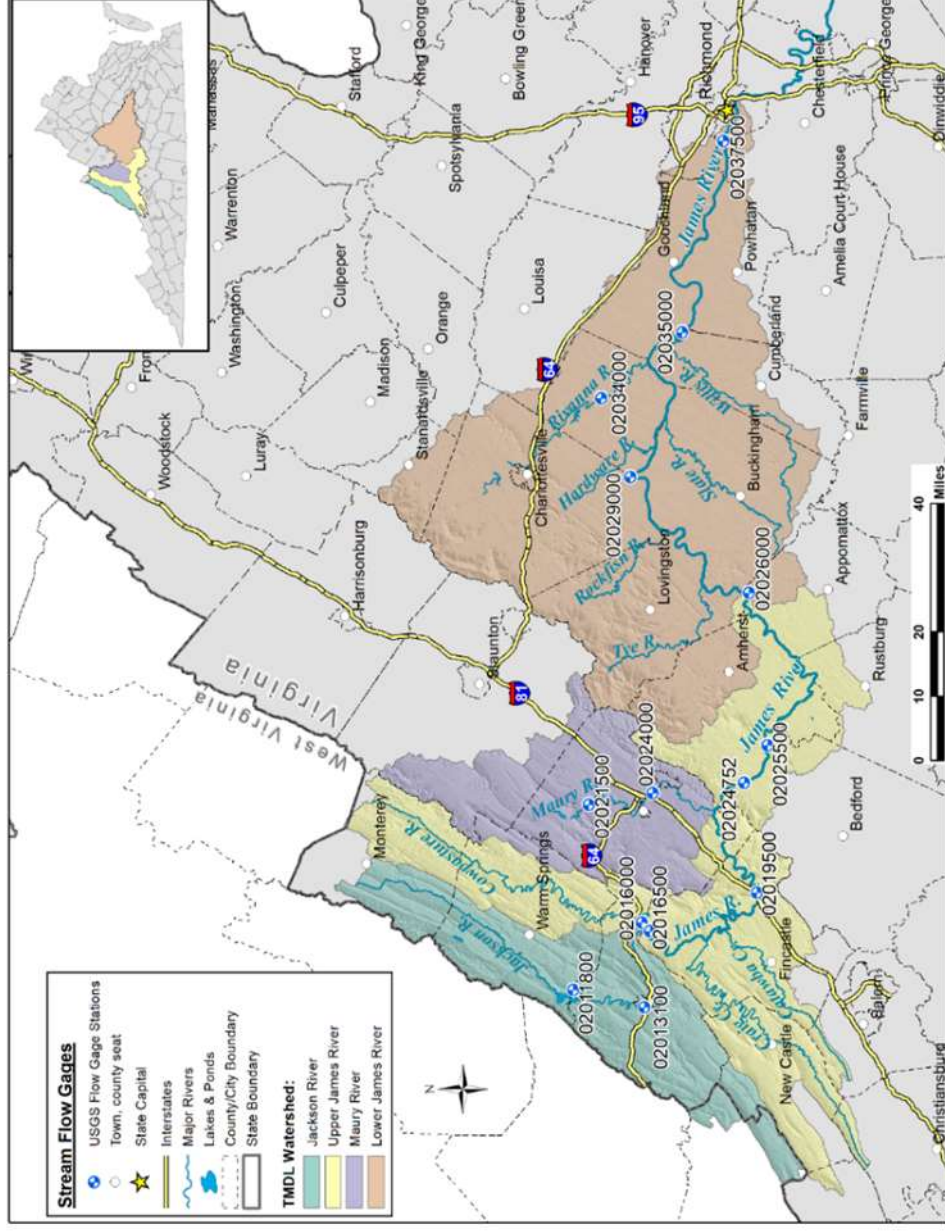


Figure 2-8. USGS flow gage stations within the James River study area. Stream flow monitoring data from these gage stations were used in the hydrology calibration model.

2.4 Suspended Sediment Concentration (SSC) Monitoring Data

PCBs are hydrophobic and tend to attach to soil and sediment particles, therefore an integral part of modeling PCBs in the James River study area was understanding the fate and transport of sediment. DEQ collected water column samples in the James River and its tributaries during base and high flow events. The samples were filtered in the laboratory, separating the suspended sediment. The mass of the sediment in each sample was determined. Suspended sediment concentration (SSC) data, provided in units of mg/L, were used to calibrate the sediment component of the watershed model. The locations of the DEQ water quality monitoring stations where SSC samples were collected are shown in **Error! Reference source not found.** Chapter 9:A.6 includes the SSC data used for model calibration. At some water quality stations, two or fewer samples were collected in a single year. Given the sparse data, sediment calibration relied on a “weight-of-evidence” approach that compared the

simulated outputs with the observed data using multiple lines of evidence. The process of calibrating the sediment component of the model is explained in Chapter 9:Appendix E:.

2.5 *Total Organic Carbon (TOC) Data*

DEQ collected water column samples to determine total organic carbon (TOC). TOC may consist of decaying natural organic matter originating from plant fragments, algal blooms, bacteria, etc., and was reported as a concentration (mg/L). Samples were also analyzed for dissolved organic carbon (DOC) concentration (mg/L), a measure of the quantity of organic carbon dissolved in the water column. TOC, DOC and particulate organic carbon (POC), which is derived by subtracting DOC from TOC, were important water quality constituents used to calculate bioaccumulation factors (BAFs) and TMDL endpoints (**Error! Reference source not found.**). TOC was also used to calculate model parameters that were used to model PCB fate and transport. Details on how TOC data were used during PCB calibration are provided in Appendix F: A.6 tabulates the TOC data used during the Jackson, Maury, Upper and Lower James River PCB TMDL development.

2.6 *PCB Concentration Monitoring Data*

DEQ collected samples to assess PCB concentration in fish tissue, sediment-attached PCB concentration, and PCB concentration in the water column. The resulting data were used in developing the James River PCB TMDL model.

2.6.1 *Fish Tissue PCB Concentration Data*

DEQ collected a variety of fish during 1995, 2001, 2003-2005, 2014, and 2017-2019 within the James River and its tributaries and tested their tissue for PCBs. Figure 2-10 shows the locations of the DEQ monitoring stations where fish tissue samples were collected. DEQ collects fish tissue samples to assess PCB contamination. The primary human exposure pathway for PCBs is consuming contaminated fish flesh. Segment-specific fish tissue PCB concentration data measured in units of ng (nanograms, 10^{-9} g) of PCBs per gram of fish tissue were used to calculate BAFs and TMDL endpoints. The unit of ng per gram unit is equivalent to parts per billion, ppb. Refer to Appendix A for additional discussion on the selection of the fish tissue record and derivation of TMDL endpoints. DEQ's fish tissue monitoring data used in this study can be found in Appendix B.

PCB TMDL for Jackson River, Maury River, Upper and Lower James River Watersheds

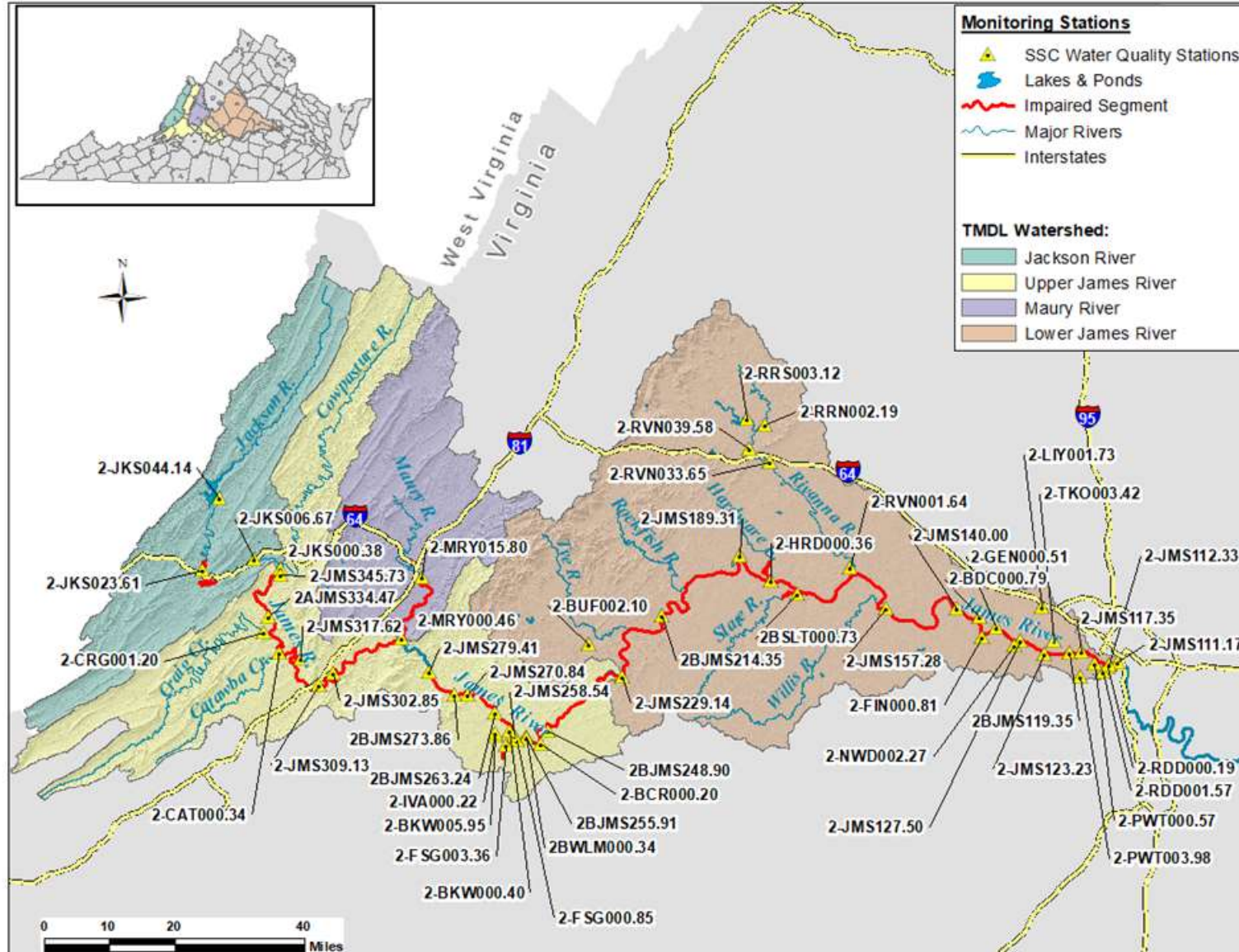


Figure 2-9. Suspended sediment concentration (SSC) water quality stations in the James River study area. These stations were used to conduct the sediment model calibration.

PCB TMDL for Jackson River, Maury River, Upper and Lower James River Watersheds

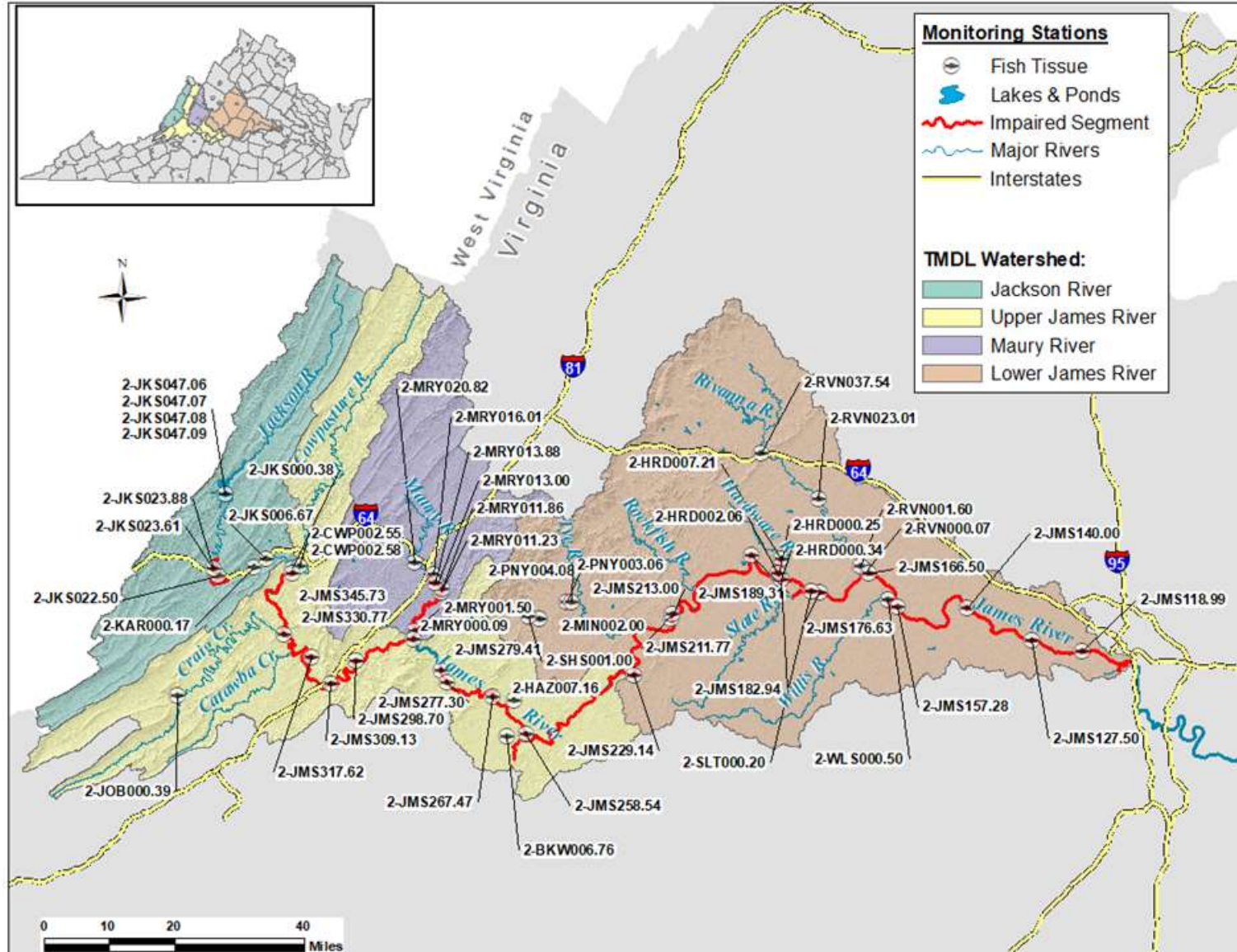


Figure 2-10. Water quality stations with fish tissue PCB concentration data in the James River study area. These stations were used to calculate the bioaccumulation factor (BAF) and PCB endpoint values.

Fish tissue data were plotted to visualize the spatial distribution of PCB concentrations from upstream to downstream within each TMDL watershed (Figure 2-11 to Figure 2-14). The y-axis of the graph is PCB concentration, and the x-axis shows the station ID grouped by TMDL watershed. Stations are sorted left to right from upstream to downstream, and the data are further divided by fish species in each column, by symbol and color. Also plotted are the VDH fish consumption advisory level (100 ng/g) and the DEQ fish tissue screening value (18 ng/g).

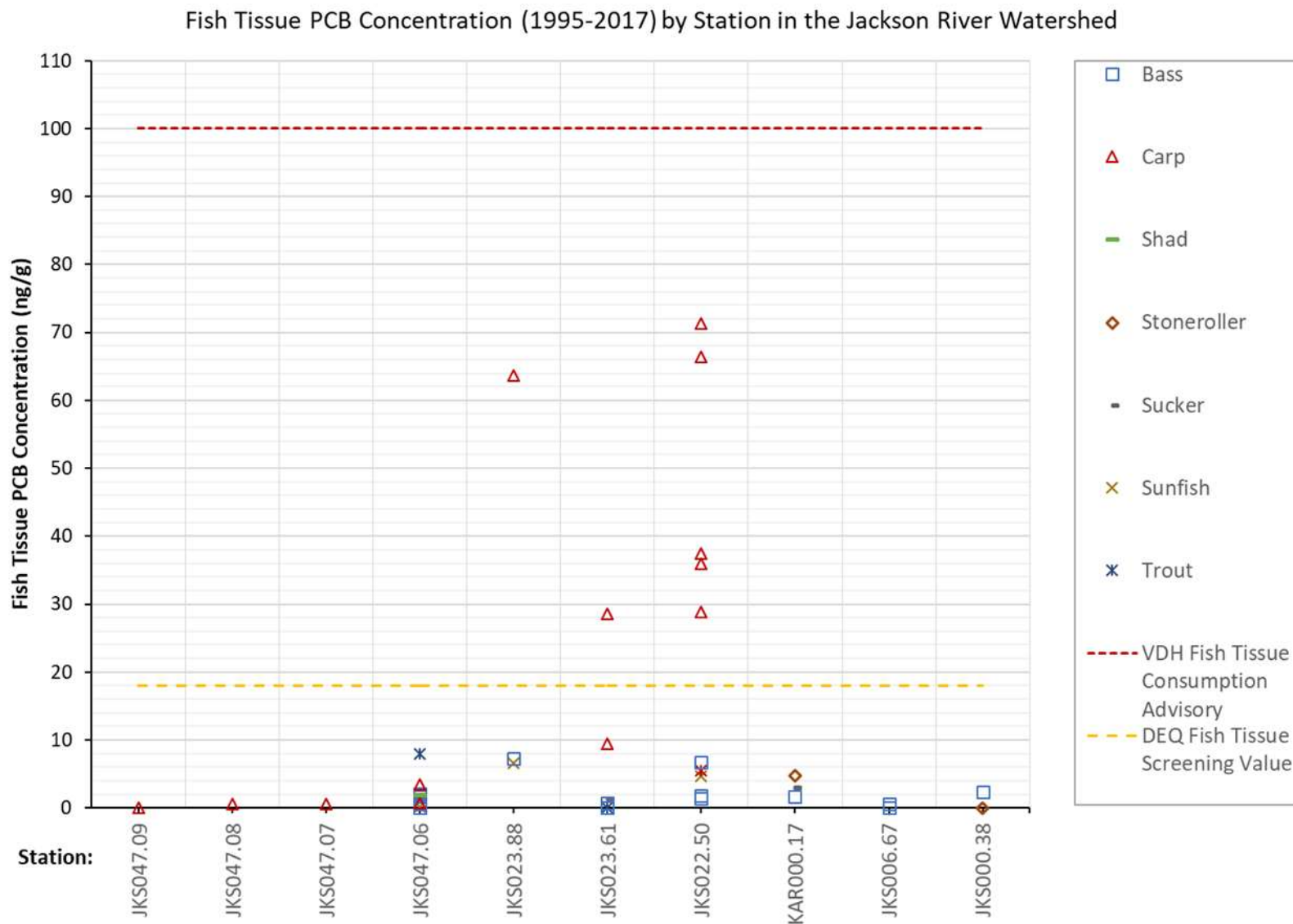


Figure 2-11. Jackson River Watershed fish tissue PCB concentrations (ng PCB/g fish tissue) from DEQ sampling. Observed data are partitioned by station within the TMDL watershed and are graphed moving from upstream to downstream (left to right). The legend indicates the fish species type.

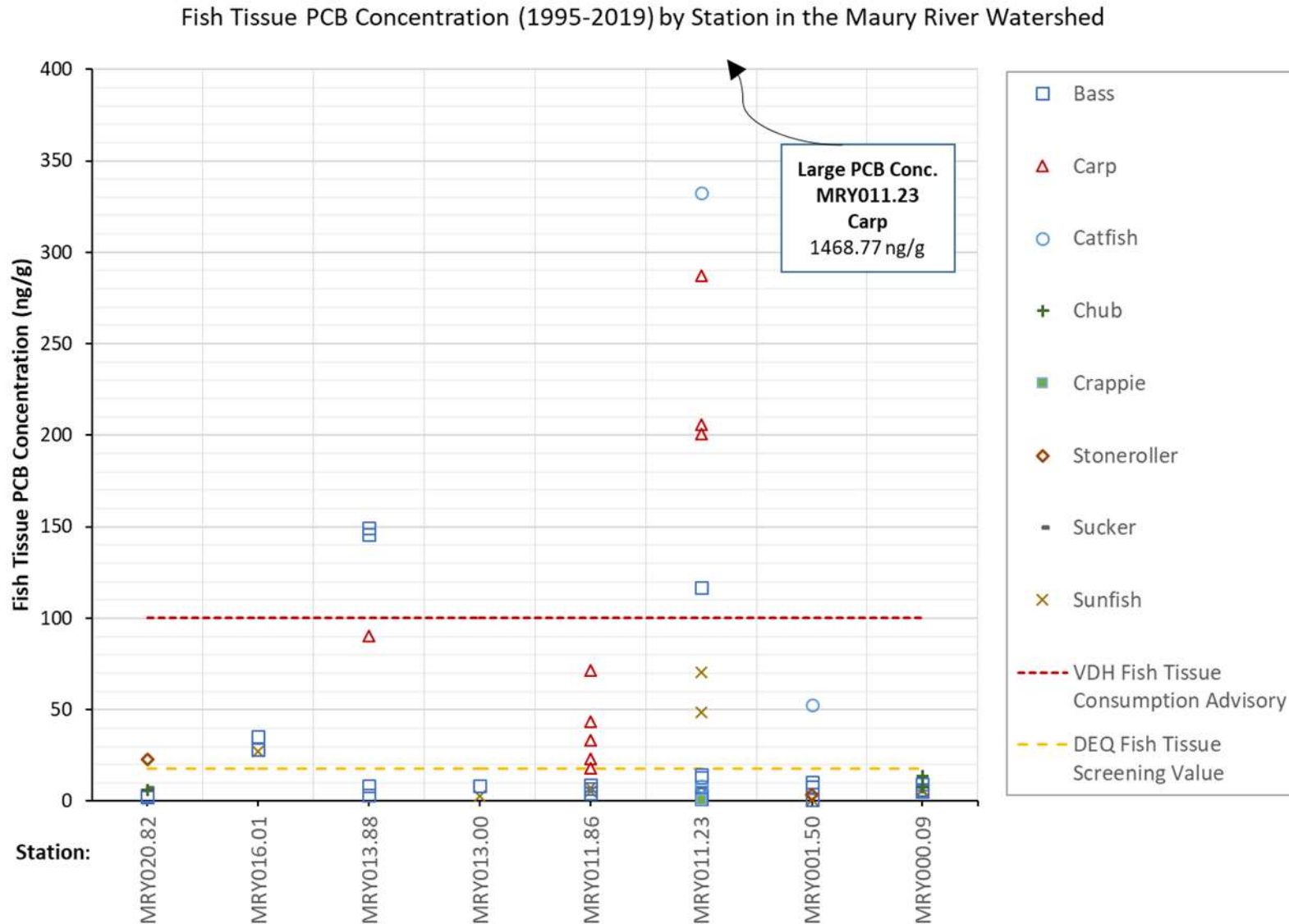


Figure 2-12. Maury River Watershed fish tissue PCB concentrations (ng PCB/g fish tissue) from DEQ sampling. Observed data are partitioned by station within the TMDL watershed and are graphed moving from upstream to downstream (left to right). The legend indicates the fish species type.

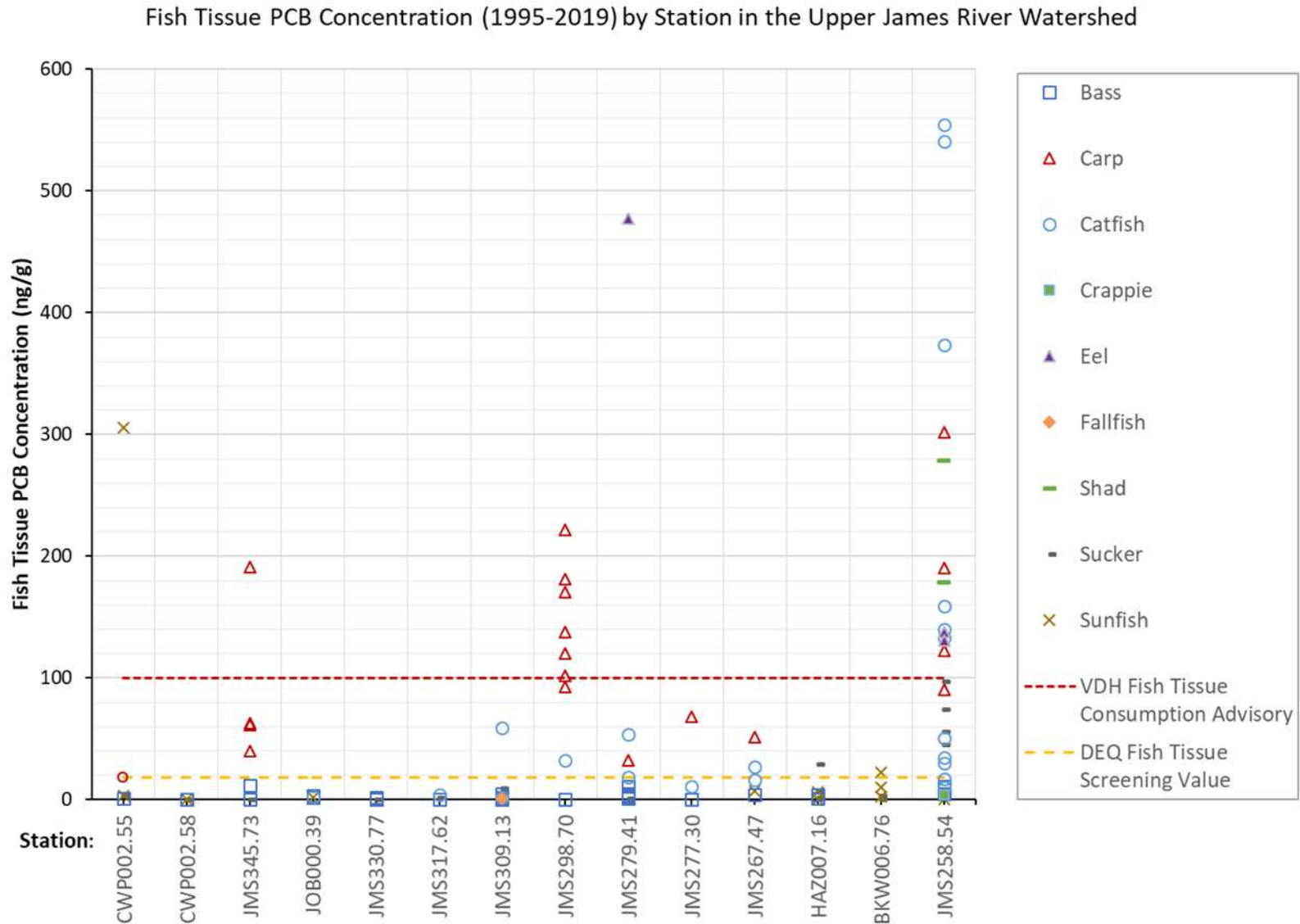


Figure 2-13. Upper James River Watershed fish tissue PCB concentrations (ng PCB/g fish tissue) from DEQ sampling. Observed data are partitioned by station within the TMDL watershed and are graphed moving from upstream to downstream (left to right). The legend indicates the fish species type.

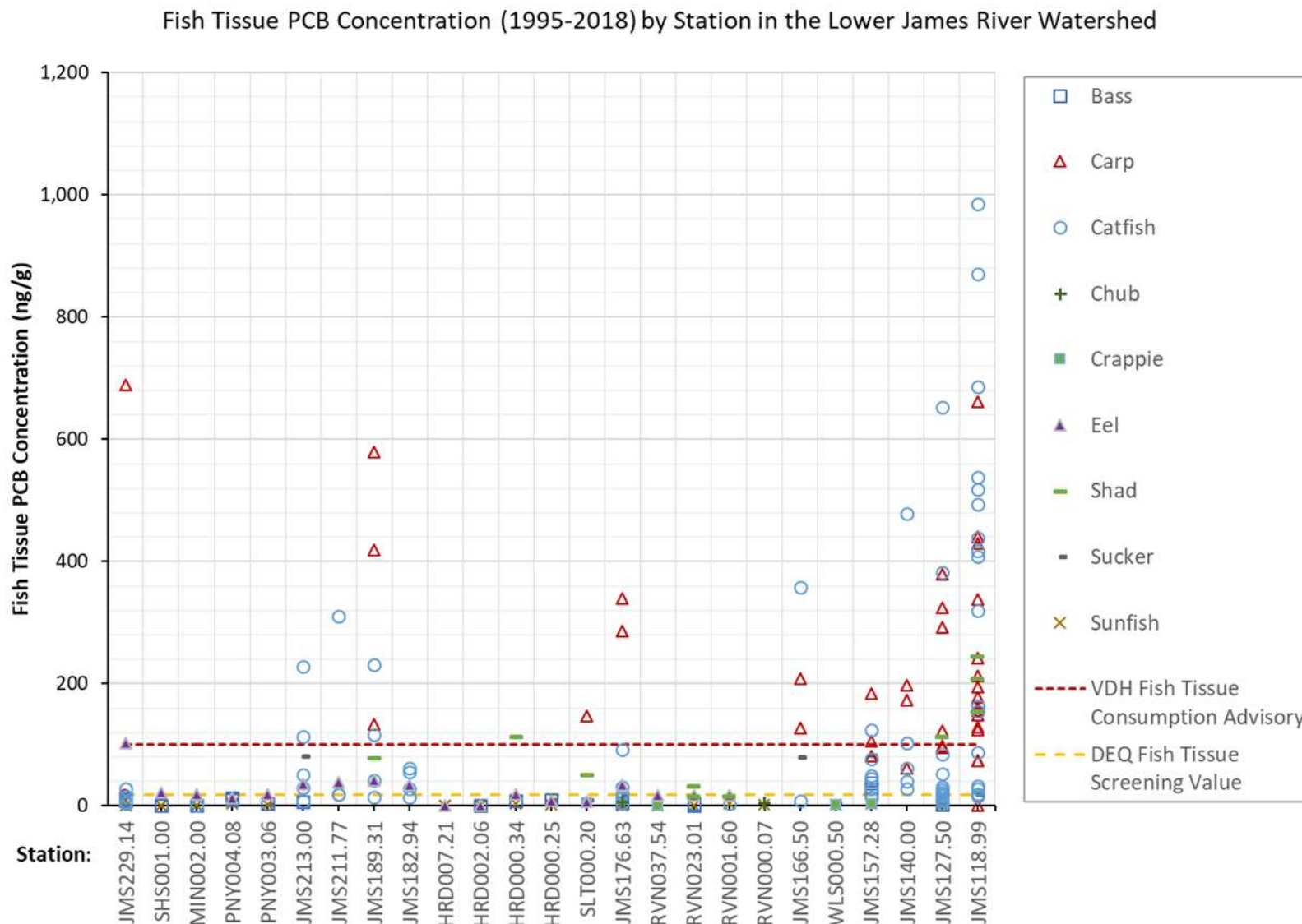


Figure 2-14. Lower James River Watershed fish tissue PCB concentrations (ng PCB/g fish tissue) from DEQ sampling. Observed data are partitioned by station within the TMDL watershed and are graphed moving from upstream to downstream (left to right). The legend indicates the fish species type.

2.6.2 Sediment-Associated PCB Concentration Data

DEQ collected instream sediment samples to measure the quantity of sediment-associated PCBs. Figure 2-15 illustrates the locations of the monitoring stations where samples were collected from 2017 to 2019. Appendix B includes the findings from DEQ's sediment-associated PCB monitoring. Sediment-bound PCB concentrations are measured in units of ng (nanograms, 10^{-9} g) of PCBs per gram of sediment. The observed sample data values were averaged and served as a starting point for initializing simulated sediment PCB concentrations at the beginning of the modeling period. The data were also used to ensure that changes in simulated sediment PCB concentrations corresponded with the observed data over time.

Figure 2-16 presents a graph of observed sediment-associated PCB concentrations measured at DEQ stations, organized by TMDL watershed. The y-axis lists PCB concentration, and the x-axis shows the monitoring stations ordered left to right from upstream to downstream and grouped by TMDL watershed. There were no sediment-associated PCB samples in the Jackson River because of a lack of accessible sediment depositional areas. In general, stations typically capture and show that PCB contamination increases from upstream to downstream. There is no maximum threshold for sediment-associated PCB concentration although sediment screening thresholds identified in DEQ's PCB strategy (DEQ, 2005a) range from 1.8 ng/g to 49 ng/g and are based on Biota Sediment Accumulation Factors (BSAFs).

PCB TMDL for Jackson River, Maury River, Upper and Lower James River Watersheds

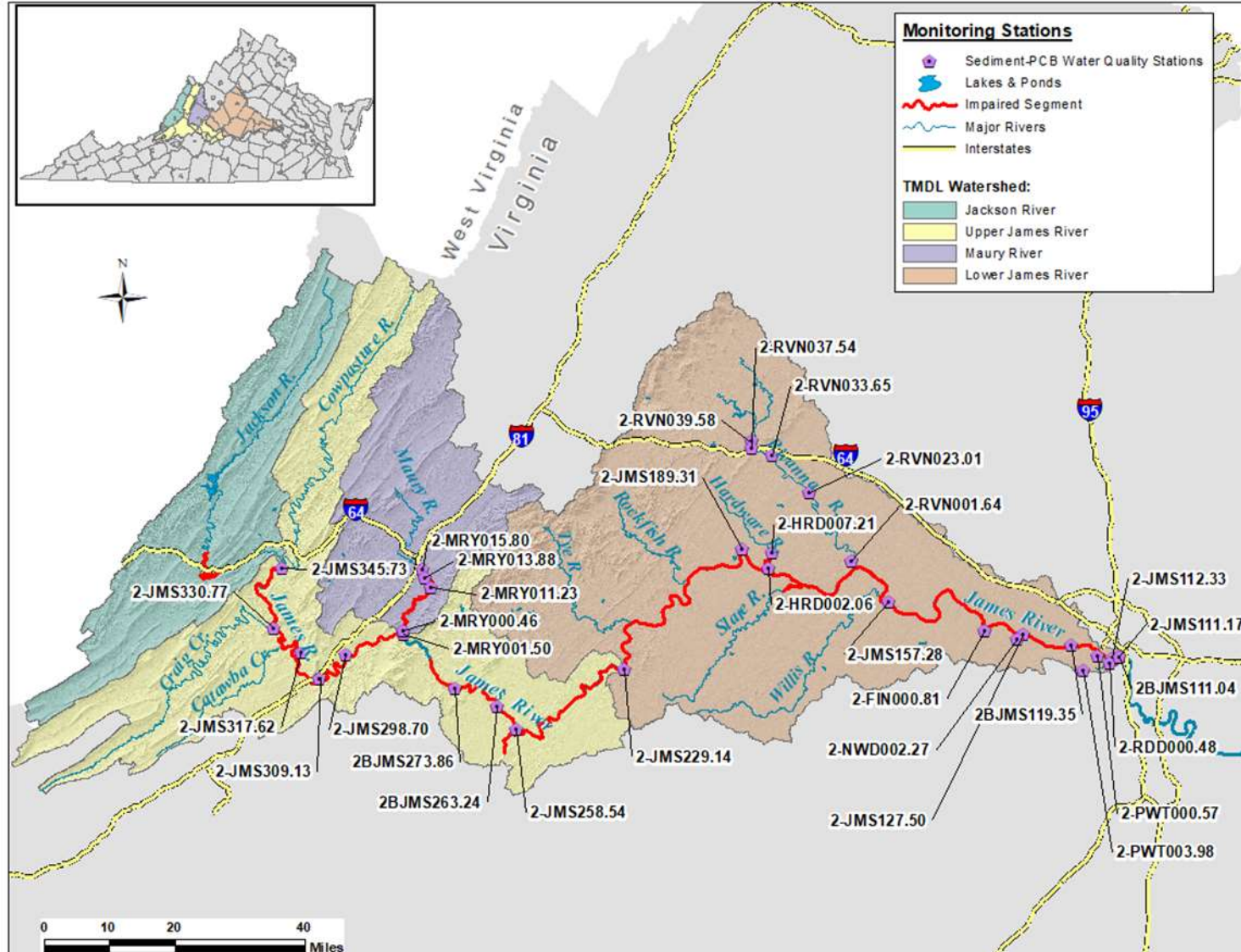


Figure 2-15. Sediment-associated PCB water quality stations in the James River study area. At these stations, sediment samples were collected and tested for sediment-attached PCB concentrations. The observed data from these stations were used to calculate initial concentrations in the PCB model.

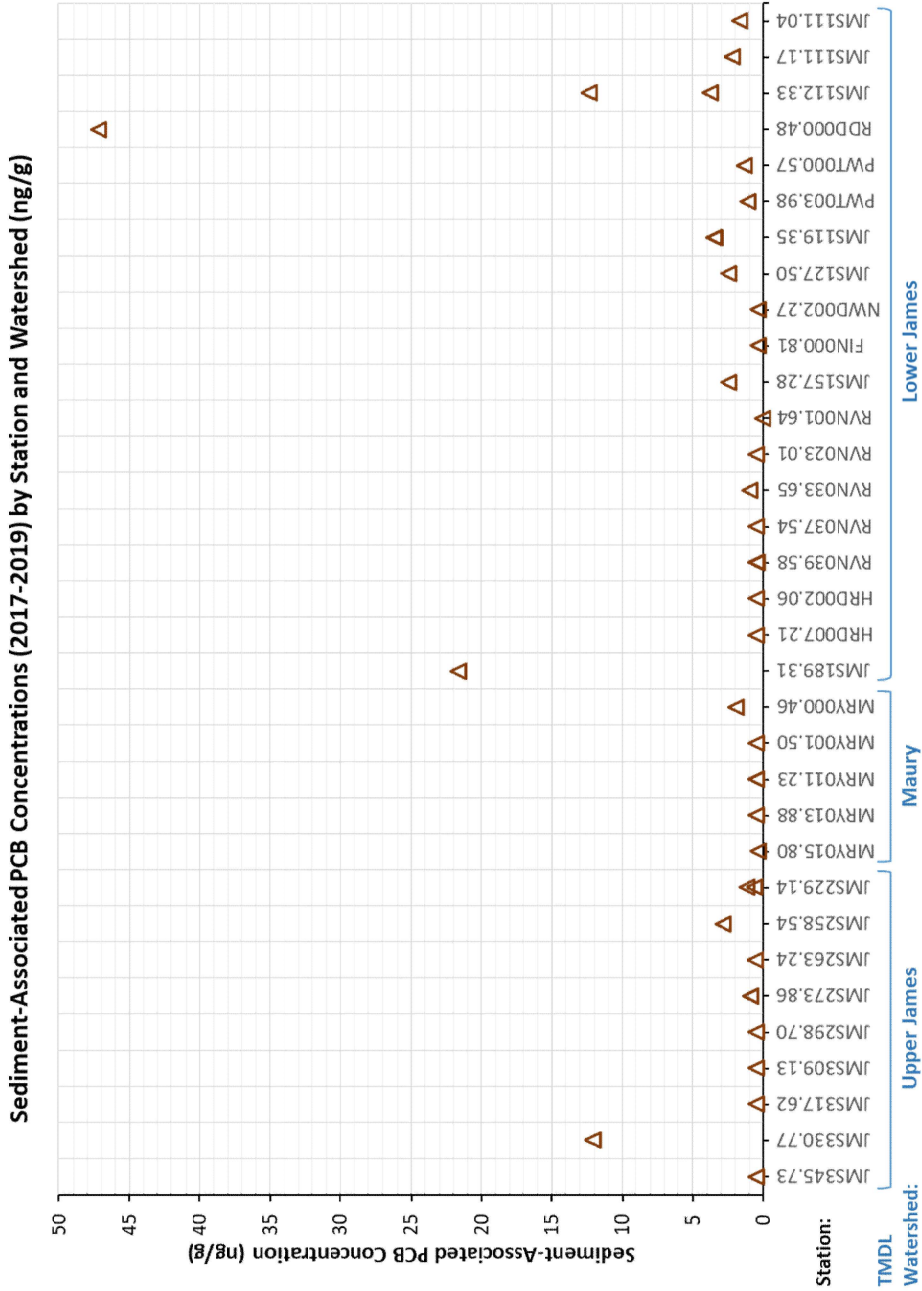


Figure 2-16. Sediment-associated PCB concentrations (ng PCBs/g sediment) in DEQ sediment samples. Observed data are partitioned by station and TMDL watershed and are graphed upstream to downstream (left to right).

2.6.3 Water Column tPCB Concentration Data

DEQ collected water column samples during dry/base flow and wet/elevated flow conditions from the James River and its tributaries to determine PCB concentrations in units of pg (picograms, 10^{-12} g) per liter of water, which is the equivalent to parts per quadrillion (ppq). This concentration in the water column quantifies PCBs associated with suspended particulate matter as well as “dissolved” PCBs in the ambient water column, i.e., PCBs in the water and are not sediment associated. Figure 2-17 illustrates the station locations where samples were collected. Water column PCB concentration sample results are shown in Appendix B. For each water quality sample, DEQ summed the concentration from all detected PCB congeners to calculate the concentration of total PCBs (tPCB) in addition to the concentration of each PCB homolog group. The tPCB water column concentration was used to calibrate PCB fate and transport in the model. Two or fewer samples were collected in a single year at some water quality stations. Calibrating on the available water column tPCB concentration data used a

“weight-of-evidence” approach that compared the simulated outputs using multiple lines of evidence. The PCB weight-of-evidence calibration process is detailed in Chapter 9:Appendix F:.

Sediment concentration (SSC) and water column PCB data collected between 2017-2019, were used in the model. SSC and PCB samples were often collected on the same day. Using similar calibration periods for the sediment and PCB components of the model and employing observed sample data that were collected on the same day meant the PCB component of the James River PCB TMDL model could be confidently built on the sediment component.

Table 2-5 shows the number of samples in each TMDL watershed that exceeds its respective endpoint. Figure 2-18 shows the results of the 2017-2019 water column tPCB sampling, illustrating PCB concentrations from upstream to downstream in the study area. The y-axis of the graph is the water column tPCB concentration, and the x-axis shows the station ID sorted left to right from upstream to downstream. Stations are grouped by TMDL watershed, and the graph includes dashed lines for the endpoints of each TMDL watershed with values denoted in the legend. In each of the TMDL watersheds, at least one observed sample exceeded the endpoint concentration.

Table 2-5. Number of water quality samples exceeding their respective endpoint in each TMDL Watershed and percent exceedance.

TMDL Watershed	TMDL Endpoint (pg/L)	No. of Samples		Percent Exceedance (%)
		Exceeding Endpoint /	No. of Samples	
Jackson River	580	2 / 13		15%
Upper James River	120	41 / 52		77%
Maury River	400	2 / 8		25%
Lower James River	52	57 / 58		98%

PCB TMDL for Jackson River, Maury River, Upper and Lower James River Watersheds

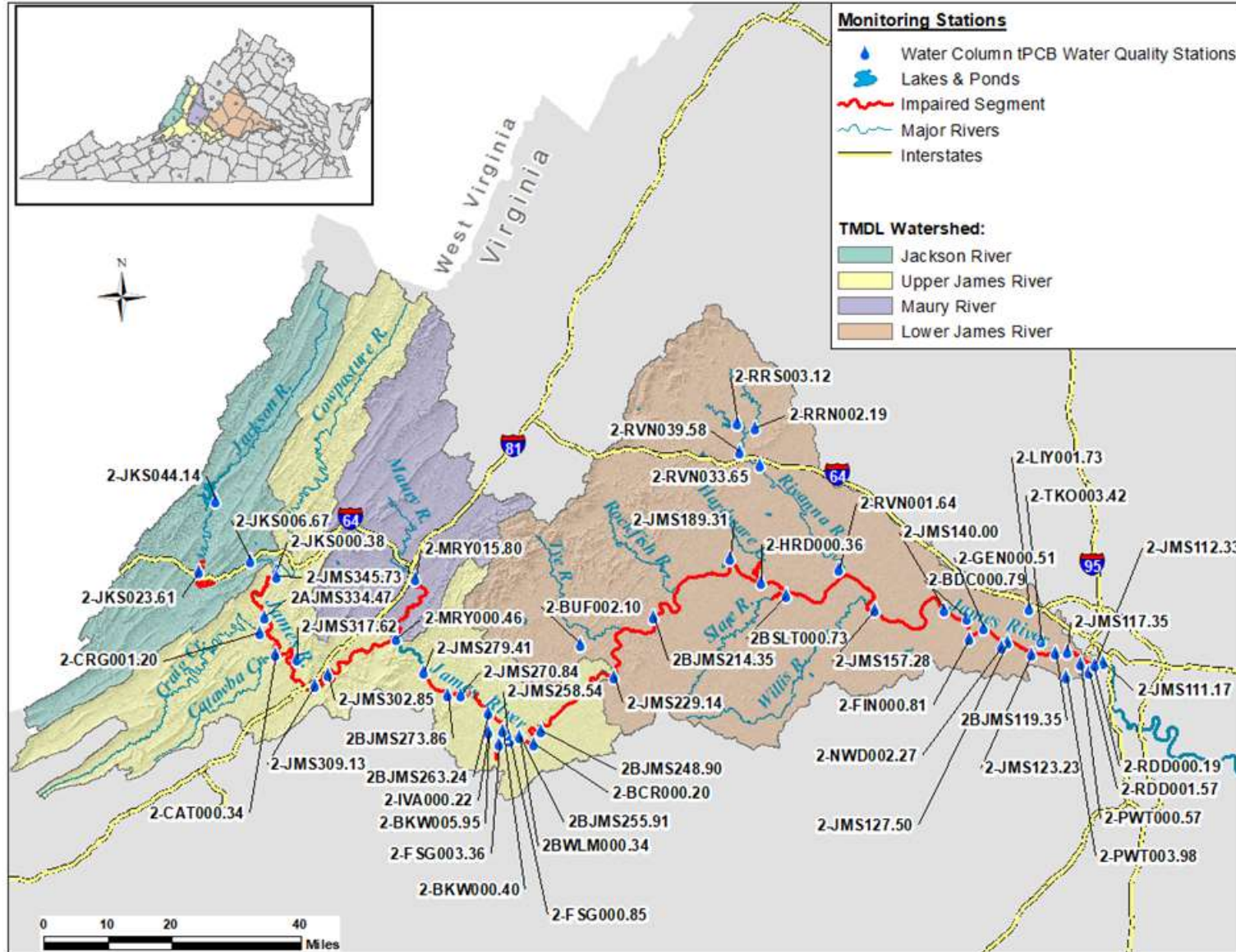


Figure 2-17. Water column tPCB water quality stations in the James River study area. These stations were used to conduct the PCB model calibration.

PCB TMDL for Jackson River, Maury River, Upper and Lower James River Watersheds

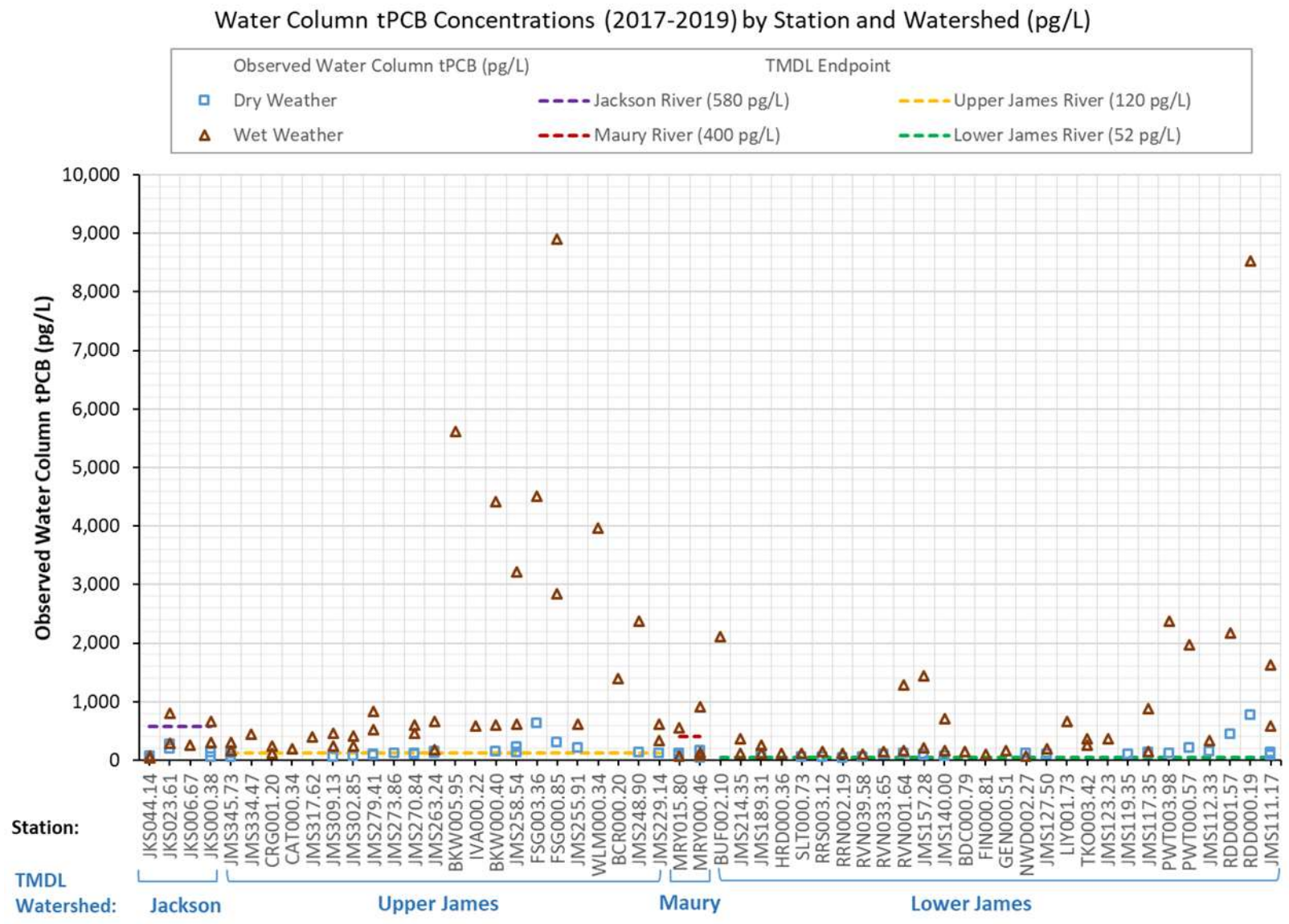


Figure 2-18. Water column tPCB concentrations (pg PCB/L water) from DEQ sampling used in the model. Observed data are partitioned by station and TMDL watershed. Graph lists stations upstream to downstream (left to right), with TMDL endpoints for each TMDL watershed.

Chapter 3: Source Assessment

The source assessment chapter describes the currently available data on the sources of PCBs in the James, Maury and Jackson River PCB TMDL study area. Please refer to Appendix C for detailed information. Point- and nonpoint- sources contribute to the PCB loadings found in the impaired segments of the James River watershed. Permitted point sources (e.g., those that are regulated in the Virginia Pollutant Discharge Elimination System (VPDES)), include municipal wastewater treatment plants, and other permitted facilities from industrial or commercial activities that have been identified by DEQ as potentially contributing PCB loadings. Nonpoint sources include: known and suspected runoff (e.g., runoff from contaminated sites, railyards and railway spurs, electrical substations and pollutant spills); less certain sources are categorized as non-regulated surface sources and include uncharacterized sources that contribute background PCBs to the land and water surfaces; atmospheric deposition; and sediment within the channel stream bottom. This chapter describes the types of PCB sources and how they were included in the James River PCB TMDL model. Detailed information regarding the estimation of PCB loads for each of the sources found in James River study area can be found in Appendix C.

3.1 *Permitted Sources*

This section lists the specific permitted facilities that have been identified as possible sources of PCBs. VADEQ originally provided tPCB data from 102 Virginia Pollutant Discharge Elimination System (VPDES) permitted facility dischargers in the study area to use in establishing baseline loads and waste load allocations: 26 municipal wastewater treatment facilities, 2 municipal combined sewer systems (CSS), 58 industrial stormwater general permitted facilities (ISWGP), and 16 individual industrial permitted facilities (IP). The tPCB data were either generated by the permittee or default values were utilized when absent. Additionally, VADEQ provided tPCB data from 22 terminated or expired VPDES permitted facility dischargers in the study area to use in establishing baseline loads: 2 municipal wastewater treatment facilities, 14 ISWGPs, and 6 industrial IPs. All three categories of permitted dischargers were modeled as point sources. Appendix C provides permit-specific details.

In addition to the permitted facilities there are eleven municipal separate storm sewer systems (MS4s) in the James River study area. These are municipal regions that convey impervious surface stormwater runoff from within their boundary through a permitted discharge point. MS4s will address the PCB load in their runoff that is discharged through their stormwater

conveyance system. Additional details about the PCB loads from the MS4 permits are provided in Appendix C.

3.2 *Nonpoint Sources*

Nonpoint sources included contaminated sites, stormwater runoff from unspecified surface sources (including unspecified stormwater, unidentified contaminated sites, loads from small tributaries, atmospheric deposition to land surfaces, and unspecified point sources), atmospheric deposition to the surface water, and streambed sediment. Table 3-1 lists the nonpoint sources considered in the James River PCB TMDL.

Table 3-1. James River nonpoint PCB sources.

Nonpoint Sources	PCB Load
Contaminated Sites	
Volunteer Remediation Program Sites	Varies by site
Railyards and Railway Spurs	7.02×10^{10} pg PCB/ton of sediment
Electrical Substation	1.29×10^{12} pg/PCB/ton of sediment
Pollution Response Program (PREP) Spills	Varies by Spill
Surface Sources	
Unspecified Surface Sources ¹	Varies by land use category
Atmospheric Deposition	8.90×10^3 pg/m ² /year
Streambed Sediment	Varies by stream segment

¹ Unspecified surface sources represent PCB loads supported by the observed data whose specific location have yet to be identified.

3.2.1 Contaminated Sites

The PCB load for contaminated sites is modeled as a potency factor that estimates the mass of PCBs washed off per ton of sediment runoff from the contaminated site. Contaminated sites with the potential for long-term contamination of the soil, such as former manufacturing facilities with known PCB contamination, terminated permit sites, railyards, and electrical substations, were assigned “contaminated” land use categories that are similar hydrologically, pedologically and geophysically to the existing land use types (e.g., Forest, Cropland, Pasture, Residential, etc.). Since the location of Pollution Response Program (PREP) spills have been recorded in VDEQ’s PREP database, these PCB sources are also identified as loads from contaminated sites. However, because a PREP spill is an isolated incident, PREP PCB spills were modeled as direct inputs into the stream or as deposition onto the land surface as a “one-time” event based on the recorded date of the spill.

3.2.2 Unspecified Surface Sources

Unspecified surface source is a term that collectively describes PCB loadings from uncertain origins that drain to the James, Maury and Jackson Rivers during runoff events. This

source category represents PCB load concentrations observed in instream water column samples, but whose specific location have yet to be identified. The term “direct drainage” was used in the Potomac River PCB TMDL to describe unspecified stormwater runoff, unidentified contaminated sites, and unspecified point source discharges (ICPRB, 2007). The Roanoke River PCB TMDL referred to these as “urban background/unidentified sources” (DEQ, 2009) whereas these source types were recognized as “uncharacterized sources” in the New River PCB TMDL (DEQ, 2018). Sources in the James River PCB TMDL study area that are recognized as contributing to the land surface category include loads from unidentified contaminated sites, unspecified stormwater runoff from commercial land use areas, atmospheric deposition to land surfaces, loads from small tributaries that are not explicitly specified in the model, and unspecified point source discharges. Unspecified surface sources were modeled as a load applied to all land area not part of the contaminated sites, railyards, electrical substations, or PREP spills. DEQ will continue to search for these unaccounted sources that contribute to the PCB impairment as part of TMDL implementation and, upon identification, will identify mechanisms to target load reductions.

3.2.3 Atmospheric Deposition

Atmospheric deposition is due to aerosolized PCBs that settle out of the atmosphere.

This source was applied on all water surfaces in the James, Maury and Jackson River watersheds at a constant rate throughout the year.

3.2.4 Streambed Sediment

The streambed sediment source accounts for legacy PCBs that are present in the aquatic environment and are adsorbed to sediment.

3.2.5 Biosolids

Twenty-six VPDES Municipal WWTPs are considered potential sources of PCBs to the James, Maury, Jackson River watersheds and are allocated a load. Whether legacy or from more recent sources, PCBs can originate from unknown areas within municipality collection systems where conveyance to the treatment plants occurs. After treatment, a small percentage can be released with the effluent. Observations have shown that PCB concentrations entering WWTPs via influents are typically elevated when compared to the concentrations that exit the facilities. Given PCBs extreme hydrophobicity, the tendency is for PCBs to adsorb to available solids. WWTPs, operating properly, can remove 80-99% of solids from the WWTP effluent.

Given this, it is reasonable to conclude that most PCBs are settling out of WWTP's in sewage sludge.

When treated and used for agronomic purposes, sewage sludge is referred to as biosolids, and requires a permit administered under the Virginia Pollution Abatement (VPA) permit program (9VAC25-32-10 et. seq.) or the VPDES permit program (9VAC25-31-10 et seq.). When biosolids are land applied, regulations require treatment to significantly reduce pathogens and vector attraction. Regulations also include pollutant concentration limits for heavy metals and PCBs. Section 9VAC25-32-317 of the VPA permit program requires that PCBs be monitored within sewage sludge and are considered acceptable for application only when the concentration is less than 50 mg/Kg (ppm) of total solids (dry weight basis). Permit regulations also require spreading according to sound agronomic requirements with consideration for topography, hydrology, and the use of appropriate setbacks depending on site-specific conditions.

While it has been the practice to apply biosolids at numerous fields within the study area, application sites are likely insignificant sources of PCBs in the James, Maury and Jackson River watersheds. Samples collected from fields located in other watersheds in Virginia that have received biosolids applications show an arithmetic mean concentration of 0.15 mg/Kg, well below the allowed 50 mg/Kg. Further, with adherence to the agronomic requirements specified in the VPA regulations, prospective loadings derived from stormwater runoff from this source would be considered *de minimis*.

Chapter 4: TMDL Technical Approach

A key component in developing a TMDL is establishing the relationship between pollutant loadings (both point and nonpoint) and instream water quality conditions. Once this relationship is developed, management options for reducing pollutant loadings to streams can be assessed. In developing a TMDL, it is critical to understand the processes that affect the fate and transport of the pollutants that are impairing the waterbody of concern. Pollutant fate and transport was evaluated using a variety of tools, including monitoring, geographic information systems (GIS), and computer simulation models. This chapter discusses the critical considerations and modeling framework.

4.1 *Critical Considerations*

PCBs exist in the environment in many different forms, i.e., as a suspended airborne contaminate, as a freely available (“dissolved”) constituent in the water column, attached to suspended particulates in the water column, attached to sediment deposited on the streambed, and associated with soils on the land surface (e.g., contaminated sites). Understanding the PCB concentrations found in each of these forms requires an understanding of the fate and transport of PCBs within a watershed. Establishing a strong hydrologic representation (or model) of the watershed is an important initial step in assessing the fate and transport of PCBs in the environment. A sufficiently well-calibrated hydrologic model creates a foundation upon which the model’s pollutant fate and transport components can be developed.

A critical assumption when developing the James River PCB TMDL pollutant fate and transport model is that the water quality grab samples collected by DEQ were representative of the stream cross section. For this to be entirely accurate, the section of stream would need to be a continuously well-mixed medium when sampled. In reality, this is likely not the case. However, this is a necessary assumption because continuous sampling across the entire cross section of every stream and tributary is not feasible. To account for this and other uncertainties inherent in pollutant fate and transport modeling, a conservative modeling approach was used to ensure that the model did not underestimate PCB concentration. Additionally, an explicit margin of safety (MOS) of 5% was incorporated into the TMDL.

4.2 *Modeling Framework*

The TMDL development process often relies on the use of a watershed-based model that integrates both point and nonpoint pollutant sources and simulates instream hydrologic and

water quality processes. The Hydrological Simulation Program–FORTRAN (HSPF) version 12 (Bicknell *et al.*, 2005) was used to model sediment and PCB transport and fate in the James River study area.

The HSPF model simulates nonpoint source runoff and pollutant loadings, performs flow routing through streams, and simulates instream water quality processes. HSPF estimates runoff from both pervious and impervious parts of the watershed and stream flow in the channel network. The sub-module PWATER (water budget pervious) within the PERLND (pervious land) module simulates runoff from pervious areas (e.g., agricultural land). Runoff from impervious areas is modeled using the IWATER (water budget impervious) sub-module within the IMPLND (impervious land) module. The simulation of flow through the stream network is performed using the HYDR (hydraulic behavior) and ADCALC (advection of fully restrained constituents) sub-modules within the RCHRES (stream reaches and reservoirs) module. While HYDR routes the water through the stream network, ADCALC calculates variables used for simulating convective transport of the pollutant in-stream.

Fate and transport of PCBs on pervious and impervious land segments is simulated using the SEDMNT (sediment production and removal) and PQUAL (quality constituents pervious) sub-modules within the PERLND module and SOLIDS (solids accumulation and removal) and IQUAL (quality constituents impervious) sub-modules within the IMPLND module. Fate and transport of PCBs in stream water is simulated using the sediment transport (SEDTRN) sub-module and general constituent pollutant (GQUAL) sub-module within the RCHRES module. Each component of HSPF contains a series of parameters that control hydrologic and constituent behavior. During calibration, model parameters and pollutant sources are adjusted. The simulated outputs were analyzed against the observed data, and if an adequate calibration was not achieved then the parameters and source loads were further adjusted in an iterative cycle. Model development and calibration are further explained in the next chapter and Appendices D, E, and F.

Chapter 5: Model Setup for PCB TMDL Development

Building the James River study area PCB TMDL HSPF model involved two major stages. The first stage involved watershed characterization where relevant meteorological, hydrological and constituent source data were collected, processed, and converted into variables and parameters for the model. The second stage, calibration, entailed comparing the model outputs with observed data and adjusting model parameters and variables until the model adequately simulated the observed data. This chapter provides a summary of model development.

5.1 Watershed Segmentation

One of the first steps in the watershed characterization process was delineating the watershed into subwatersheds in order to capture the diversity in hydrology and geomorphology. The study area consists of four TMDL watersheds subdivided based on the location of major tributary junctions and PCB impaired segments. Organizing by major tributaries helped expedite modeling processes due to the large size of the James River study area. Dividing the study area into subwatersheds allowed for more detailed and representative modeling. Rather than assuming the entire watershed is hydrologically homogenous, each subwatershed featured different parameters and proportions of land use types. Subwatersheds were delineated based on the stream network, hydrologic and land use variability, and the locations of PCB sources and DEQ water quality monitoring stations. Where possible, subwatersheds were typically delineated so that a subwatershed outlet coincided with a DEQ water quality monitoring station. This ensured better comparability of simulated and observed data. Table 2-1 includes the number of subwatersheds and respective areas for each TMDL watershed. Figure 2-1 shows the relative position of the subwatersheds within the James River study area.

5.2 Input Data Requirements

5.2.1 Land Use, Soils, and Topography Data

Land use, soils, and topographic data were used for estimating various model parameters. Soils data were used to estimate hydrologic parameters that determine surface, interflow, and groundwater patterns, ultimately impacting the water balance. Land use data were used to determine the percentage of pervious and impervious surface area. Stream network data from the high-resolution National Hydrography Dataset (NHDPlusHR) were used to identify

perennial streams and the primary stream network (USGS, 2019). Topography was assessed using seamless 10-meter resolution digital elevation models from the USGS 3D Elevation Program (USGS, 2019) and were the basis for subwatershed delineation and calculating terrain slopes. Additional detail about the data discussed here is provided in Chapter 2.

5.2.2 Meteorological Data

Meteorological data (e.g., precipitation, temperature, wind speed, dew point temperature, percent sun) drive mass balance, water quality models like HSPF. The James River PCB TMDL model was developed using meteorology measurements from weather stations that are monitored and quality controlled by the NCEI (NCEI, 2019). The data from these stations (Table 2-2) were accessed to generate time series inputs for meteorological variables which were then used to calculate the water balance. Generally, the data provided by the NCEI were recorded in daily intervals. Since the model simulated at hourly time steps, an HSPF supplemental application called WDMUtil, a utility program to manage Watershed Data Management (WDM) files, was used to disaggregate the daily meteorological data into hourly data.

5.2.3 Hydrologic Withdrawals

Water withdrawals were identified in the James River study area that potentially influence stream flow rate over time (Table 5-1). Monthly withdrawal data were used to estimate average daily withdrawal rates for the facilities. These withdrawals were simulated using time series applied to the specific reach within each subwatershed.

Table 5-1. Withdrawal rates used in modeling the James River study area.

TMDL Watershed	Facility	Major Tributary	Withdrawal Rates (mgd) ¹
Jackson	Paint Bank Fish Cultural Sta.	Jackson River	3.57
	Covington Plant Westrock	Jackson River	37.27
	Jackson River WTP ²	Jackson River	2.53
	Clifton Forge WTP ²	Jackson River	1.12
	Homestead Golf Irrigation & Snow Production	Jackson River	0.03
	Virginia Hot Springs	Jackson River	0.85
	Bath County Regional Water System	Jackson River	0.03
	Laurel Hill Trout Farm-South Monterey	Jackson River	3.12
	Ingleside Dairy Farm, Inc.	Maury River	0 – 0.02
	Buena Vista Plant (Moline)	Maury River	0.02
Maury	Lexington Golf & Country Club	Maury River	0.03
	Maury River WTP ²	Maury River	1.35
	Goshen Service Area	Maury River	0.05
	Laurel Hill Trout Farm - Goshen	Maury River	0.8

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

TMDL Watershed	Facility	Major Tributary	Withdrawal Rates (mgd) ¹
Upper James	Craigsville Service Area	Maury River	0.18
	Augusta Springs Service Area	Maury River	0.07
	College Hill WTP ²	James River - Fishing Cr.	0.41
	Tinker Cr-Catawba Cr Diversion	Catawba Cr.	1.55
	Boonsboro Country Club	James River - Fishing Cr.	0.04
	Eagle Eyrie WTP ²	James River - Fishing Cr.	0.02
	Amherst County Service Area - Lanum WTP ²	James River - Fishing Cr.	0.35 – 0.7
	Abert WTP ²	James River - Fishing Cr.	0.3
	Riverville Mill WTP ²	James River - Fishing Cr.	6.31
	Georgia-Pacific Big Island WTP ²	James River - Fishing Cr.	14.74
	New Castle Plant	James River - Fishing Cr.	0.09
	Gladstone Service Area	Craig Cr.	0
	Pedlar Reservoir Intake	James River - Fishing Cr.	9.69
	Cliftondale Country Club	James River - Fishing Cr.	0
	Millboro Service Area	Cowpasture River	0.11
	Coursey Spring Fisheries	Cowpasture River	13.63
	Willis Mountain Mining Complex	Willis River	0.02
	Windy Hill Sports Complex	James River - Reedy Cr.	0.01
	James H. Ritchie	James River - Reedy Cr.	0
	Willow Oaks Country Club	James River - Reedy Cr.	0.05
	Richmond (City) WTP ²	James River - Reedy Cr.	62.91
	Henrico County WTP ²	James River - Reedy Cr.	24.55
	The Country Club of Virginia-Westhampton	James River - Reedy Cr.	0.05
	Foundry Golf Club	James River - Reedy Cr.	0.04
	Richmond Country Club, Inc	James River - Reedy Cr.	0.02
Lower James	Amherst (Town) WTP ²	James River - Reedy Cr.	0.3
	Kanawha Club	Tye River	0.01
	James River Corr. Cntr WTP ²	James River - Reedy Cr.	0.57
	Hermitage Golf Course	James River - Reedy Cr.	0.09
	Kelona Farms Inc	James River - Reedy Cr.	0.01
	Storage Reservoir (Cwvsc)	Hardware & Slate Rivers	1.44
	Royal Stone Plant	James River - Reedy Cr.	0.22 – 0.77
	Anderson Creek Quarry	James River - Reedy Cr.	0.33
	East Coast Transport, James River Intake	James River - Reedy Cr.	6.55
	Bremo Bluff Power Plant	Hardware & Slate Rivers	0.02
	Saunders Brothers, Inc.	Hardware & Slate Rivers	0 – 0.2
	Cobbs Creek Reservoir Temporary Construction Withdrawal	Tye River	0.03
	Rees Vineyard	Hardware & Slate Rivers	0
	Thomas Wheaton	Rockfish River	0
	Lovington Service Area	Tye River	0.03
	Schuyler Service Area	Tye River	0.02
	Scottsville WTP ²	Rockfish River	0 – 0.05
	Montebello Fish Station	Rockfish River	0.07 – 0.61
	Lake Monticello Golf Course	Tye River	0.01
	Lake Monacan-Stoney Creek (Wintergreen)	Rivanna River	0.32 – 0.52
	Lake Monticello WTP ²	Rockfish River	0.54
	Glenmore Country Club	Rivanna River	0.04
	Fluvanna Correctional Unit	Rivanna River	0.2
	Keswick Hall & Golf Club	Rivanna River	0.1

TMDL Watershed	Facility	Major Tributary	Withdrawal Rates (mgd)¹
	Observatory Hill WTP ²	Rivanna River	1.38 – 1.51
	Birdwood Golf Course	Rivanna River	0.1
	Meadowcreek Golf Course	Rivanna River	0.01
	Old Trail Golf Club	Rivanna River	0.04
	Crozet WTP ²	Rivanna River	0.62
	Farmington Country Club	Rivanna River	0.1
	South Rivanna WTP ²	Rivanna River	7.19
	North Rivanna WTP ²	Rivanna River	0.36

¹million gallons per day

²Water Treatment Plant

5.3 *Representation of Sources*

The James River PCB model simulates the fate and transport of sediment and PCBs through the watershed. This section describes how the loads for both constituents are categorized and input into the model. Loads are input into the model as point sources or rainfall-runoff driven nonpoint sources.

5.3.1 **Sediment Sources**

5.3.1.1 *Surface Runoff*

Instream sediment is part of a healthy ecosystem and serves an important role in the environment. When modeling sediment sources for this TMDL, the goal is not to limit the concentration of sediment instream but to understand the fate of this primary transport vector for PCBs from surface detachment, to runoff, to instream suspended sediment. One significant source of PCBs in the study area is contaminated land areas (both known and unknown). Since PCBs have a high affinity for sediment, the sediment washoff from these land areas can contaminate the stream network with the attached PCBs. Sediment is washed off the land surface through two steps: detachment and removal. Within the model, soil and sediment are detached and “stored” on the land surface through raindrop impact. Sediment is then available for wash off during a surface runoff event. When runoff occurs, the soil and sediment are carried into the stream network. The surface runoff of sediment is a nonpoint source of sediment.

5.3.1.2 *Channel Bed Sediment Scouring*

When stream velocity is sufficiently high, the streambed will experience increased shear stress. This shear stress can cause bed sediment to be scoured, suspended into the water column, and carried downstream (Figure 5-1). HSPF is capable of simulating this process. HSPF simulates scour, transport, and deposition. Channel scouring is considered a nonpoint

source of sediment because it occurs throughout the stream and is generally a major contributor to observed PCB concentrations after significant precipitation events.

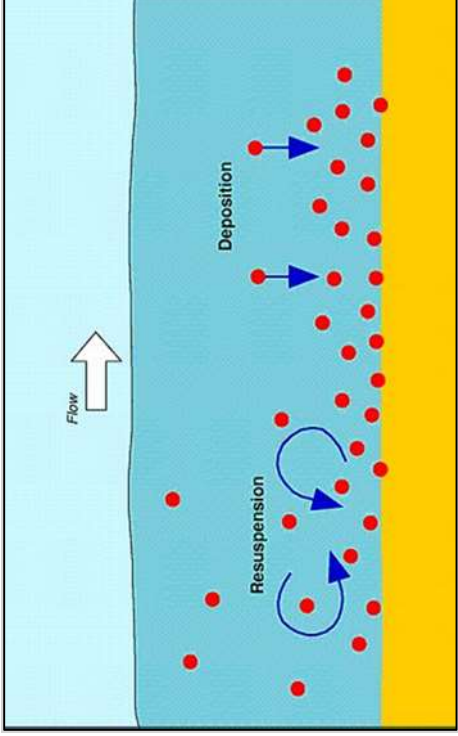


Figure 5-1. Scouring/resuspension and deposition of sediment in a stream (OzCoasts, 2021).

5.3.1.3 Permitted Sediment Sources

A contributing category of sediment to the study area are permitted point source facilities. The effluent from facilities such as wastewater treatment plants (WWTPs) and industrial plants are monitored and measured for total suspended solids (TSS). The loads from these facilities contribute to the instream suspended sediment concentrations (SSC). They are input into the model with a single point of entry into the stream network. Table 5-2 details the mean monthly flow rate, the mean monthly TSS concentrations for the permitted sources, and the timeframe these mean values encompass.

Table 5-2. Permitted TSS point sources in James River study area.

TMDL Watershed	Facility Name	Permit ID	Mean Monthly Flow (mgd) ^a	Mean TSS (mg/L)	Data Timeframe	Receiving Stream
Jackson River	CSX Transportation Inc - Clifton Forge ^b	VA0003344	0.047	0.000	1/08-7/16	Jackson River
	Rail Over River Industrial Park LLC ^b	VA0003450	0.151	4.575	1/08-1/15	Jackson River
	WestRock Virginia LLC - Covington	VA0003646	0.000	3.114	1/08-1/19	Jackson River
	Clifton Forge Town Wastewater Treatment Plant ^b	VA0022772	1.512	0.12	1/08-9/14	Jackson River
	Covington City - Wastewater Treatment Plant	VA0025542	1.923	0.836	1/08-12/19	Jackson River
	Alleghany County - Low Moor WWTP	VA0027979	0.155	2.918	1/08-12/19	Jackson River

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

TMDL Watershed	Facility Name	Permit ID	Mean		Data Timeframe	Receiving Stream
			Monthly Flow (mgd) ^a	Mean TSS (mg/L)		
Maury River	Dominion Energy - Bath County Power Station	VA0053317	4.862	1.617	1/08-12/19	Back Creek
	Hot Springs Regional STP	VA0066303	0.316	4.089	1/08-12/19	Hot Springs Run
	Alleghany Co - Lower Jackson River Regional WWTP	VA0090671	1.028	2.004	10/10-12/19	Jackson River
	Modine Manufacturing Co - Buena Vista	VA0002771	0.050	0.060	1/08-12/19	Noels Run
Upper James	Mohawk Industries Inc	VA0004677	0.390	0.329	1/08-12/19	Maury River
	Bontex Inc	VA0004791	0.268	0.725	1/08-12/19	Maury River
	Buena Vista STP	VA0020991	3.528	0.330	1/08-12/19	Maury River
	Lexington-Rockbridge Regional WQCF	VA0088161	0.903	4.305	1/08-12/19	Maury River
	DOC - Augusta Correctional Center	VA0091821	0.408	0.799	9/08-12/19	Smith Creek
	GP Big Island LLC	VA0003026	11.942	0.888	1/08-12/19	James River
	BWXT Nuclear Operations Group Inc	VA0003697	1.057	5.243	1/08-12/19	James River
	Framatome Inc - MAR	VA0004774	0.003	0.126	1/08-12/19	James River
	VCI Lynchburg Foundry ^b	VA0006262	0.321	3.497	1/08-10/11	James River
	Greif Riverville LLC - Fibre Plant	VA0006408	5.914	0.949	1/08-12/19	James River
	Buchanan Town - Sewage Treatment Plant	VA0022225	0.064	1.038	1/08-12/19	James River
	Lynchburg Regional Wastewater Treatment Plant	VA0024970	11.760	0.236	1/08-12/19	James River
	Amherst Co Service Authority Ivanhoe	VA0063657	0.005	0.217	1/08-12/19	Fawn Creek, UT
	Craig New Castle PSA WWTP Outfall 001	VA0064599	0.183	3.437	1/08-12/19	Craig Creek
Maury River	Roanoke Cement Co - Botetourt County	VA0072397	3.456	0.000	1/08-12/19	Catawba Creek
	Western Virginia Water Authority (WVWA)	VA0076350	0.008	0.166	1/08-12/19	James River
	Eagle Rock WWTP Outfall 001					
	Town of Glasgow WWTP	VA0083712	0.268	1.631	1/08-12/19	James River
	Reusens Hydroelectric Plant	VA0087114	1.420	0.000	1/08-12/19	James River
	Western Virginia Water Authority (WVWA) Glen Wilton WWTP	VA0089273	0.004	0.738	1/08-12/19	James River
	Campbell County Landfill ^b	VA0091723	0.024	0.000	1/08-3/14	UT, Tussocky Creek
	Falwell Industrial Landfill ^b	VA0092258	0.014	0.000	4/09-1/16	UT, Little Opossum Creek

TMDL Watershed	Facility Name	Permit ID	Mean		Data Timeframe	Receiving Stream
			Monthly Flow (mgd) ^a	Mean TSS (mg/L)		
Lower James	Dominion - Bremono Power Station	VA0004138	2.948	0.341	1/08-12/19	James River
	James River Correction Center	VA0020681	0.060	5.476	1/08-12/19	James River
	DOC Powhatan Correctional Center	VA0020699	0.240	1.535	1/08-12/19	James River, UT
	VA Correctional Center for Women	VA0020702	0.195	1.152	1/08-12/19	James River
	Scottsville WRRF	VA0025470	0.066	1.647	1/08-12/19	James River
	Camelot WWTP ^b	VA0025488	0.135	5.858	1/08-1/13	Moore's Creek
	Moore's Creek					
	Advanced Water Resource Recovery Facility	VA0025518	9.691	0.758	1/08-12/19	Moore's Creek
	Cooper Industries LLC	VA0027065	0.010	0.000	1/08-12/19	South Fork Rivanna River, UT
	Buckingham Co Water System/Dillwyn STP	VA0027294	0.054	1.382	1/08-12/19	Whispering Creek, UT
	Rutledge Creek WWTP	VA0031321	0.312	2.892	1/08-12/19	Rutledge Creek
	DOC - Buckingham Correctional Center	VA0066460	0.244	2.405	1/08-12/19	Turpin Creek
	Glenmore WRRF	VA0086584	0.117	1.562	1/08-12/19	Rivanna River
	Amherst County Landfill Permit Number 181	VA0088684	0.022	0.000	1/08-12/19	Buffalo River, UT
	Nelson County Regional STP	VA0089729	0.120	1.422	1/08-12/19	Black Creek
	Oilville Wastewater Treatment Plant ^c	VA0092428	0.300	0.000	-	Horsepen Creek
	Dutoy Creek WWTP	VA0090727	0.060	0.867	1/08-12/19	Dutoy Creek, UT
	Dominion Energy - Bear Garden Generating Station	VA0090891	0.673	0.000	1/11-12/19	James River
	Tenaska Virginia Generating Station	VA0090905	1.525	0.000	1/08-12/19	Rivanna River

^amillion gallons per day; ^bsite is no longer active; ^cFacility not built.

5.3.2 PCB Sources

5.3.2.1 Point Source Dischargers

The James River Study area contains four types of VPDES permits that are modeled as point sources for PCBs: municipal wastewater treatment plants (WWTP), combined sewer systems (CSS), industrial stormwater general permits (ISWGP), and individual industrial permitted facilities (IP). DEQ provided flow and mean concentration information for permitted point sources of PCBs (Tables 5-3 to 5-6), respectively. The mean flows for WWTPs and IPs are calculated from the Discharge Monitoring Reports (DMR) for the period January 2008 to June

2019. Mean flows for ISWGP were calculated from the facility drainage areas. As noted in the table, the mean tPCB concentration for many of these point sources is based on statewide Standard Industrial Classification (SIC) default values (DEQ, 2016) since they were not screened for PCBs during TMDL development. Refer to Appendix C for greater detail on the approach used to calculate point source loads.

Table 5-3. Municipal Wastewater Treatment Plant (WWTP) Facilities in the James River study area as of December 2019, unless noted otherwise.

TMDL Watershed	Facility Name	Permit ID	Mean Flow (mgd) ^a	Mean tPCB Concentration (pg/L)
Jackson River	Covington City - Wastewater Treatment Plant	VA0025542	1.9190	938.9
	Alleghany County - Low Moor WWTP	VA0027979	0.1543	255.6
	Hot Springs Regional STP	VA0066303	0.3159	1,707.1 ^b
	Alleghany Co - Lower Jackson River Regional WWTP	VA0090671	0.9646	1,707.1 ^b
Maury River	Buena Vista STP	VA0020991	1.3128	1,707.1 ^b
	Lexington-Rockbridge Regional WQCF	VA0088161	0.9025	1,707.1 ^b
	DOC - Augusta Correctional Center	VA0091821	0.3691	250.3
	Buchanan Town - Sewage Treatment Plant	VA0022225	0.0641	183.3
Upper James	Lynchburg Regional Wastewater Treatment Plant	VA0024970	11.8727	712.9
	Amherst Co Service Authority Ivanhoe	VA0063657	0.0046	1,640.9
	Craig New Castle PSA WWTP Outfall 001	VA0064599	0.1831	142.4
	Western Virginia Water Authority (WVWA) Eagle Rock WWTP Outfall 001	VA0076350	0.0084	577.3
	Town of Glasgow WWTP	VA0083712	0.2673	607.7
	Western Virginia Water Authority (WVWA) Glen Wilton WWTP	VA0089273	0.0038	780.8
	James River Correction Center	VA0020681	0.0446	1,707.1 ^b
	DOC Powhatan Correctional Center	VA0020699	0.2366	1,707.1 ^b
	VA Correctional Center for Women	VA0020702	0.1668	1,707.1 ^b
	Moores Creek Advanced Water Resource Recovery Facility	VA0025518	9.7148	1,707.1 ^b
Lower James	Buckingham Co Water System/Dillwyn STP	VA0027294	0.0542	1,707.1 ^b
	Rutledge Creek WWTP	VA0031321	0.3156	1,707.1 ^b
	Scottsville WRRF	VA0025470	0.0665	1,707.1 ^b
	DOC - Buckingham Correctional Center	VA0066460	0.2476	1,707.1 ^b
	Glenmore WRRF	VA0086584	0.1173	1,707.1 ^b
	Nelson County Regional STP	VA0089729	0.1229	1,707.1 ^b
	^c Oilville Wastewater Treatment Plant	VA0092428	<0.3000	1,707.1 ^b
	Dutry Creek WWTP	VA0090727	0.0370	17.7

^amillion gallons per day; Municipal Facility mean flows calculated from DMRs from Jan. 2008-Dec. 2019.

^bDefault tPCB concentration based on a statewide municipal dataset (DEQ, 2016).

^cFacility not built.

Table 5-4. Municipal Combined Sewer Systems (CSS) in the James River study area.

TMDL Watershed	Combined Sewer System	Permit ID	Drainage Area (acres)	Mean tPCB Concentration (pg/L)
Upper James	City of Lynchburg	VA0024970	1,137.4	159,265
Lower James	City of Richmond ^a	VA0063177	11,098.9	11,906.68

^a Acreages are based on the outfalls that drain into the Lower James River TMDL watershed. The outfalls that drain into the tidal portion of the James are not included.

Table 5-5. Industrial Stormwater General Permit (ISWGP) Facilities in the James River study area as of December 2019.

TMDL Watershed	Facility Name	Permit ID	Mean Flow (mgd)^a	Mean tPCB Concentration (pg/L)
Jackson River	Chemtrade Solutions LLC - Covington	VAR050182	0.002	2,333.0 ^b
	Material Handlings Solutions	VAR050440	0.046	580
	Covington City - Peters Mountain Landfill	VAR051392	0.004	1,738.6 ^b
	WestRock Virginia LLC - Low Moor	VAR052319	0.034	1,496.0 ^b
	Converting Plant			
Maury River	Blue Ridge Resource Authority	VAR051408	0.032	1,738.6
	Southers Auto Salvage LLC	VAR051827	0.007	1,169.7 ^b
	Auto Recyclers LLC	VAR051901	0.021	678,247
	Auto Towing and Repair LLC	VAR052111	0.003	1,169.7 ^b
	City of Lexington Public Works Facility	VAR052411	0.01	17,923.0 ^b
	Virginia Auto Parts Incorporated	VAR050167	0.012	1,169.7 ^b
	Candler Oil Company Incorporated	VAR050169	0.005	822.1 ^b
Upper James	Davis-Frost Inc	VAR050172	0.008	36.5
	Delta Star Incorporated	VAR050173	0.041	1,325.0
	Crawford Oil Company Incorporated	VAR050181	0.006	822.1 ^b
	Parker Hannifin Corporation - Powertrain Division	VAR050261	0.023	192.0 ^b
	Flowserve Lynchburg Operations	VAR050266	0.007	5,103
	Schwerman Trucking Company	VAR050270	0.008	3,408 ^b
	Hanwha Azdel	VAR050391	0.019	192 ^b
	United Parcel Service Inc - Lynchburg	VAR050447	0.001	3,408 ^b
	WestRock Converting LLC	VAR050524	0.017	3,422
	Republic Services of Lynchburg	VAR050710	0.019	17,923.0 ^b
	Botetourt County Landfill	VAR050712	0.628	1,738.6 ^b
	Cooper Steel of Virginia LLC	VAR050737	0.018	3,469.9 ^b
	Amherst County Landfill Permit Number 563	VAR051354	0.003	297.4
	Rolling Frito-Lay Sales LP - Lynchburg Bin	VAR051551	0.001	3,408 ^b
	International Paper Company	VAR051585	0.023	1,402.5
	KDC/One Lynchburg	VAR051906	0.003	2,333.0 ^b
	Sonoco Recycling LLC - Madison Heights	VAR051959	0.018	51,860.2
	Region 2000 Regional Landfill - Livestock Rd Fac	VAR051994	0.021	255
	Watts Petroleum Corporation - Lynchburg	VAR052022	0.002	822.1
	Banker Steel Company LLC	VAR052109	0.006	3,469.9 ^b
	Madison Heights Auto Parts	VAR052182	0.028	1,474
	Griffin Pipe Products Co LLC - Lynchburg	VAR052212	0.036	14,670.6 ^b

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Porters Properties Lynchburg LLC	VAR052226	0.021	495.7
Foss Industrial Recycling LLC - Lynchburg	VAR052309	0.015	150,186.7 ^b
Munters - Natural Bridge Station	VAR052383	0.003	3,378.1
AOC Metal Works - Lynchburg	VAR052393	0.004	611.0 ^b
BRC Investments LLC	VAR052403	0.002	150,186.7 ^b
Slocum Adhesives Corporation	VAR052456	0.003	2,333.0 ^b
Clear Water Manufacturing	VAR052508	0.033	1,584 ^b
Slocum Adhesives Corporation- Carroll Ave	VAR052530	0.003	2,333
Lower James			
Glad Manufacturing Company	VAR050222	0.040	44.7
Brooks Auto Sales	VAR050630	0.007	1,169.7 ^b
UPS Freight- Richmond	VAR050657	0.005	3,408.0 ^b
623 Landfill	VAR050730	0.067	9,874 ^b
United Parcel Service - Charlottesville	VAR050780	0.001	3,408.0 ^b
BFI Fluvanna Transcylery	VAR050820	0.007	150,186.7 ^b
M and M Service and Salvage Yard Incorporated	VAR050960	0.019	1,169.7 ^b
Harry A Wright's Inc	VAR050965	0.048	1,169.7 ^b
Ivy Materials Utilization Center	VAR050973	0.035	17,923.0 ^b
Republic Services of Charlottesville	VAR050974	0.002	17,923 ^b
Chesterfield Auto Parts	VAR051102	0.046	1,169.7 ^b
Mullite Plant	VAR051580	0.006	2,333.0 ^b
Van Der Linde Recycling	VAR051853	0.005	150,186.7 ^b
Buckingham Branch Railroad	VAR051926	0.001	3,054.0
County Line Auto Parts	VAR052030	0.020	1,169.7 ^b
Morris Industries Incorporated	VAR052269	0.002	1,584.0 ^b
Tenaska Virginia Generating Station	VAR052356	0.027	125.4 ^b
Panorama Paydirt	VAR052458	0.010	2,333.0 ^b

^amillion gallons per day

^bDefault tPCB concentration based on a statewide municipal dataset (DEQ, 2016).

Table 5-6. Individual Industrial Permitted (IP) facilities in the James River study area as of December 2019.

TMDL Watershed	Facility Name	Permit ID	Process	SW	Mean Flow (mgd) ^a	Mean tPCB Concentration (pg/L)
Jackson River	WestRock Virginia LLC - Covington	VA0003646	30.2	0.113	0.113	2,631 ^b
	Dominion Energy - Bath County Power Station	VA0053317	69.99	NA	NA	190.1 ^b
	Modine Manufacturing Co - Buena Vista	VA0002771	0.032	NA	NA	19,234.5 ^b
Maury River	Mohawk Industries Inc	VA0004677	0.026	0.174	0.174	560,411.0 ^b
	Bontex Inc	VA0004791	0.108	NA	NA	1,532.9 ^b
	GP Big Island LLC	VA0003026	12.08	0.12	0.12	2,636.6
Upper James	BWXT Nuclear Operations Group Inc	VA0003697	0.393	0.2	0.2	5,172.8
	Framatome Inc - MAR	VA0004774	0.003	NA	NA	220.3
	Greif Riverville LLC - Fibre Plant	VA0006408	5.95	0.19	0.19	1,498.4
	Roanoke Cement Co - Botetourt County	VA0072397	8.16	2.45	2.45	915.0 ^b
	Reusens Hydroelectric Plant	VA0087114	0.104	0.003	0.003	2,432.7
Lower James	Dominion - Bremono Power Station	VA0004138	1.80	0.27	0.27	1,663.5

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Cooper Industries LLC	VA0027065	0.010	NA	47,347.0 ^b
Amherst County Landfill Permit Number 181	VA0088684	101.3	NA	1,738.6 ^b
Dominion Energy - Bear Garden Generating Station	VA0090891	0.325	0.039	125.4 ^b
Tenaska Virginia Generating Station	VA0090905	0.494	NA	125.4 ^b

^amillion gallons per day; Process WWTP mean flows were derived from DMRs and SW mean flows were derived adhering to the identical approach used for the ISWGP.

^bDefault tPCB concentration based on a statewide municipal dataset (DEQ, 2016).

In addition to the permitted facilities there are eleven municipal separate storm sewer systems (MS4s,

Table 5-7) in the study area. These are municipal regions that convey impervious surface stormwater runoff from within their boundary through a permitted discharge point. Appendix C describes in further detail the PCB loads generated from the MS4 permittees.

Table 5-7. MS4s in the James River PCB TMDL study area

TMDL Watershed	MS4 Entity	Permit ID	Service Area (ac)
Upper James	Central Virginia Community College	VAR040118	32
	Lynchburg City	VAR040008	7,834
	Albemarle County	VAR040074	14,167
Lower James	Charlottesville City	VAR040051	5,733
	Chesterfield County	VA0088609	4,678
	Department of Juvenile Justice	VAR040128	51
	Henrico County	VA0088617	20,835
	Piedmont Virginia Community College	VAR040108	60
	City of Richmond ^a	VA0063177	9,975
Upper James and Lower James	University of Virginia	VAR040073	1,198
	Virginia Department of Transportation	VA0092975	6,426

^a Acreages are based on the outfalls that drain into the Lower James River TMDL watershed. The outfalls that drain into the tidal portion of the James are not included.

5.3.2.2 Nonpoint Sources

Nonpoint source pollutant load is driven by runoff. Nonpoint sources of PCBs are those that do not have a defined entry point into the stream network. These sources include known PCB contaminated sites as well as sources associated with the unspecified surface load. Known contaminated sites can include former manufacturing facilities, sites associated with terminated permits, railyards and rail spurs, and electrical substations. They may also include PCB spills if the spill occurred on the land surface and was not directly released into the stream.

Within the model, nonpoint sources are assigned a washoff potency factor (pg/ton) that defines the quantity of PCBs in pg per ton of sediment that are washed off the land surface. Higher potency factors indicate elevated contamination and more PCB washoff during a storm event. When watershed surface areas are assigned a washoff potency factor, sediment surface runoff becomes a primary contamination pathway. Table 5-8 lists the contaminated sites in the James River PCB TMDL study area. PReP PCB spills were modeled as direct inputs into the stream or as deposition onto the land surface as a “one-time” event based on the recorded date of the spill. Appendix C identifies the occurrences of potential PCB spills reported to DEQ.

Table 5-8. Areas of railyards/railway spurs, contaminated sites, electric substations, and terminated permits in the James River study area.

TMDL Watershed	Site Description	Estimated Area (ac)
Jackson River	Railyards/Railway spurs	277.3
	Electric substations	16.6
	Terminated Permits	424.2
Maury River	Railyards/Railway spurs	11.6
	Electric substations	15.0
Upper James River	Railyards/Railway spurs	404.7
	Electric substations	38.5
	Terminated Permits	427.5
Lower James River	Buick Property (former)	2.7
	100 Everett Street Site	267.0
	Railyards/Railway spurs	174.6
	Electric substations	55.4
	Terminated Permits	245.5

When simulated PCB data were compared with water quality samples, the results suggested that there are PCB sources in the James River study area that were not being accounted for in the model. Even with all known sources input into the model, including those from contaminated sites, atmospheric deposition, and streambed sediment, the model underestimated the instream PCB concentration during high flow events beyond an acceptable margin of error. This under prediction is consistent with results from similar PCB TMDL studies recently completed in Virginia (DEQ, 2009; DEQ, 2018) and indicates that additional PCB loading to the James, Maury and Jackson Rivers are occurring. As a result, an unspecified surface source category was added to account for PCB sources in the James River study area that have yet to be identified. Because the location of the contributing surface sources is unknown, the unspecified source category was applied to all land surfaces that are not within a contaminated site. Additional details on how the unspecified surface sources are input into the PCB fate and transport model and how its load was calculated during calibration can be found in Appendix E.

5.3.2.3 **Legacy Sources**

Two legacy sources of PCBs are atmospheric deposition and streambed sediment. PCBs that were released into the atmosphere during industrial manufacturing persist. Over time, these PCBs may settle out from the atmosphere and deposit on the ground. Research has shown that PCB atmospheric deposition may be elevated near urban areas, manufacturing facilities, or contaminated sites (Totten *et al.*, 2006). However, because data were not available to quantify varying atmospheric deposition rates within the James River study area, it was assumed that PCB atmospheric deposition was uniform over the study area. PCBs from atmospheric deposition to land were considered as a component of the unspecified surface source category. The ability of PCBs to persist in the environment also means streambed sediment that was contaminated years prior may continue to release PCBs back into the water column if disturbed. PCBs are considered uncontrollable when in the atmosphere or once released to waterbodies and ubiquitously deposited in the streambeds of free-flowing systems. Consequently, PCBs within the streambed sediment were not considered for reduction when allocating PCBs, but in the interest of developing a representative model, they were included as PCB sources.

5.4 **Model Calibration and Validation**

Model calibration is the iterative process of selecting model parameters, producing simulated outputs, comparing the outputs with observed data, adjusting the model parameters, and repeating the process. The goal was to develop a model that provided a reasonably accurate representation of the James River PCB TMDL study area. This section details the procedures used to calibrate the James River PCB TMDL HSPF model.

5.4.1 **Hydrology**

Hydrologic calibration and validation are critical components of the TMDL development process. Establishing an accurate hydrology component enables better modeling of pollutant fate and transport. HSPF is a rainfall-runoff model whose hydrology is driven by precipitation and evapotranspiration time series and shaped by the various unique subwatershed characteristics. Quality controlled meteorology data from the NCDL weather stations (noted in Section 2.2.4) were used to create those meteorological time series. The observed data used for calibration comparison were from USGS flow gages, which convert stream stage/height values into flow rates based on stage-discharge relationships. The USGS data were also subject to quality control. When modeling stream hydrology, the calibration and validation

periods that were used encompassed both high flow/wet years and low flow/dry years. During the five-year calibration period, the model's hydrologic parameters were adjusted to fit the simulated flow outputs to the observed flow data. The validation period, which was also five years, was used to confirm the accuracy of the simulated model. During validation, model parameters were not adjusted.

Hydrologic calibration and validation entailed qualitative and quantitative weight of evidence analysis. In terms of the qualitative analysis, both the simulated and observed flow rates were plotted on time series graphs to visualize how the simulation fits the observed data. For the quantitative analysis, several statistical criteria specifically selected for hydrologic calibration and outlined in a VADEQ TMDL Guidance Memo were used (DEQ, 2003) (**Error! Reference source not found.**9). The focus of the hydrology calibration was to analyze the model's ability to accurately simulate flow during high flow conditions (storm events) and during low flow conditions (baseflow). The high and low flow periods determined the critical conditions for the water quality model. It is during these periods that pollutant concentrations may increase and violate the water quality standard. Other general model fit statistics analyze the entire modeling period with equal weight. Appendix E contains details for the hydrologic calibration process and the results for the James River PCB TMDL study area.

Table 5-9. Default criteria for hydrologic calibration.

Variable	Percent Error
Total Volume	±10%
50% Lowest Flows	±10%
10% Highest Flows	±15%
Storm Peaks	±15%
Seasonal Volume Error	±10%
Storm Volume Error	±20%

5.4.2 Sediment

Sediment model calibration was conducted in two phases. The first phase simulated the detachment and removal/washoff of sediment from the land surface. The second phase simulated the instream sediment processes such as bed sediment scouring/resuspension, transport, and deposition. In both phases, the calibration involved qualitative, graphical, and quantitative analyses.

In the first phase, sediment runoff data were not available to assist with sediment model calibration. Measuring the sediment runoff load from a land parcel would be costly, time-consuming, and impractical to do on a scale as large as the James River study area. Therefore,

sediment model calibration entailed plotting the time series of sediment storage and removal and comparing it to expected trends. In a watershed, sediment storage is expected to increase gradually over time and decrease after precipitation events due to spikes in removal rate. This trend was observed with the simulated outputs. Additionally, the simulated removal rates were compared with known sediment removal ranges for various land use types. The simulated rates were calibrated within expected known ranges.

The second phase of calibration used instream SSC samples collected by DEQ. **Error! Reference source not found.** marks the locations of the DEQ water quality monitoring stations in the James River PCB TMDL study area that were used during sediment calibration. SSC and TSS are slightly different water quality measurements. Whereas the methodology for measuring TSS was originally created for analyzing wastewater samples, SSC is more commonly used for natural water samples (Gray *et al.*, 2000). For the purpose of this study, it was appropriate to use SSC and TSS data interchangeably to denote the quantity of suspended sediment instream. The model outputs for the sediment component included flow and SSC values. Under a wide range of flow regimes, the simulated SSC values were compared with the observed instream SSC data. Model parameters were adjusted until simulated outputs were representative of the observed data and could produce the expected sediment concentrations given certain flow conditions. Appendix D details the process of sediment calibration and the results of the calibration for James River.

5.4.3 PCBs

PCBs were simulated as a pollutant that could exist in two states, sediment-associated and “dissolved.” Sediment-associated PCBs were simulated as runoff from the land surface and as suspended instream particulate. “Dissolved” PCBs were only simulated instream. For the purpose of modeling, dissolved was understood as PCBs that are freely suspended in the water column, not attached to sediment, and readily available for uptake. HSPF is capable of modeling pollutants instream as both sediment-associated and dissolved, and the proportion at which they exist in each state is dependent on adsorption/desorption model parameters.

During calibration, PCB sources were designated under two categories, sources with a known load and sources with an uncertain load. Sources with a known load included any sources with a quantifiable load such as atmospheric deposition to water surfaces, known contaminated sites (i.e., spills, railyards and spurs, electrical substations), and streambed sediment where a specific measurement has been completed. Sources with an uncertain load included surface load sources (net atmospheric deposition to land surfaces, unspecified and

regulated stormwater runoff, loads from unidentified contaminated sites, and unspecified point source discharges). Appendix E provides additional detail on the model parameters used during calibration and the final results for the James River PCB TMDL model.

5.5 *Existing Conditions*

The existing conditions model run was used to identify which PCB sources were the largest contributors to the instream PCB concentration. The simulated loads from the existing conditions model provided the relative magnitude of loading from various sources and were used as general guidance for prioritizing sources for reduction when developing allocation scenarios. **Error! Reference source not found.** gives an overview of the contribution from each source type to the instream PCB concentration at the outlet of each TMDL watershed in the James River PCB TMDL study area. Detailed tables with the PCB concentration and load magnitude are presented in Appendix E. Note Table 5-10 measures relative contribution in percent and is not comparable to the source breakdown load tables presented in the Executive Summary nor the tables in Chapter 6. This relative daily contribution table was calculated by sequentially toggling on and off single sources within the model and outputting the mean daily concentration at the TMDL watershed outlet. This information is valuable in understanding the relative impact the different sources have on the instream PCB concentrations once transport factors are considered. The source breakdown load tables are computed from a back calculation of the TMDL.

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Table 5-10. Relative contributions of different PCB sources to the instream PCB concentration for existing conditions in the James River PCB TMDL study area.

TMDL Watershed	Streambed Sediment (%)	Atmospheric Deposition (%)	Known Contaminated Sites³ (%)	CSO	Permits (%)	Surface Load Unspecified (%)	Surface Load Regulated (%)	Boundary Inputs (%)
Jackson	14	<1	<1	–	9	77	–	–
Maury	<1	<1	<1	–	16	84	–	–
Upper James ¹	<1	<1	<1	<1	3	55	32	9 ¹
Lower James ²	<1	<1	<1	<1	5	5	34	55 ²

¹Upstream contributions from the Jackson and Maury Rivers account for 9% of the PCB load in the Upper James River.

²Upstream contributions from the Jackson, Maury, and upper James Rivers account for 55% of the PCB load in the Lower James River.

³Includes loads from spills, railyards and spurs, electrical substations, and former manufacturing facilities.

Chapter 6: TMDL Allocations

The objective of a TMDL is to allocate allowable loads among different pollutant sources so that the appropriate control actions can be taken to achieve WQSs (USEPA, 1991a).

6.1 Background

The objective of the PCB TMDL for the James River study area was to determine what reductions in PCB loadings from point and nonpoint sources were required to meet state WQSs. The state water quality standard for PCBs is 580 pg/L unless the PCB fish TV is exceeded. If the PCB fish TV is exceeded, a more protective, segment-specific BAF-calculated water quality endpoint is often necessary to support the fish consumption designated use. The TMDL is the maximum allowable PCB load required for an impaired segment to achieve WQSs (or water quality endpoint) and considers all significant contributing sources. The sources can be separated into nonpoint and point sources, and loads from these sources are defined in the following TMDL equation:

$$TMDL = WLA_{Total} + LA + MOS$$

Eq. 6-1

Where:

WLA_{Total} = waste load allocation (point source contributions, future conditions i.e., growth; accounts for point source facilities inadvertently excluded from TMDL);
 LA = load allocation (nonpoint source contributions); and
 MOS = margin of safety.

The Virginia Department of Environmental Quality has introduced an updated PCB water quality standard (WQS) that sets the instream PCB water quality criteria (WQC) at 580 pg/L and determines compliance with the “human health” criteria by relying on the assumption of [an] “average amount of exposure on a long-term basis.” As the revised WQC may not always meet the goal of restoring the consumption use when applying a long-term average exposure, a BAF-calculated water column tPCB endpoint which is lower than the WQC was used for three of the four impaired waterbodies within the study area. The procedure for determining the pollutant allocation to meet the instream concentration TMDL endpoint is summarized here, with results from this procedure/analysis for the James River impaired segments presented in Table 6-1. The modeled output for the impaired segments is neither normal nor lognormally distributed, so as directed in a DEQ-issued memorandum (DEQ, 2022), the median of the modeled output was used to develop the PCB TMDLs.

- Using meteorological inputs from the appropriately determined harmonic mean flow year (HMFY), analyze the resulting modeled, 365 daily average instream PCB concentrations to determine which specific statistic of central tendency (i.e., mean or median) of that modeled output should be compared against the TMDL endpoint to determine if the allocation scenario being assessed meets the TMDL endpoint.
- Determine whether the TMDL calibration model output is normal/lognormal or whether the distribution is neither.
 - If the model output is normally distributed, select the arithmetic mean as the measure of central tendency for aggregating model output over the simulation period.
 - If the model output is lognormally distributed, select the geometric mean as the measure of central tendency for aggregating model output over the simulation period.
 - If model output distribution is neither normal nor lognormal, a median of the model output will need to be the measure of central tendency for aggregating model output over the simulation period.
- If the **mean** of model output is **greater than** the endpoint specific to the waterbody:
 - Use the upper 95% confidence limit (CL) of the mean as the basis for reductions.
- If the **mean** of model output is **less than** the endpoint and the:
 - Upper 95% confidence limit of the mean (arithmetic, Eq. 6-2 or geometric, Eq. 6-3) is *greater than* the endpoint, use this statistic as the basis for reductions. If the upper 95% CL is *less than* the endpoint, find the daily value closest to the upper 95% CL that is above the endpoint but is less than the 90th percentile of a normal curve composed from the mean and standard deviation of the model output. Use this value as the basis for reductions.
- If the **median** of model output is **greater than** the endpoint:
 - Use the upper 95% CL of the median (Eq. 6-4) as the basis for reductions.
- If the **median** of model output is **less than** the endpoint:
 - Upper 95% CL of the median (Eq. 6-4) is *greater than* the endpoint, use this statistic as the basis for reductions. If the upper 95% CL is *less than* the endpoint, find the daily value closest to the upper 95% CL that is *greater than* the endpoint but no greater than the 90th percentile of the model output dataset. Use this value as the basis for reductions.

$$\begin{aligned} \text{Upper 95\% confidence limit of the arithmetic mean} &= \text{Arithmetic Mean} + 1.96 \times (\text{standard deviation of daily averages}) \div \sqrt{\text{count of daily averages}} \\ \text{Upper 95\% confidence limit of the geometric mean} &= \exp(\text{arithmetic mean of log-transformed daily values}) + 1.96 \times \exp(\text{standard deviation of log-transformed daily averages}) \div \sqrt{\text{count of daily averages}} \\ \text{Upper 95\% confidence limit of the median}^1 &= 365 \times 0.5 + 1.96 \times \sqrt{(365 \times 0.5 \times (1 - 0.05))} \end{aligned}$$

Eq. 6-2

Eq. 6-3

Eq. 6-4

¹Assumes one has 365 modeled, daily average instream PCB concentration. Round result up to the nearest whole number.

Table 6-1. Arithmetic mean and median statistics for existing conditions for the James River impaired segments. The median modeled output statistics were used to develop the PCB TMDLs.

Arithmetic Mean Modeled Output Statistic	Existing Conditions PCB concentration (pg/L)	Median Modeled Output Statistic	Existing Conditions PCB concentration (pg/L)
Jackson River (endpoint 580 pg/L)			
Mean	461	Median	127
Upper 95% CL	547	Upper 95% CL	129
90 th percentile	1,501	90 th percentile	1,502
Maury River (endpoint 400 pg/L)			
Mean	657	Median	67
Upper 95% CL	859	Upper 95% CL	67
90 th percentile	2,187	90 th percentile	2,256
Upper James River (endpoint 120 pg/L)			
Mean	290	Median	40
Upper 95% CL	363	Upper 95% CL	47
90 th percentile	777	90 th percentile	830
Lower James River (endpoint 52 pg/L)			
Mean	157	Median	40
Upper 95% CL	187	Upper 95% CL	52
90 th percentile	489	90 th percentile	506

6.2 Accounting for Critical Conditions and Seasonal Variations

Current EPA regulations [40 CFR 130.7(c)(1)] require TMDLs to consider critical conditions for stream flow, loading, and water quality parameters. Such an approach provides additional assurance that TMDLs, when implemented, will meet the long-term average instream condition of the WQC or TMDL endpoint under a wide variety of flow regimes that affect PCB concentrations.

6.2.1 Selection of Representative Modeling Period

The model calibration period was selected to capture the available PCB monitoring data. For allocation, a harmonic mean flow year (HMFY) was calculated to establish the allocation period. A HMFY is frequently used to account for critical flow conditions when developing TMDLs for contaminants that impact human health on a lifetime exposure scale (USEPA,

1991b). Unlike arithmetic and geometric means, harmonic means tend to be influenced by small values more than large values, and out of the three Pythagorean means, the harmonic mean is the smallest. Choosing the HMFY as the allocation period prioritizes low flow conditions, since low flow conditions typically result in higher instream concentrations of PCBs and greater potential exposure to humans. The modeled PCB loads from nonpoint sources generally do not fluctuate from year to year, and point sources have a larger influence on low flows than high flows. Given two year-long allocation periods, one during an arithmetic mean flow year and one during the HMFY, PCB concentrations will typically be greater in the HMFY allocation period than the arithmetic mean flow year. Using the HMFY as the allocation period ensures that the TMDL addresses critical, low flow conditions.

HMFYs were calculated using the full record of observed flow data from the USGS gage in each impaired segment. The following equation is used to calculate harmonic mean flow:

$$H = \frac{n}{\sum(1/Q_i)}$$

Eq. 6-2

Where:

- H = harmonic mean flow, cfs;
- n = number of observations (365); and
- Q_i = daily mean flow for day i .

The harmonic mean flows from each gage were then compared with the annual harmonic mean flows from recent flow data (2001-2020). The year with the harmonic mean flow that best matched the harmonic mean flow from the full flow record was selected as the HMFY for a given segment. Table 6-2 lists the selected HMFY allocation year for each impaired segment.

Table 6-2. TMDL allocation modeling period for each impaired segment.

Impaired Segment	TMDL Allocation Modeling Period (HMFY)
Jackson River	2010
Maury River	2011
Upper James	2010
Lower James	2002

6.2.2 Seasonal Variability

The HSPF continuous simulation model developed for this project incorporated the seasonal variations of the meteorological and other seasonally varying variables. Seasonal variability was also addressed during the monitoring phase of the project. DEQ collected water

column PCB concentration samples, sediment-associated PCB concentration samples, fish tissue samples, and SSC samples in various seasons. The model was calibrated with attention to any seasonal bias.

The HMFY allocation period encompasses an entire calendar year. Using a full continuous calendar year as the allocation period and daily simulated PCB outputs in the TMDL development further ensures that seasonal variability is considered. The TMDL was developed using a PCB endpoint that applies throughout the year. The purpose of this TMDL project is to address water quality impairments due to high levels of PCBs in fish tissue. Since PCBs bioaccumulate, it is also worth noting that seasonal variations may not be as important as long-term annual variations (USEPA, 2011).

6.3 *Margin of Safety (MOS)*

A Margin of Safety (MOS) is factored into a TMDL to account for various sources of uncertainty. The MOS can be either explicit, as an additional load reduction requirement, or implicit, which incorporates conservative assumptions within the development and application of the TMDL model. In accordance with past Virginia PCB TMDLs, an explicit MOS of 5% was used in this study which was subtracted from the TMDL total when calculating the LA (DEQ, 2009). In addition to the explicit MOS, conservative estimations of all appropriate factors affecting PCB loadings in the watershed were used. These estimations provide an additional implicit MO. A sample of conservative assumptions and approaches taken during model development include:

- When conducting model PCB calibration, the unspecified surface source load was created to include sources in the watershed that were not identified. When calibrating the load rate from this source, a more conservative estimate was used to ensure that allocation reductions would sufficiently address the unidentified sources.
- The decay rate of PCBs was not modeled. In a watershed, PCBs decay at an extremely slow rate. Since this was not modeled it provides a more conservative estimate of instream PCB concentrations.
- During allocation, if a scenario output simulated values within 5% of the TMDL endpoint, further PCB load reductions were made.

Creating a TMDL with conservative modeling measures helps to ensure that no water quality standard exceedances will occur if the TMDL pollutant allocation reductions are achieved.

6.4 Waste Load Allocation (WLA)

6.4.1 Future Conditions

The production of PCBs was banned in the late 1970's, although a “newly identified” or contemporary source that can contribute PCB loads includes “inadvertent production” (DEQ, 2016). While it may be a reasonable assumption that any increase in population, human or otherwise, in the James River study area would not lead to a substantial rise in the PCB load, an allocation for a future condition is included to account for facilities that are not currently regulated under a VPDES permit but may require a permit in the years to come. A future conditions load is included in the WLA for each impaired segment. This accounts for PCBs dischargers that may be newly identified in the future and were inadvertently excluded during development of the TMDL, i.e. the future conditions are when more sources have been identified. The WLA for Future Conditions was calculated as 0.1% of the TMDL for each impaired segment. While this is not considered “future growth”, the inclusion of this allocation is consistent with the future growth concept (DEQ, 2014a). It is possible that future land use changes will lead to different sediment loading scenarios from current conditions, but it was within our professional judgement that such changes will have a negligible impact on PCB loads.

6.4.2 Permitted Sources

The Waste Load Allocation (WLA) specified the maximum allowable PCB load from permitted sources without exceeding the TMDL endpoint. To calculate a WLA for each discharger, the TMDL endpoint concentration from the applicable TMDL study watershed where the facility is located was applied while using the appropriate flow. For municipal facilities, the design flow was used. For stormwater-based outfalls the contributing outfall drainage area was used. For those industrial dischargers that had outfalls with comingled process and stormwater flows, the mean of the daily maximum flows obtained from the DMR were used to calculate each facility's WLA. For example, if the current mean PCB concentration at a continuously discharging outfall of a permitted source was 3,000 pg/L, and the facility was located in the Jackson River watershed, the baseline PCB load was calculated by multiplying the mean concentration by the average flow rate from the outfall. This load would need to be reduced to the WLA condition by decreasing the mean concentration to the TMDL endpoint for the Jackson River, 580 pg/L, and applying the design flow of the treatment system specific to the discharging outfall.

The existing PCB loads and WLAs for MS4 regions in the James River study area were calculated at the localized outlet of each MS4 region. These loads were derived based on impervious surface acreage within each MS4 region and their intersection with nonregulated surface load sources and contaminated sites, which have defined PCB loading rates. Loads from industrial stormwater permitted facilities located within an MS4 region are assigned to the industrial permitted facility (i.e., excluded from the MS4 load), whereas MS4 permit holders are assigned a WLA that applies to the existing runoff from within their boundary area where attainment of the TMDL endpoint is achieved at the study area outlet. Reductions to nonpoint sources during the allocation phase are reflected in the WLA reductions for MS4s.

Tables 6-3 to 6-5 list the permitted sources in the James River PCB TMDL study area by permit type: Municipal Wastewater Treatment Plant (WWTP) Facilities, Industrial Stormwater General Permit Facilities (ISWGP), Individual Industrial Permit Facilities (IP), and MS4 regions, respectively. Each table identifies the total baseline PCB load from each permit, the WLA presented on an annual and daily basis, and the percent reduction necessary. Of note, the annual loads and WLAs are presented using two significant figures to be consistent with the WQS. The approach used to generate daily loads is presented in Section 6.7.2. A “NA” (i.e., not applicable) in the % reduction column means the permitted facility is currently generating a load that is less than the WLA. A dash (“–”) also means the projected load is less than the WLA but the effluent has not yet been screened for PCBs using the low level PCB analytical method. Note that the ISWGP loads in Table 6-4 and IP loads in Table 6-5 are the combined load from all outfalls (i.e., a single load is applied to the entire facility).

Table 6-3. Baseline PCB Load and Waste Load Allocations of Municipal Wastewater Treatment Plant (WWTP) Facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Baseline			% Reduction
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	
Jackson River	Covington City - Wastewater Treatment Plant	VA0025542	2,500	2,400	16	4
	Alleghany County - Low Moor WWTP	VA0027979	55	400	2.7	NA
	Hot Springs Regional STP	VA0066303	750 ^a	360	2.4	52
	Alleghany Co - Lower Jackson River Regional WWTP	VA0090671	2,300 ^a	2800	19	–
Maury River	Buena Vista STP	VA0020991	3,100 ^a	1,200	8.3	61
	Lexington-Rockbridge Regional WQCF	VA0088161	2,100 ^a	1,700	11	19
	DOC - Augusta Correctional Center	VA0091821	130	240	1.6	NA

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

TMDL Watershed	Facility Name	Permit ID	Baseline			
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	% Reduction
Upper James	Buchanan Town - Sewage Treatment Plant	VA0022225	16	39	0.26	NA
	Lynchburg Regional Wastewater Treatment Plant	VA0024970	12,000	4,600	31	62
	Amherst Co Service Authority Ivanhoe	VA0063657	11	2.5	0.017	77
	Craig New Castle PSA WWTP Outfall 001	VA0064599	36	29	0.19	19
	Western Virginia Water Authority (WVWA) Eagle Rock WWTP Outfall 001	VA0076350	6.7	3.3	0.022	51
	Town of Glasgow WWTP	VA0083712	220	82	0.55	63
	Western Virginia Water Authority (WVWA) Glen Wilton WWTP	VA0089273	4.1	3.3	0.022	20
Lower James	James River Correction Center	VA0020681	110 ^a	16	0.10	85
	DOC Powhatan Correctional Center	VA0020699	560 ^a	33	0.22	94
	VA Correctional Center for Women	VA0020702	390 ^a	22	0.14	94
	Moore Creek Advanced Water Resource Recovery Facility	VA0025518	23,000 ^a	1,100	7.2	95
	Buckingham Co Water System/Dillwyn STP	VA0027294	130 ^a	14	0.10	89
	Rutledge Creek WWTP	VA0031321	740 ^a	29	0.19	96
	Scottsville WRRF	VA0025470	160 ^a	14	0.10	91
	DOC - Buckingham Correctional Center	VA0066460	580 ^a	22	0.14	96
	Glenmore WRRF	VA0086584	280 ^a	27	0.18	90
	Nelson County Regional STP	VA0089729	290 ^a	16	0.11	94
	Oilville Wastewater Treatment Plant	VA0092428	0.0 ^{ab}	22	0.14	–
	Duttoy Creek WWTP	VA0090727	1.0 ^a	18	0.12	–

^a Baseline tPCB load based on a default tPCB concentration taken from a statewide municipal dataset (DEQ, 2016).

^b This facility has yet to be constructed.

NA - tPCB load reductions may not apply if the effluent has already been screened and the load is less than the WLA.
 “–” The projected load is less than the WLA but the effluent has not yet been screened for PCBs using the low level PCB analytical method.

Table 6-4. Baseline tPCB Loads and Waste Load Allocations of Industrial Stormwater General Permit (ISWGP) Facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Baseline			
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	% Reduction
Jackson River	Chemtrade Solutions LLC - Covington	VAR050182	5.0 ^a	1.2	0.0072	76
	Material Handlings Solutions	VAR050440	37 ^a	37	0.22	0
	Covington City - Peters Mountain Landfill	VAR051392	9.5 ^a	3.2	0.019	66
	WestRock Virginia LLC - Low Moor Converting Plant	VAR052319	70 ^a	27	0.16	61
	Blue Ridge Resource Authority	VAR051408	76	17	0.087	78
Maury River	Southers Auto Salvage LLC	VAR051827	11 ^a	3.8	0.019	66
	Auto Recyclers LLC	VAR051901	19,000	11	0.056	99
	Auto Towing and Repair LLC	VAR052111	5.0 ^a	1.7	0.0087	66
	City of Lexington Public Works Facility	VAR052411	250 ^a	5.7	0.029	98
	Virginia Auto Parts Incorporated	VAR050167	19 ^a	1.9	0.011	90
Upper James	Candler Oil Company Incorporated	VAR050169	5.9 ^a	0.86	0.0048	85
	Davis-Frost Inc	VAR050172	0.43	1.4	0.0078	NA
	Delta Star Incorporated	VAR050173	74	6.7	0.038	91
	Crawford Oil Company Incorporated	VAR050181	6.4 ^a	0.93	0.0052	86
	Parker Hannifin Corporation - Powertrain Division	VAR050261	6.0 ^a	3.7	0.021	38
	Flowserve Lynchburg Operations	VAR050266	47	1.1	.0062	98
	Schwerman Trucking Company	VAR050270	38 ^a	1.3	0.0073	97
	Hanwha Azdel	VAR050391	5.1 ^a	3.2	0.018	37
	United Parcel Service Inc - Lynchburg	VAR050447	2.9 ^a	0.10	0.00056	97
	WestRock Converting LLC	VAR050524	79	2.7	0.015	97
	Republic Services of Lynchburg	VAR050710	470 ^a	3.2	0.018	99
	Botetourt County Landfill	VAR050712	1,500 ^a	100	0.56	93
	Cooper Steel of Virginia LLC	VAR050737	87 ^a	3.0	0.17	97
	Amherst County Landfill Permit Number 563	VAR051354	1.4	0.56	0.0031	60

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

TMDL Watershed	Facility Name	Permit ID	Baseline				% Reduction
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)		
Upper James	Rolling Frito-Lay Sales LP - Lynchburg Bin	VAR051551	5.3 ^a	0.19	0.0011		96
	International Paper Company	VAR051585	44	3.8	0.021		91
	KDC/One Lynchburg	VAR051906	9.1 ^a	0.47	0.0026		95
	Sonoco Recycling LLC - Madison Heights	VAR051959	1,300	2.9	0.016		99
	Region 2000 Regional Landfill - Livestock Rd Fac	VAR051994	7.3	3.4	0.019		53
	Watts Petroleum Corporation - Lynchburg	VAR052022	1.9	0.28	0.0016		85
	Banker Steel Company LLC	VAR052109	31 ^a	1.1	0.0062		97
	Madison Heights Auto Parts	VAR052182	38	4.7	0.026		88
	Griffin Pipe Products Co LLC - Lynchburg	VAR052212	730 ^a	6.0	0.034		99
	Porters Properties Lynchburg LLC	VAR052226	15	3.5	0.020		77
	Munters - Natural Bridge Station	VAR052383	13	0.47	0.026		96
	AOC Metal Works - Lynchburg	VAR052393	3.2 ^a	0.63	0.0035		80
	BRC Investments LLC	VAR052403	400 ^a	0.32	0.0018		99
	Slocum Adhesives Corporation	VAR052456	10 ^a	0.53	0.0030		95
	Clear Water Manufacturing	VAR052508	71 ^a	5.4	0.030		92
	Slocum Adhesives Corporation- Carroll Ave	VAR052530	36	1.8	0.010		95
	Foss Industrial Recycling – Farview Lynchburg	VAR052554	3,200 ^a	2.6	0.015		99
Lower James	Glad Manufacturing Company	VAR050222	2.4	2.8	0.018		NA
	Brooks Auto Sales	VAR050630	12 ^a	0.51	0.0032		96
	UPS Freight- Richmond	VAR050657	22 ^a	0.34	0.0021		99
	623 Landfill	VAR050730	910 ^a	4.8	0.030		99
	United Parcel Service - Charlottesville	VAR050780	3.1 ^a	0.047	0.00030		99
	BFI Fluvanna Transcyclery	VAR050820	1,400 ^a	0.49	0.0031		99
	M and M Service and Salvage Yard Incorporated	VAR050960	30 ^a	1.3	0.0082		96
	Harry A Wright's Inc	VAR050965	77 ^a	3.4	0.021		96

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

TMDL Watershed	Facility Name	Permit ID	Baseline			
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	% Reduction
Lower James	Ivy Materials Utilization Center	VAR050973	860 ^a	2.5	0.016	99
	Republic Services of Charlottesville	VAR050974	57 ^a	0.17	0.0011	99
	Chesterfield Auto Parts	VAR051102	75 ^a	3.3	0.021	96
	Mullite Plant	VAR051580	21 ^a	0.47	0.0030	98
	Van Der Linde Recycling	VAR051853	1,100 ^a	0.38	0.0024	99
	Buckingham Branch Railroad	VAR051926	4.2	0.071	0.00045	98
	County Line Auto Parts	VAR052030	33 ^a	1.4	0.0088	96
	Morris Industries Incorporated	VAR052269	4.0 ^a	0.13	0.00082	97
	Tenaska Virginia Generating Station	VAR052356	4.7 ^a	1.9	0.012	60
	Panorama Paydirt	VAR052458	34 ^a	0.75	0.0047	98

^a Baseline tPCB load based on a default tPCB concentration taken from a statewide Standard Industrial Classification (SIC) dataset (DEQ, 2016).

NA - tPCB load reductions may not apply if the effluent has already been screened and the load is less than the WLA.

Table 6-5. Baseline PCB Load and Waste Load Allocations of Individual Industrial Permitted (IP) Facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Baseline			
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	% Reduction
Jackson River	WestRock Virginia LLC - Covington ^a	VA0003646	64,000 ^a	27,000	180	58
	Dominion Energy - Bath County Power Station ^a	VA0053317	95,000 ^a	140,000	910	–
	Modine Manufacturing Co - Buena Vista ^a	VA0002771	860 ^a	36	0.24	96
Maury River	Mohawk Industries Inc ^a	VA0004677	330,000 ^a	310	3.0	99
	Bontex Inc ^a	VA0004791	230 ^a	120	0.79	48
	GP Big Island LLC	VA0003026	38,000	1,800	12	95
Upper James	BWXT Nuclear Operations Group Inc	VA0003697	2,200	130	0.85	94
	Framatome Inc - MAR	VA0004774	0.72	1.2	0.0077	NA
	Greif Riverville LLC - Fibre Plant	VA0006408	9,300	1,200	7.9	87
	Roanoke Cement Co - Botetourt County ^a	VA0072397	13,000 ^a	1,800	12	86

TMDL Watershed	Facility Name	Permit ID	Baseline			
			tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	% Reduction
Upper James	Reusens Hydroelectric Plant	VA0087114	400	21	0.14	95
Lower James	Dominion - Bremono Power Station	VA0004138	1,100	170	1.1	85
	Cooper Industries LLC ^a	VA0027065	650 ^a	0.72	0.0048	99
	Amherst County Landfill Permit Number 181 ^a	VA0088684	240,000 ^a	7,300	49	97
	Dominion Energy - Bear Garden Generating Station ^a	VA0090891	63 ^a	37	0.24	41
	Tenaska Virginia Generating Station ^a	VA0090905	86 ^a	130	0.84	–

^a Baseline tPCB load based on a default tPCB concentration taken from a statewide Standard Industrial Classification (SIC) dataset (DEQ, 2016).

“–” The projected load is less than the WLA but the effluent has not yet been screened for PCBs using the low level PCB analytical method.

Table 6-6. Baseline PCB Load and Waste Load Allocation of MS4 Regions in the James River Study Area.

TMDL Watershed	Impervious Area (acres)	Baseline			
		tPCB Load (mg/yr)	WLA tPCB (mg/yr)	WLA tPCB (mg/d)	% Reduction
Upper James	9,765	200,000	180,000	1,000	10
Lower James	19,049	170,000	150,000	1,000	10

A Total Waste Load Allocation ($WLA_{Subtotal}$) was calculated for each impaired calibration segment. The $WLA_{Subtotal}$ is the sum of the WLAs for all permitted point source facilities and the WLA for any applicable MS4 permits in the calibration segment. The $WLA_{Subtotal}$ does not include the WLA Future Conditions load which is included further in the chapter when discussing the TMDL. Table 6-7 lists the $WLA_{Subtotal}$ for each impaired segment.

Table 6-7. Estimated annual $WLA_{Subtotal}$ for each of the impaired segments.

Impaired Segment	Total Municipal		Total ISWGP WLA^2 (mg/yr)	Total IP WLA ³ (mg/yr)	Total MS4 WLA (mg/yr)	$WLA_{Subtotal}^4$ (mg/yr)
	WLA ¹ (mg/yr)					
Jackson River	6,000		68	170,000	–	170,000
Maury River	3,100		39	470	–	3,600
Upper James River	4,800		170	5,000	180,000	190,000
Lower James River	1,300		25	7,600	150,000	160,000

¹ Total Waste Load Allocation for Municipal Wastewater Treatment Facilities in given impaired segment.

² Total Waste Load Allocation for Industrial Stormwater General Permit Facilities in given impaired segment.

³ Total Waste Load Allocation for Individual Industrial Permit Facilities in given impaired segment.

⁴ Excludes the Future Condition; Presented as two significant figures.

6.5 Load Allocation (LA)

The Load Allocation (LA) determines the maximum allowable PCB load from non-permitted sources (primarily nonpoint sources) without exceeding the TMDL endpoint. For PCBs this load consists of known contaminated sites (e.g., railyards and railway spurs, electrical substations, and spills), unspecified surface sources, atmospheric deposition, and contaminated streambed sediment. For many other pollutants, natural background is included as a source within the LA component of a TMDL. However, since PCBs are man-made, there is no natural background PCB load and it was not included in the PCB LA for the James River study area.

Reductions are typically not assigned to streambed sediments. Realistically, given the difficulty and cost associated with removing contaminated streambed sediment, any reduction called for from this 'source' category would be unattainable. Unless there are significantly contaminated streambed sediments in localized depositional areas (e.g., immediately upstream from a dam), it is generally impractical and cost prohibitive to remediate this source of PCBs. For PCB spills, it was assumed that the areas and tributaries affected by PCB spills would be 100% cleaned up. As such, contaminated sites and the unspecified surface sources were the primary targets of the load reductions.

6.6 Allocation Scenarios

Using the HSPF model developed to simulate PCB loadings, the recommended reduction scenario that will meet the segment specific TMDL endpoints are shown in Table 6-8. A variety of allocation scenarios were evaluated to meet the PCB endpoints established by DEQ for the four impaired segments in the James River PCB TMDL study area. The scenarios and results are summarized here for Jackson River, Maury River, the Upper James River and the Lower James River. Because these are modeled scenarios, they reflect simulated instream PCB concentrations and include processes such as transport and fate of these pollutants. Each impaired segment is described in its own section to present the results of the PCB allocation scenarios.

Table 6-8. PCB source allocation scenario for the Jackson, Maury, Upper and Lower James River impaired segments.

PCB Load Source Category	Required PCB Load Reductions to Meet the TMDL Endpoint (%)			
	Jackson River	Maury River	Upper James River	Lower James River
Upstream Sources	–	–	10	8
Known Contaminated Sites	99	99	99	99
Streambed Sediment	0	0	0	0
Atmospheric Deposition	0	0	0	0
Spills	100	100	100	100
Combined Sewer Systems (CSO)	–	–	68	92
Surface Load, Unspecified	15	0	0	0
Surface Load, Regulated	–	–	10	10
Permitted	53	99	88	97

6.6.1 PCB Allocation Approach

PCB allocation scenarios include permitted sources (waste load allocation, WLA) and nonpoint sources (load allocation, LA). The WLA for MS4 permitted areas include PCB loads on the impervious areas within the MS4 Regions. Permitted and nonpoint source loads are subject to reductions needed to achieve the TMDL.

The James River PCB TMDL model generates hourly PCB concentrations at the outlet of each impaired segment. Based on the procedure presented in Section 6.1, the median of model output was used to determine what reductions in PCB loadings from point and nonpoint sources were required to meet state WQSs at the outlet of each impaired segment. An iterative process was used to reduce loads from sources until a successful allocation was achieved.

Using the calibrated model, the process of developing allocation scenarios starts with “Existing Conditions,” that is PCB loadings as calibrated. If there are permitted point source discharges in the watershed, the next model run scenario is called “Baseline Conditions”, where nonpoint sources are not changed, but permitted point sources (VPDES dischargers such as Municipal, Individual Industrial and General Stormwater dischargers) are modeled using their full permitted WLAs. The final scenario is the “TMDL” scenario, in which permitted sources are modeled using the WLAs and reductions are applied to the nonpoint sources to meet the TMDL endpoint.

All of the allocation scenarios assume that any spill of PCBs will be completely cleaned up. Reductions were applied to sources from known contaminated sites first. If a 99% reduction from known contaminated sites did not achieve the TMDL endpoint, then reductions were applied to unspecified and regulated surface load sources from commercial land use.

6.6.2 Jackson River

Observed flow data from USGS gage 01033100 (Dunlap Creek at Covington, VA) was used to assess the HMFY for the Jackson River. Comparing calendar year harmonic mean flows for the most recent 20 years (2001 – 2020), calendar year 2010 was selected as the HMFY allocation period since the annual harmonic mean flow in year 2010 (362 cfs) most closely matches the long-term harmonic mean flow (364 cfs) for the period of record from 10/1/1974 through 12/31/2020.

The TMDL endpoint for Jackson River is 580 pg/L. Under existing conditions, the median and the upper 95% CL of the model output are less than the TMDL endpoint of 580 pg/L. Based on the procedure presented in Section 6.1, the reductions shown in Table 6-8 are based on the value closest to the upper 95% CL that is *greater than* the endpoint but no greater than the 90th percentile of the model output dataset. As shown in Table 6-8, for the Jackson River TMDL scenario, loads from spills are eliminated (100% reduction), loads from contaminated sources are reduced by 99%, unspecified surface loads are reduced by 15%, and permitted sources below Lake Moomaw are reduced by 53%. The permitted source above Lake Moomaw did not require reductions since the allocated load is greater than the existing load. Overall, under the TMDL, the PCB loads from the Jackson River watershed are reduced by <1%.

6.6.3 Maury River

Observed flow data from USGS gage 02024000 (Maury River near Buena Vista, VA) was used to assess the HMFY for the Maury River. Comparing calendar year harmonic mean flows for the most recent 20 years (2001 – 2020), calendar year 2011 was selected as the HMFY allocation period since the annual harmonic mean flow in year 2011 (247 cfs) most closely matches the long-term harmonic mean flow (242 cfs) for the period of record from 10/1/1938 through the present.

The TMDL endpoint for Maury River is the segment-specific BAF-calculated PCB endpoint of 400 pg/L. Under existing conditions, the median and the upper 95% CL of the model output are less than the TMDL endpoint. Based on the procedure presented in Section 6.1, the reductions shown in Table 6-8 are based on the value closest to the upper 95% CL that is *greater than* the endpoint but no greater than the 90th percentile of the model output dataset. As shown in Table 6-8, for the Maury River TMDL scenario, loads from spills are eliminated (100% reduction), loads from contaminated sources are reduced by 99%, and permitted sources are reduced by 99%. Overall, under the TMDL, the PCB loads from the Maury River watershed are reduced by 44%.

6.6.4 Upper James River

Observed flow data from USGS gage 02026000 (James River at Bent Creek, VA) was used to assess the HMFY for the Upper James River. Comparing calendar year harmonic mean flows for the most recent 20 years (2001 – 2020), calendar year 2010 was selected as the HMFY allocation period since the annual harmonic mean flow in year 2010 (1,843 cfs) most closely matches the long-term harmonic mean flow (1,872 cfs) for the period of record from 4/1/1925 through 12/31/2020.

The TMDL endpoint for the Upper James River is the segment-specific BAF TMDL endpoint of 120 pg/L. Under existing conditions, the median and the upper 95% CL of the model output are less than the TMDL endpoint. Based on the procedure presented in Section 6.1, the reductions shown in Table 6-8 are based on the value closest to the upper 95% CL that is *greater than* the endpoint but no greater than the 90th percentile of the model output dataset. As shown in Table 6-8, for the Upper James River TMDL scenario, loads from upstream sources are reduced by 10%. Again, loads from spills are eliminated (100% reduction), loads from contaminated sources are reduced by 99%, loads from combined sewer overflows (CSOs) are reduced by 68%, regulated surface loads are reduced by 10%, and loads from permitted facilities are reduced by 88%. Overall, under the TMDL, the PCB loads from the Upper James River watershed are reduced by 16%.

6.6.5 Lower James River

Observed flow data from USGS gage 02037500 located on James River near Richmond, VA was used to assess the HMFY for the Lower James River. Comparing calendar year harmonic mean flows for the most recent 20 years (2001 – 2020), calendar year 2002 was selected as the HMFY allocation period since the annual harmonic mean flow in year 2002 (1,347 cfs) most closely matches the long-term harmonic mean flow (1,366 cfs) for the period of record from 10/1/1934 through 12/31/2020.

The TMDL endpoint for the Lower James River is the segment-specific BAF TMDL endpoint of 52 pg/L. Based on the procedure presented in Section 6.1, since the median of model output is lower than the endpoint and the upper 95% CL is greater than the endpoint, the reductions shown in **Error! Reference source not found.** are based on the upper 95% CL of the median. As shown in Table 6-8, for the Lower James River TMDL scenario, loads from upstream sources are reduced by 5%. Again, loads from spills are eliminated (100% reduction), loads from contaminated sources are reduced by 99%, loads from combined sewer overflows (CSOs) are reduced by 92%, regulated surface loads are reduced by 10%, and loads from

permitted facilities are reduced by 97%. Overall, under the TMDL, the PCB loads from the Lower James River watershed are reduced by 42%.

6.7 *Summary of the TMDL Allocation Scenario for PCBs*

PCB TMDLs were developed for four impaired segments within the James River PCB TMDL study area. The TMDL addresses the following issues:

1. Simulated average daily PCB concentrations in the James, Maury and Jackson Rivers do not exceed upper 95% CL of the modeled median of their respective TMDL endpoints.
2. PCBs are a hydrophobic pollutant that tend to associate with soil and sediment. The nonpoint runoff load was modeled by calibrating the SSC component of the model, then simulating PCB runoff as sediment attached. Using this multilayered model that simulated sediment fate and transport and PCB fate and transport ensured that the model adequately represents what is occurring in the study area.
3. The TMDL was developed considering all known sources (contaminated sites, permitted, and legacy sources) as well as regulated and nonregulated surface sources.
4. An explicit margin of safety (MOS) of 5% was included in the TMDL equations.
5. A future conditions load was included to account for facilities that may come on-line in the years to come. The WLA Future Conditions load is proportional to the TMDL. Table 6-9 lists the future conditions load for the TMDL watersheds in the James River PCB TMDL study area. The WLA_{Total} is equal to the $WLA_{Subtotal}$ plus the $WLA_{Future\ Conditions}$.
6. Critical flow conditions were considered by using the harmonic mean flow year while developing the TMDLs for each impaired segment. Harmonic mean flow is recommended by the USEPA when the human health impact due to a pollutant is considered over a lifetime exposure period (USEPA, 1991b).
7. Flows fluctuate seasonally due to changes in precipitation and monthly variable hydrology parameters. Each TMDL accounts for these seasonal effects.

Using Equation 6-1, a summary of each impaired segment's PCB TMDL allocation scenario is given in Table 6-10. Each TMDL equation was developed using the HMFY allocation period for each impaired segment (Table 6-2).

Table 6-9. WLA for Future Conditions for the TMDL watersheds in the James River PCB TMDL study area.

Impaired Segment	WLA ^{Future Conditions}	
	(mg/yr)	Percent of TMDL (%)
Jackson River	300	0.10
Maury River	470	0.10
Upper James River	560	0.10
Lower James River	450	0.10

Table 6-10. Maximum annual PCB loadings (mg/yr) at the outlet of each TMDL watershed in the James River PCB TMDL study area.

Impaired Segment	WLA ^{Total} (mg/yr) ¹	LA ² (mg/yr) Equation to Achieve the TMDL Endpoint	MOS ³ (mg/yr)	TMDL (mg/yr) ⁴
Jackson River	170,000	110,000	15,000	300,000
Maury River	4,100	440,000	23,000	470,000
Upper James River	190,000	340,000	28,000	560,000
Lower James River	160,000	270,000	22,000	450,000

¹ WLA^{Total} includes future conditions.

² The LA is the remaining loading allowed after the MOS and WLA^{Total} were subtracted from the TMDL as determined for the downstream end/outlet of the impaired segment.

³ Explicit MOS (5%).

⁴ Expressed as two significant figures.

6.7.1 Source Category Breakdown

Table 6-11 summarizes the annual existing load, WLA, LA, and percent reduction after allocation by source category for each impaired segment in the James River PCB TMDL study area. The tables include WLA Future Conditions to account for point source PCB dischargers that may be regulated under a VPDES permit in the future and are equal to 0.10% of the TMDL. The LA and existing loads for the nonpoint sources are the average annual loads based on each source's contribution to the instream PCB concentration at the outlet of each impaired segment. Existing loads for nonpoint sources are back calculated from the final TMDL and are a function of the load allocation percent reduction. The existing loads are not to be used as accurate estimates of the current nonpoint source load. Rather they provide guidance and a visual estimation of how much load needs to be reduced to meet the TMDL.

Table 6-11. Average annual PCB load at the outlet of Jackson, Maury, and Upper and Lower James River watersheds expressed by source category.

Source Category	Existing Load (mg/yr)	Jackson River			Reduction (%)
		WLA (mg/yr)	LA (mg/yr)		
Upstream Sources					
Known Contaminated Sites	83		1		99
Streambed Sediment	11,795		11,795		0
Atmospheric Deposition	11		11		0
Spills	0		0		100
Combined Sewer Systems (CSO)					

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Source Category	Existing Load (mg/yr)	WLA (mg/yr)	LA (mg/yr)	Reduction (%)
Surface Load, Unspecified ²	116,781		99,264	15
Surface Load, Regulated	0	0		0
Permitted	164,727	173,028		-5
WLA Future Conditions ¹		296		
TOTAL	293,397	173,324	111,071	3
Maury River				
Upstream Sources				
Known Contaminated Sites	110		1	99
Streambed Sediment	1		1	0
Atmospheric Deposition	42		42	0
Spills	0		0	100
Combined Sewer Systems (CSO)				
Surface Load, Unspecified ²	439,139		439,139	0
Surface Load, Regulated	0	0		
Permitted	355,762	3,645		99
WLA Future Conditions ¹		467		
TOTAL	795,054	4,112	439,183	44
Upper James River				
Upstream Sources	73,216		65,895 ³	10
Known Contaminated Sites	1,255		13	99
Streambed Sediment	181		181	0
Atmospheric Deposition	832		832	0
Spills	<1		0	100
Combined Sewer Systems (CSO)	3,104		993	68
Surface Load, Unspecified ²	277,574		277,574	0
Surface Load, Regulated	200,306	180,275		10
Permitted	83,452	9,880		88
WLA Future Conditions ¹		564		
TOTAL	639,920	190,719	345,488	16
Lower James River				
Upstream Sources	265,825		244,559 ⁴	8
Contaminated Sites	720		7	99
Streambed Sediment	1,367		1,367	0
Atmospheric Deposition	1,562		1,562	0
Spills	<1		0	100
Combined Sewer Systems (CSO)	<1		<1	92
Surface Load, Unspecified ²	18,293		18,293	0
Surface Load, Regulated	169,327	152,394		10
Permitted	272,789	8,995		97
WLA Future Conditions ¹		448		
TOTAL	729,883	161,837	265,788	42

¹ WLA Future Conditions account for permitted facilities that were omitted or may come on-line in the future and are equal to 0, 10% of the TMDL.

² Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not explicitly specified in the model, stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

³ The LA accounts for upstream TMDLs (i.e., Jackson River, Maury River).

⁴ The LA accounts for upstream TMDLs (i.e., Jackson River, Maury River, and Upper James River).

6.7.2 Daily Loads

A court ruling by the U.S. Court of Appeals for the District of Columbia Circuit in the case *Friends of the Earth, Inc. v. EPA, et al.*, resulted in requirements for daily maximum load calculations, in addition to the average annual load tabulated in the previous section (Friends of

the Earth, Inc. v Environmental Protection Agency, et al., 2006). Setting a *maximum daily* load will help ensure that the annual loads given in Tables 6-13 to 6-16 are appropriately distributed such that on any given day the PCB water quality standard will be met. The loadings in the annual load tables, being of a longer-term, will more directly assure compliance with the TMDL endpoint.

Daily loads are expressed as Maximum Daily Limit (MDL) and were derived using the approach found in the USEPA Technical Support Document for Water Quality-based Toxics Control (USEPA, 1991b). The following equation was used:

$$MDL = LTA \times e^{[z\sigma - 0.5\sigma^2]}$$

Eq. 6-3

Where:

MDL = maximum daily limit (mg/day);

LTA = long-term average (mg/day);

z = 97th percentile of standard normal probability distribution (z-score);

$\sigma^2 = \ln(CV^2 + 1)$; and

CV = Coefficient of variation of daily instream concentration.

The LTA is the annual WLA divided by the number of days in the year (365). The CV is a measure of the instream variability of the initial condition for PCBs and is calculated by dividing the standard deviation by the mean of the distribution of daily PCB concentrations. The 97th percentile was selected as the probability of occurrence, for consistency with limits set in VPDES permits. By using the 97th percentile, the MDL can be expected to be exceeded no more than 3% of the time.

CVs were calculated specifically for each impaired watershed segment to account for the variability in PCB concentrations that are affected by the direct impacts of stormwater on the stream hydrology. Table 6-12 includes the CV, the z score, and the calculated multiplier used to convert the LTA to an MDL.

The LTA-to-MDL multipliers calculated for the impaired segments in the James River PCB TMDL study area presented in Table 6-12. , were used to convert the annual WLA to a daily load for stormwater-based permits. The permit types for this approach included MS4s. To simplify the conversion, the average annual WLA for MS4s in the Lower James River, as an example, was multiplied by 0.0063 (i.e., 2.3/365) to yield a daily load expressed as mg/d.

The multipliers included in Table 6-12. were also used to convert the LA and MOS elements of the TMDL equations for each impaired segment in the James River PCB TMDL study area. The resulting daily maximum loadings for each impaired segment are shown in Table 6-13.

Table 6-12. Components of Maximum Daily Load Calculations for MS4s and LAs.

Impaired Segment	CV	z-score (97th percentile)	LTA-to-MDL multiplier
Jackson River	220	1.88	2.20
Maury River	310	1.88	1.90
Upper James River	260	1.88	2.02
Lower James River	190	1.88	2.31

Table 6-13. Maximum daily PCB loadings (mg/day) at the impaired segment outlets in the James River study area.

Impaired Segment	WLA_{Total} (mg/day)¹	LA² (mg/day)	MOS³ (mg/day)	TMDL (mg/day)⁴
Jackson River	1,200	650	89	1,900
Maury River	24	2,300	120	2,400
Upper James River	1,000	1,900	160	3,100
Lower James River	1,000	1,700	140	2,800

¹ WLA_{Total} includes future conditions.

² The LA is the remaining loading allowed after the MOS and WLA were subtracted from the TMDL as determined for the downstream end/outlet of the impaired segment.

³ Explicit MOS (5%).

⁴ Expressed as two significant figures

Chapter 7: TMDL Implementation and Reasonable Assurance

The PCB TMDL developed for the James River TMDL study area is designed to achieve the selected water quality endpoints. Once this TMDL has been approved by EPA, measures must be taken to reduce pollution levels from both point and nonpoint sources, with an emphasis on those sources with the greatest relative impact on use impairments. The following sections outline the framework used in Virginia to provide reasonable assurance that the required pollutant reductions can be achieved.

7.1 Water Quality Management Planning

As part of the Continuing Planning Process, DEQ staff will present the TMDL WLAs to the State Water Control Board (SWCB) for inclusion in the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e) and Virginia's Public Participation Guidelines for Water Quality Management Planning.

7.2 Staged/Adaptive Implementation

In general, Virginia intends for the required control actions, including appropriate best management practices (BMPs), to be implemented in a staged or iterative process that places emphasis on those known sources with the largest impact on water quality. The iterative implementation of pollution control actions in the watershed has several benefits:

1. Enables tracking of water quality improvements following implementation through follow-up stream monitoring.
2. Provides a measure of quality control, given the uncertainties inherent in computer simulation modeling.
3. Provides a mechanism for developing public support through periodic updates on BMP implementation and water quality improvements.
4. Helps ensure that the most cost-effective practices are implemented first.
5. Allows for the evaluation of the adequacy of the TMDL in achieving WQSSs.

7.3 Implementation of Waste Load Allocations

Federal regulations require that all new, revised, and reissued 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)). Permits should be submitted to EPA for review, as applicable.

To implement the WLA component of the TMDL, DEQ utilizes the VPDES Program under the authority delegated by EPA. Requirements of the permit process should not be duplicated in the TMDL process as, depending on the type and nature of a point source discharge, the WLA component is to be addressed solely through the discharge permit. Federal regulations allow permits to use best management practices (BMPs) in lieu of numeric effluent limitations under certain conditions (40 CFR 122.44(k)). The regulation, in subsections 3 and 4, states that BMP-supported water quality based effluent limits (WQBELs) can be used where “Numeric effluent limitations are infeasible; or [t]he practices are reasonably necessary to achieve effluent limitations and standards or to carry out the purposes and intent of the CWA.” Because BMPs are appropriate and reasonably necessary to achieve water quality standards and to carry out the goals of the Clean Water Act for the James River watershed, DEQ will use “non-numeric” WQBELs to comply with the WLA provisions of the TMDL. BMPs will be implemented through Pollutant Minimization Plans (PMPs) as the primary PCB reduction strategy.

There may be circumstances where a VPDES facility with the potential for discharging PCBs may have been excluded from the development of this TMDL. A small percentage (0.10%) of the PCB TMDL has been set aside as “Future Conditions” to account for these situations. For these occurrences, Permit Special conditions may be incorporated into relevant VPDES facilities that were excluded during TMDL development.

7.3.1 Wastewater Treatment Plants

Effluent from municipal Wastewater Treatment Plants (WWTP) are asked to meet the BMP-based WQBELs for total PCB concentrations at the point of discharge as stipulated in the VPDES permit. The discharge concentration BMP-based WQBELs serve as an effective surrogate to demonstrate that permittees are meeting established PCB waste load allocations. Direct measurement of PCB effluent concentrations compared against TMDL endpoints, or when appropriate Virginia’s WQC, is the expected method for demonstrating that permitted discharges are consistent with the assumptions and requirements of this TMDL.

7.3.2 Stormwater

DEQ regulates stormwater discharges associated with industrial activities through its VPDES program and regulates stormwater discharges from municipal separate storm sewer systems (MS4s) through the Virginia Stormwater Management Program (VSMP). While covered by different regulations, permits allowing the discharge of industrial stormwater and stormwater

from MS4s are administered through VPDES permits. All new or revised stormwater permits must be consistent with the assumptions and requirements of any applicable TMDL WLA.

Industrial Stormwater. Discharges from industrial stormwater are derived from precipitation, as opposed to process wastewaters. In the James River study area industrial stormwater discharges are regulated under VPDES general permits. Discharge concentration BMP-based WQBELs serve as an effective surrogate to demonstrate that permittees are meeting established PCB waste load allocations. Direct measurement of PCB effluent concentrations and evaluation against TMDL endpoints, including Virginia's WQC where applicable, is the expected method for demonstrating permitted discharges are consistent with the assumptions and requirements of this TMDL.

Municipal Separate Storm Sewer Systems – MS4s. For MS4 individual and general permits, DEQ expects the permittee to address the stormwater based TMDL wasteload allocations through their local TMDL Action Plan with the identification and iterative implementation of BMPs in a manner that is consistent with the maximum extent practicable (MEP) standard (CWA § 402(p)(3)(B)(iii)). These expectations have been discussed with MS4 permittees in the James River study area (e.g., City of Lynchburg, City of Richmond, VDOT, etc.) throughout the TMDL development process. Permittee implementation of an individual control strategy includes determining BMP effectiveness. If BMPs are showing to not be effective, then the permit must require the MS4 to expand or better tailor its stormwater management program to ensure consistency with the assumptions and requirements of this TMDL and the permittee's WLA. DEQ will continue to work during permit renewal cycles to ensure reasonable progress is made that will extend into the next permit term as necessary.

MS4s have the flexibility to optimize reductions in stormwater pollutants by implementing BMPs and other requirements of the MS4 permit in an iterative process. Successive permits continually adapt to current conditions, BMP effectiveness and technology, on a location-by-location basis, taking into consideration such factors as condition of receiving waters, specific local concerns, a comprehensive watershed plan, MS4 size, current ability to finance the program, beneficial uses of receiving water, hydrology, geology, and capacity to perform operation and maintenance. Permittees will be strongly encouraged to participate in the development of PCB TMDL Implementation Plans, which are mechanisms used to address non-

point sources, as recommendations from stakeholder input may provide a basis for modifications to their stormwater management plan.

7.3.3 Insignificant Dischargers

Waste load allocations are assigned to permittees considered to be significant dischargers of PCBs. Significant discharges of the PCBs have reasonable potential to cause or contribute to the instream impairment. Conversely, incidental or insignificant discharges of the PCBs may occur but not at levels considered to cause or contribute to the impairment, therefore not necessitating the establishment of waste load allocations for these dischargers. For example, there may be residual PCB loads coming from a small, permitted wastewater treatment sewage discharge or from industrial sites where PCBs have not been used and reflect background conditions. Discharges of PCBs from residential WWTP packages with a design flow of less than 0.2 million gallons per day are considered to be negligible and are therefore not included in the TMDL and are not assigned a WLA. The exception being if the WWTP is treating an area that may have historic industrial input.

Building Demolition and Associated Construction Stormwater. With the uncertainty of PCB loading from this source, and in considering the transient nature both spatially and temporally of demolition projects for buildings that are at least 10,000 square feet of floor space and built or renovated before January 1, 1980, WLAs have not been developed and assigned under this TMDL. However, to mitigate the possible stormwater conveyance of PCBs from demolition debris, the Construction General Permit No. VAR10 requires the operator to develop, implement, and maintain a Stormwater Pollution Prevention Plan (SWPPP) for demolition activities of old buildings that contribute stormwater discharges to PCB impaired waters such as those described in this TMDL. Moreover, a SWPPP would be applicable where these demolition activities may occur within MS4 areas assigned a WLA.

7.3.4 TMDL Modifications for New (Previously Unknown Sources) or Expanding Dischargers

Permits issued for facilities with WLAs developed as part of a TMDL must be consistent with the assumptions and requirements of these WLAs, per EPA regulations. In cases where a new permit from a previously unknown source of PCBs or proposed permit modification occurs in a TMDL watershed and is therefore affected by a TMDL WLA, permit and TMDL staff will calculate loads for the new or expanding permit based on facility monitoring data or default

PCB concentrations from a statewide dataset based on the appropriate Standard Industrial Classification (DEQ, 2016). DEQ is developing internal procedures to assist staff in these cases. Additional load will be taken from Future Conditions.

7.4 Implementation of Load Allocations

The TMDL program does not impart new implementation authorities. Therefore, DEQ intends to use existing programs to the fullest extent in order to attain its water quality goals. The measures for unspecified nonpoint source reductions are implemented in an iterative process using a wide array of BMPs.

7.4.1 Implementation Plan Development

A TMDL implementation plan must address, at a minimum, the requirements specified in the Code of Virginia, Section 62.1-44.19.7. State law directs the State Water Control Board to “develop and implement a plan to achieve fully supporting status for impaired waters. 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.” EPA outlines the minimum elements of an approvable implementation plan in its 1999 “Guidance for Water Quality-Based Decisions: The TMDL Process.” The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain WQSs, monitoring plans, and milestones for attaining WQSs.

In order to qualify for other funding sources, such as EPA’s Section 319 grants, additional plan requirements may need to be met. The detailed process for developing an implementation plan has been described in the “TMDL Implementation Plan Guidance Manual,” available at:

<https://www.deq.virginia.gov/home/showpublisheddocument/6849/637511609521170000>.

Watershed stakeholders will have opportunities to provide input and to participate in the development of a TMDL implementation plan. Regional and local offices of DEQ, DCR, and other cooperating agencies are technical resources that can assist in this endeavor.

With successful completion of implementation plans, local stakeholders will have a blueprint to restore impaired waters and enhance the value of their land and water resources. Additionally, development of an approved implementation plan may enhance opportunities for obtaining financial and technical assistance during implementation.

7.4.2 Staged Implementation Scenarios

The purpose of the staged implementation scenarios is to identify one or more combinations of implementation actions that will result in the reduction of controllable sources to the maximum extent practicable using cost-effective, reasonable BMPs for nonpoint source control.

DEQ expects that implementation of this PCB TMDL to occur in stages, and that full implementation of the TMDL is a long-term goal with the overall timeline to be defined by key stakeholders including property owners of contaminated sites. An example of an initial implementation step may include further evaluation of PCB data results as each analytical sample result is comprised of 209 PCB congeners which can be used to provide insight on prospective sources. Depending on the source of the PCBs to the instream contamination, each PCB result can have a unique “fingerprint”. Follow-up use of available statistical tools may identify possible source areas that match these “fingerprints”. Watershed areas that contain railyards, for instance, can be further evaluated to determine if they contribute greater PCB loads than indicated by this study. Specific goals for subsequent phases of implementation will be determined based on the results of the source identification process. If previously unknown PCB sources are discovered, subsequent implementation phases can include the installation of BMPs used to control sediment (i.e., contaminated) from entering the waterbody. Methods to reduce PCBs can be part of the implementation plan development.

7.4.3 Link to Ongoing Restoration Efforts

Nonpoint source reductions are assigned to sources including known contaminated sites, railyards, historic spills or nonregulated surface sources (the sum of net atmospheric deposition to land surfaces, loads from small tributaries that are not explicitly specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and unspecified point source discharges). Contaminated streambed sediments can also be considered within this category but are not expressed within this TMDL as controllable sources.

Implementation of this TMDL will contribute to on-going water quality improvement efforts in the James River watershed and efforts aimed at restoring water quality. Under the adaptive implementation approach, the Commonwealth intends to use existing programs in order to attain water quality goals. Available programmatic options include a combination of regulatory authorities, such as the Toxics Substances Control Act (TSCA), as well as state programs including the Voluntary Remediation Program (VRP), Toxics Contamination Source Assessment Policy, and the Virginia Environmental Emergency Response Fund (VEERF). The

PCB Strategy for the Commonwealth of Virginia, published in October 2004, establishes the general strategy and outlines the regulatory framework and state initiatives that Virginia could use to address PCB impaired waterbodies (DEQ, 2005b).

Atmospheric deposition sources of PCBs can be numerous and difficult to quantify. PCBs enter the air through a variety of pathways, and the deposition of PCBs from the atmosphere to the land surface and the volatilization of PCBs from the land to the atmosphere are not well understood. Atmospheric deposition studies may help identify these pathways, and efforts to remediate contaminated sites can help reduce possible atmospheric contributions.

PCBs in streambed sediments are contributing to the system through the dynamic relationship between the sediment and water processes. This occurs through sediment resuspension and/or partitioning from sediment through desorption. To address contaminated bed sediments where localized hot spots exist (e.g., depositional area behind a dam), mechanical or vacuum dredging could be explored as an option to permanently remove PCBs from the system.

7.4.4 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders must identify potential funding sources available for implementation during the development of the implementation plan in accordance with the “Virginia Guidance Manual for Total Maximum Daily Load Implementation Plans”. Potential sources for implementation may include Virginia Environmental Emergency Response Fund (VEERF), EPA Section 319 funds (applicable to BMPs used to reduce upland soil erosion), the Virginia State Revolving Loan Program, the Virginia Water Quality Improvement Fund, and landowner contributions. The TMDL Implementation Plan Guidance Manual contains additional information on funding sources, as well as government agencies that might support implementation efforts and suggestions for integrating TMDL implementation with other watershed planning efforts.

7.4.5 Follow-up Monitoring

Following the development of the TMDL, DEQ will continue to monitor the PCB impaired waterbodies for 1) the possible detection of uncharacterized sources within the unspecified surface load, and 2) to measure progress in reducing PCBs to the impaired waters as established by fish tissue meeting the restoration goal. As funding is available, and as identified by the “fingerprinting” source identification approach, it is recommended that monitoring of streambed sediments, soil, and water column be continued by DEQ through special studies. A follow-up study to determine progress made to restore the fish consumption use will also be

performed in accordance with the Statewide Fish Tissue and Sediment Monitoring Program. The purpose, location, parameters, frequency, and duration of the special studies monitoring will be determined by the DEQ staff, in cooperation with stakeholders. The follow-up fish tissue monitoring station(s) will be in similar locations as the listing stations and should be representative of the original impaired segments. The details of the follow-up monitoring will be outlined in the annual Fish Tissue and Sediment Monitoring Plan prepared by DEQ's Water Monitoring and Assessment Program.

7.5 Attainability of Designated Use

The goal of a TMDL is to restore impaired waters so that numeric and narrative 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. In the case of this PCB TMDL, pollutant load reductions were developed to lower the instream concentrations in order to protect the fish tissue levels for safe consumption by humans. Implementing cost-effective and reasonable best management practices to reduce PCB loads to the maximum extent practicable will ultimately result in attaining the TMDL. 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. 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 Clean Water Act and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10 paragraph I).

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

1. Naturally occurring pollutant concentration prevents the attainment of the use.
2. Natural, ephemeral, intermittent, or low flow conditions prevent the attainment of the use unless these conditions are compensated by the discharge of sufficient volume of pollutant discharges without violating state water conservation.
3. 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.

4. Dams, diversions, 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.
5. 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.
6. 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 EPA, 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 river segments during and subsequent to the implementation of these measures to determine if WQSSs 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 river's uses fully restored using pollution controls and BMPs. If, however, WQSSs 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 waterways 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 State Water Control Board 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 use attainability analysis 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.

Chapter 8: Public Participation

Public participation was elicited at every stage of the TMDL development in order to receive inputs from stakeholders and to apprise the stakeholders of the progress made. A series of three Technical Advisory Committee meetings and two public meetings during development of the TMDL. TAC participants included representatives from the City of Lynchburg, Albemarle County, Environmental Standards Inc., Dutoy Creek WWTP, Virginia Department of Transportation, Henrico County MS4, Dominion Energy, Chesterfield County, Falls of the James Scenic Advisory Committee, Virginia Association of Municipal Wastewater Agencies, Roanoke Valley-Alleghany Regional Commission, WestRock, City of Richmond, Bontex, Inc., Virginia Manufacturers Association, One Environmental Group, Ivy Materials Utilization Center, Sonoco Recycling, Inc., Griffin Pipe Products Co LLC, James River Association, Modine Manufacturing, AquaLaw, BWXT Nuclear Operations, Rockbridge Area Conservation Council, University of Virginia, Jackson River Preservation Association, Chesapeake Bay Foundation, Waste Management, CHA Companies, Hampton Roads Sanitation District, New River Geographics, Vaught Landscaping, Appalachian Bronzeback Adventures, Riverside Outfitters, Central Virginia Planning District Commission, Natural Bridge Soil and Water Conservation District, M&M Service and Salvage Yard, Van der Linde Recycling, Blueridge Resource Authority, Roanoke Cement Company, Rutledge Creek WWTP, Amherst County Service Authority, Hanwha Azdel, Greif Packaging-Riverville Mill, Lexington-Rockbridge Regional Water Quality Control Facility.

The first Public Meeting was held on Tuesday, January 12, 2021, and held virtually through a webinar platform (76 attendees). The meeting, hosted by DEQ staff, included background information on PCBs and related human health concerns, long term PCB monitoring data from the study area, and an overview of the TMDL process was used in this project. Representatives from Virginia Tech's Biological Systems Engineering Department discussed the modeling process and tools that were used to predict PCB fate and transport. The comment period for the first public meeting ended February 11, 2021. Five public comments were received. The comments received and DEQ's response to those comments are documented in Appendix G:

The first Technical Advisory Committee (TAC) meeting was held on February 24, 2021, and was conducted virtually through an online webinar platform due to the Covid-19 State of Emergency. Presentations included an overview of the James River (Upper and Lower), Maury

River, and Jackson River PCB TMDL project including problem identification, PCB monitoring results and prospective sources. The meeting was attended by 54 people.

The second and third TAC meetings were held on August 2nd, 2022 (14 people attending) and November 2nd, 2022 (11 people attending), respectively. The primary focus of these meetings was to discuss changes in the WQC and to review draft PCB source allocation scenarios.

The second and final Public Meeting to present the draft PCB TMDL report for the James River study area was held on February 15, 2024, and more than 30 people attended the meeting. The public comment period for the second public meeting ended March 18, 2024. Seven public comments were received. The comments received and DEQ's response to those comments are documented in Appendix G:.

DEQ revised the draft PCB TMDL report for the James River study area in response to public comments after the final public meeting. Another 30-day public comment was offered from December 2, 2024 – January 6, 2025, to invite feedback on the changes made to the PCB baseline loads and Waste Load Allocations. No comments were received during the public comment period.

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Glossary of Terms

Atmospheric Deposition

In which a constituent currently suspended in the atmosphere deposits onto the land and water surface either via precipitation (wet deposition) or a gradual settling process not driven by precipitation (dry deposition).

Allocation

That portion of a receiving water's loading capacity that is attributed to one of its existing or future pollution sources (nonpoint or point) or to natural background sources.

Allocation Scenario

A proposed series of point and nonpoint source allocations (loadings from different sources), which are being considered to meet a water quality planning goal.

Background levels

Levels representing the chemical, physical, and biological conditions that would result from natural geomorphological processes such as weathering and dissolution.

Baseline PCB load

The initial or reference PCB load analytically measured from effluent that is discharged through permitted outfalls. Typically this tPCB effluent screening measurement occurs during TMDL development, or shortly after. Over time, dischargers take new measurements to establish *existing* PCB loads, which they then compare to the baseline PCB load. A PMP is required when the baseline load exceeds the assigned WLA.

BASINS (Better Assessment Science Integrating Point and Nonpoint Sources)

A computer-run tool that contains an assessment and planning component that allows users to organize and display geographic information for selected watersheds. It also contains a modeling component to examine impacts of pollutant loadings from point and nonpoint sources and to characterize the overall condition of specific watersheds.

Best Management Practices (BMP)

Methods, measures, or practices that are determined to be reasonable and cost-effective means for a land owner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.

Bioaccumulation

The accumulation of a chemical in an organism through all source pathways including water, diet, and contaminated sediment.

Calibration

The process of adjusting model parameters within physically defensible ranges until the resulting predictions give a best possible good fit to observed data.

Calibration Segment

A defined subdivision of the James River study area. Calibration segments were used to allow for easier modeling and to isolate sources and hydrologic features. Fifty-six calibration segments were used for calibration. The calibration segments are interconnected meaning the model outputs from some segments were inputs for other segments.

Direct nonpoint sources

Sources of pollution that are defined statutorily (by law) as nonpoint sources that are represented in the model as point source loadings due to limitations of the model. Examples include: PCB oil spills and atmospheric deposition.

Endpoint

The final goal of the TMDL. Calculated from bioaccumulation factors and VDH and DEQ fish tissue screening thresholds, this value establishes the water column PCB concentration that has to be attained in order to restore the fish consumption use. Endpoints are specific to each calibration segment.

HSPF (Hydrological Simulation Program-Fortran)

A computer-based model that calculates runoff, sediment yield, and fate and transport of various pollutants to the stream. The model was developed under the direction of the U.S. Environmental Protection Agency (EPA).

Hydrology

The study of the distribution, properties, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere.

Load allocation (LA)

The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background.

Margin of Safety (MOS)

A required component of the TMDL that accounts for the uncertainty about the relationship between the pollutant loads and the quality of the receiving waterbody. The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models).

Maximum Extent Practicable (MEP)

MEP is an iterative standard, which evolves over time as urban runoff management knowledge increases. As such, the operator's MS4 program must continually be assessed and modified to incorporate improved programs, control measures, BMPs, etc., to attain compliance with water quality standards (From 9 VAC 25-870-10).

Model

Mathematical representation of hydrologic and water quality processes. Effects of land use, slope, soil characteristics, and management practices are included.

Nonpoint source

Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources include contaminated sites, PCB fluid spills, and railyards and railway spurs. Another nonpoint source includes non-regulated surface loads, i.e. atmospheric deposition to land surface in the watershed and potential contaminated areas located throughout the watershed that have not yet been identified.

Outfall

The discharge point of a point source into a stream, river, or lake.

Polychlorinated Biphenyls (PCB)

An organic compound chemically defined as two bonded benzene rings with 1 to 10 chlorine atoms substituted around the perimeter of the rings. PCBs are man-made chemicals and were manufactured during the early 20th century for use in heavy machinery. The chemical structure of PCBs allows them to be very stable. As a result, they persist in the environment and are found in soils, streams, and the atmosphere. PCBs also bioaccumulate in fatty tissue. PCBs are an endocrine disruptor which mean they interfere the hormonal system in mammals. They are also a probable carcinogen. Although, PCB production in the United States was banned by Congress in 1979, their toxicity and longevity mean they continue to be a concern for public health.

Point source

Pollutant loads discharged at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. Point sources can also include pollutant loads contributed by tributaries to the main receiving water stream or river.

Pollution

Generally, the presence of matter or energy whose nature, location, or quantity produces undesired environmental effects. Under the Clean Water Act for example, the term is defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Reach

Segment of a stream or river.

Runoff

That part of rainfall or snowmelt that runs off the land into streams or other surface water. It can carry pollutants from the air and land into receiving waters.

Sediment-Associated Pollutant

A pollutant with a high affinity for attaching to soil or sediment. If a pollutant is sediment-associated, modeling the fate and transport of sediment through the watershed is a key component of the model development process and provides a more accurate representation of pollutant contamination pathways.

Simulation

The use of mathematical models to approximate the observed behavior of a natural water system in response to a specific known set of input and forcing conditions. Models that have been validated, or verified, are then used to predict the response of a natural water system to changes in the input or forcing conditions.

Subwatershed

A subdivision of the calibration segments. Subwatersheds were delineated based on a number of factors: continuity of the stream network, similarity of land use distribution, and monitoring station locations.

Total Maximum Daily Load (TMDL)

The sum of the individual wasteload allocations (WLA's) for point sources, load allocations (LA's) for nonpoint sources and natural background, plus a margin of safety (MOS). TMDLs can

be expressed in terms of mass per time, toxicity, or other appropriate measures that relate to a state's water quality standard.

Total Organic Carbon (TOC)

A water quality measurement of the total amount of organic carbon in a sample. Carbon in water may be in the form of decaying natural organic matter such as plant fibers.

Urban Runoff

Surface runoff originating from an urban drainage area including streets, parking lots, and rooftops.

Validation (of a model)

Process of determining how well the mathematical model's computer representation describes the actual behavior of the physical process under investigation. This follows the calibration of the model and ensures that the calibrated values adequately represent the watershed.

Wasteload allocation (WLA)

The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation.

Water quality standard

Law or regulation that consists of the beneficial designated use or uses of a water body, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular water body, and an anti-degradation statement.

Watershed

A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Appendix A: Setting TMDL Endpoints – Derivation of Water Column PCB Targets for TMDL Development

A.1 Introduction

This Appendix details the procedures and equations used to calculate the TMDL endpoints for the James River impaired segments. The endpoints were calculated using bioaccumulation factors (BAF) which relate the concentration of a pollutant in a stream to the concentration of pollutant found within each fish species. Fish tissue samples were used to calculate the total PCB (tPCB) TMDL endpoint since ingestion of PCB-contaminated foods is a common exposure pathway for PCB related illness. Figure 2-10 in the main document shows the extent of the impaired stream segments in the James River study area and the water quality stations where fish tissue samples were collected. Using the procedure explained here, consideration was given to: 1) fish tissue data set robustness, and 2) the importance of the fish species from a recreational or consumption value. DEQ's fish species selection rationale included:

1. When possible, a mean PCB concentration was calculated using fish sample size ≥ 8 and water concentration (WQ) target ≤ 580 pg/L¹; if these criteria were not met, then the WQ target was not considered for that species as an individual TMDL endpoint.
2. A WQ target >580 pg/L was not used to avoid skewing results to a level greater than the criterion.

In the absence of a site-specific endpoint that is more protective of water quality, the DEQ WQC (580 pg/L or ppq) is considered the default PCB TMDL endpoint and is equivalent to DEQ's 18 ppb fish tissue value (TV) included in the Water Quality Assessment Guidance (DEQ, 2021a). Eqn. A-1 and Eqn. A-2 describe the calculations of Virginia's PCB WQC and PCB fish TV, respectively.

¹ The development of these TMDLs coincided with the revision to 9 VAC-25-260-140. Consequently, the numeric WQC (640 pg/L) was revised to 580 pg/L relatively late in the TMDL development process. For the James and Maury Rivers, the site-specific TMDL endpoints selected for the allocations are more sensitive than the revised WQC. For the Jackson River, the site-specific TMDL endpoint was greater than the revised WQC (580 pg/L), therefore, the revised WQC is the TMDL endpoint for Jackson River.

$$\text{Water Quality Criterion} = \frac{RL \times BW}{CSF \times CR \times BCF}$$

Eqn. A-1

$$\text{Fish Tissue Value (TV)} = \frac{RL \times BW}{CSF \times CR}$$

Eqn. A-2

Where:

RL = human health criteria at risk level 0.00001 (1 in 100,000 population)

BW = average adult body weight of 80 kg (176.4 lbs.)

CSF = cancer potency factor of 2 (USEPA-IRIS, 1997)

CR = fish consumption rate of 0.022 kg/day

BCF = USEPA recommended bioconcentration factor of 31,200 (USEPA, 1980)

The equation used to derive the Virginia PCB WQC differs from that used to calculate the fish tissue threshold value by using a Bioconcentration Factor (BCF), which was empirically derived in the 1980's using experimental data that compared the chemical concentrations in the water to fish tissue. When calculating the WQC, the mathematical derivation using the BCF value only considers a single fish exposure pathway to PCBs (i.e., water passing over the gills). The newer BAF approach, recommended by the U.S. Environmental Protection Agency (USEPA) for persistent pollutants like PCBs, considers food and sediment (ingestion/contact) as fish exposure pathways (USEPA 2000; 2003). The James River site-specific PCB TMDL endpoints were calculated using site-specific BAFs and the fish tissue threshold. Calculated endpoints that are more protective than the WQC (i.e., less than 580 pg/l or ppq) are preferred as long as the data set meets the basic requirements for sample size and the species is of recreational interest (or it serves as a surrogate for recreationally important species). When the calculated BAF endpoint is greater than (i.e., less protective) than the WQC, the WQC becomes the default endpoint.

A.2 BAF Calculation Approach

The BAF calculation approach described here includes the consideration of multiple fish tissue samples collected from 1995 through 2019 and the use of available Total Organic Carbon (TOC) and Particulate Organic Carbon (POC) data to estimate Dissolved Organic Carbon (DOC). The entire computational approach is included within this Appendix to provide context.

The Virginia Department of Health (VDH) used an allowable fish tissue total PCB (tPCB) concentration screening threshold of 54 ng/g (ppb) until 2012, when the VDH fish tissue screening value was revised to 100 ppb. Until recently, DEQ used a fish TV of 20 ppb but as

described in the 2022 Water Quality Guidance Manual (DEQ, 2021a) lowered it to 18 ppb. The 100 ppb fish tissue screening value from VDH and 18 ppb fish TV from DEQ were considered when calculating site-specific James River PCB TMDL endpoints.

The site-specific allowable tPCB instream concentration, expressed in pg/L (or parts-per-quadrillion, ppq) for a given fish species may be calculated by dividing the allowable screening threshold concentration considered by a species-specific adjusted total BAF, which has units of liters per kg (L/kg). The instream PCB concentration TMDL endpoint for a given river segment is often based on the PCB concentration associated with the fish species that poses the greatest risk to humans when the fish is consumed.

Total BAF (TBAF) values represent the ratio of the tPCB concentration in a fish's wet tissue to the tPCB concentration in water. Baseline BAF (BLBAF) values are TBAF values normalized by the fraction of freely dissolved tPCBs in the water column and fish tissue lipid content. BLBAF values are used to identify those species that are most susceptible to accumulating and storing PCBs. BLBAF values are used to calculate adjusted total BAF values which are normalized for comparison among the species within a river segment. The adjusted total BAF value in a given river segment ($ATBAF_{RS}$) is the ratio of tPCB concentration in fish tissue to the tPCB concentration in water normalized across the fish samples within a river segment. The $ATBAF_{RS}$ is calculated using a series of equations, as described in this appendix.

USEPA provides four methods for developing BAF values (USEPA, 2003). Method 1, which uses monitoring data to calculate the BAF values, was applied in this analysis. To provide an accurate TMDL endpoint, a temporal window for recent water quality, sediment, and fish tissue data has been established from the available DEQ data. Water quality data are available from 2017-2019. Depending on the impaired area, fish tissue samples were collected beginning in 1995, 2002-2005, 2014, and 2017-2019. Using data from the different time periods is supported by the temporal consistency of observed fish tissue PCB concentrations. Moreover, the perceived impact on the overall BAF result for each impairment by using fish tissue from 1995 is negligible as 1) the samples sizes (n) from 1995 were small (see Appendix B) and 2) the tissue concentrations are in-line with recent fish data, and 3) the endpoints were derived using the arithmetic mean derived from the BAF values of all the recreational species collected over the full sampling period. The flow chart included at the end of this appendix (A.6) provides a visual representation of the process used in the example calculation to reach a potential instream TMDL endpoint.

A.2.1 Total BAF values (TBAF_{HR})

DEQ collects fish tissue samples at specific locations. Fish tissue sample data may be associated with water quality data collected at a given water quality monitoring station that falls within the home range of a given fish species. Home range, defined as the normal distance that a given fish species travels, can range from 1, 2, or 5 miles upstream and downstream of the fish tissue collection site depending on the species. Multiple fish species and multiple fish of the same species may be sampled at a given fish sampling location on a given date. An individual fish tissue sample consists of one to ten fish of the same species. This sample type is known as a composite.

The median tPCB concentration in the water column is calculated for each water quality station using all or some subset of the data collected at that station (note that data from some stations may not be applicable to all species depending on the location of the fish sampling site relative to the water quality monitoring station) (ICPRB, 2007). A species-specific home range total BAF (TBAF_{HR}) is calculated using the results from an individual fish tissue sample (note an individual sample result can contain a composite of up to 10 individual fish, and the average of the median tPCB values of the water column samples that fall within the home range of that species, Eq. A 3 (USEPA 2000; 2003):

$$[\text{TBAF}]_{\text{HR}} = (t [\text{PCB}]_{\text{tissue}}) / [\text{tPCB}]_{\text{water}} \quad \text{Eqn. A 3}$$

Where:

TBAF_{HR} = the tPCB concentration in a given species' fish tissue divided by the average median tPCB concentration in the water column within that species' home range (L/kg)

tPCB_{tissue} = concentration of tPCB in wet fish tissue (ng/g)

tPCB_{water} = average median concentration of tPCB in water (µg/L)

The median TBAF_{HR} values for each species in a river segment was used to determine the median total BAF value for a given river segment (TBAF_{RS}) for each species (ICPRB, 2007). The home range of a given species applied to a specific sample represents the area within a stream reach to which that fish (or multiple fish) is exposed and may accumulate PCBs based on the observed water quality. Median TBAF_{RS} values may be used for comparison purposes; however, TBAF_{HR} values, and not the median TBAF_{RS} values, are used to calculate BLBAF and ATBAF_{RS} values. Trophic-level BAF values are determined by pooling the species samples by trophic level and calculating the geometric means (USEPA, 2003).

A.2.2 Baseline BAF values (BLBAF_{HR})

Baseline BAF_{HR} (BLBAF_{HR}) values are used to normalize the TBAF_{HR} values using the fraction of freely dissolved tPCBs in the water (F_d) and the fish tissue lipid content. For each species, the tPCB concentration in an individual fish tissue sample is normalized by that fish tissue's measured lipid fraction, and then divided by the average fraction of freely-dissolved tPCBs within the species home range (F_{d+HR}), Eq. A 4 (USEPA, 2003):

$$[BLBAF]_{HR} = [TBAF]_{HR} / F_{(d+HR)} - 1 \times 1 / \text{lipid} \quad \text{Eqn. A 4}$$

Where:

BLBAF_{HR} = tPCB concentration in an individual fish tissue sample divided by the average concentration of freely-dissolved tPCB in the species home range, and normalized by that species lipid fraction (L/kg).

F_{d+HR} = fraction of the species' home range tPCB concentration in water that is freely-dissolved (unitless)

Lipid = fraction of tissue that is lipid (unitless)

A.2.3 Fraction of freely-dissolved tPCB (F_d)

The freely-dissolved tPCB fraction in the water column is a function of dissolved and particulate organic carbon concentrations in the water column. The freely-dissolved fraction (F_d) of tPCB in the water column for a single homolog is calculated using Eq. A 5 (USEPA, 2000; 2003),

$$F_{(d+H)} = 1 / (1 + POC \times K_{(ow_H)} + 0.08 \times DOC \times K_{(ow_H)}) \quad \text{Eqn. A 5}$$

Where:

F_{d+H} = dissolved fraction of tPCB in water (unitless) for a single homolog

POC = particulate organic carbon concentration (mg/L)

DOC = dissolved organic carbon concentration (mg/L)

K_{ow_H} = partitioning coefficient for tPCB (L/mg)

There are 209 unique chemical congeners that comprise the tPCB parameter. Octanol-water partitioning coefficients (K_{ow_H}) for specific PCB congeners range over four orders of magnitude. These 209 congeners are uniquely grouped by the total number of chlorine atoms and the position of each chlorine atom on the biphenyl chemical structure into 10 distinct groupings, or homologs. Each homolog has a distinct number of chlorine atoms; however, the

location of the chlorine atoms is not considered when grouping PCBs by homolog. The octanol-water partitioning coefficient (K_{ow_H}) for each homolog is listed in Table A 1 (ICPRB, 2007). The partitioning coefficient is usually expressed as $\log K_{ow}$, the base 10 logarithm of the water partition coefficient. For example, the partitioning coefficient K_{ow_tri} is expressed as $\log K_{ow_H} = 5.425$, or $10^{5.425}$ L/kg, in the last column of Table A 1. Homolog-specific partitioning coefficients. To calculate an F_{d-HR} representative of tPCBs in the home range of a given fish species, F_{d-H} must be calculated for each water column sample PCB homolog using Eq. A 5.

Table A-1. Homolog-specific partitioning coefficients.

Homolog	$\log K_{ow_H}$	K_{ow_H} (L/kg)
$K_{ow_mono+di}$	4.675	47,315
K_{ow_tri}	5.425	266,073
K_{ow_tetra}	6.005	1,011,579
K_{ow_penta}	6.525	3,349,654
K_{ow_hexa}	6.73	5,370,318
K_{ow_hepta}	7.235	17,179,084
K_{ow_octa}	7.6	39,810,717
K_{ow_nona}	7.915	82,224,265
K_{ow_deca}	8.18	151,356,125

Source: ICPRB, 2007

The fraction of freely-dissolved PCBs in the water column (F_{d-WC}) is calculated as the product of individual homolog F_{d-H} values and observed water column tPCB homolog concentrations, summed over all homologs and divided by the water column tPCB concentration (the sum of all PCB homolog concentrations). This homolog-weighted freely dissolved fraction (F_{d-WC}) is calculated for each water column sample within each fish species home range. The homolog-weighted freely dissolved fraction for each water quality station (F_{d-WQ}) is calculated as the median F_{d-WC} . A species-specific $BLBAF_{HR}$ is calculated using the average of the F_{d-WQ} values within a species home range (F_{d-HR}) through Eq. A 4. The species-specific baseline BAF for each river segment ($BLBAF_{RS}$) is the median of the species-specific $BLBAF_{HR}$ values in a given river segment.

A.2.4 River Segment Species-Specific Adjusted Total BAFRS Values (ATBAFRS)

The species-specific $ATBAF_{RS}$ is calculated using Eq. A 6:

$$A \text{ [TBAF]}_{RS} = [(BL \text{ [BAF]}_{RS} * medianlipid) + 1] * F_{(d-RS)} \quad \text{Eqn. A 6}$$

Where:

$$ATBAF_{RS} = BLBAF_{RS} \text{ normalized by median lipid content and the fraction of freely dissolved tPCBs in the river segment (L/kg)}$$

medianlipid = median lipid content of a given species for a given river segment
(unitless)

F_{d-RS} = fraction of freely dissolved tPCBs in water for a given river segment (unitless)

For a given species in a given river segment, the median lipid content and F_{d-RS} are calculated to determine the species-specific ATBAF_{RS}. The median of all species-specific lipid content across fish tissue stations within a river segment is determined and used in Eq. A 6. The fraction of freely dissolved tPCBs in water for a given river segment (F_{d-RS}) is calculated as the median of all F_{d-HR} values within a single river segment for a given species.

To determine the instream tPCB TMDL endpoints considered for each fish species in a stream reach, each of the fish tissue tPCB screening thresholds cited (18 ppb and 100 ppb) were divided by the ATBAF_{RS}.

A.3 Results

Site-specific PCB TMDL endpoints were calculated for each fish species collected from the four impaired segments within the James River TMDL study area. When applying DEQ's 18 ppb TV, a site-specific PCB value was derived for the individual fish species within each impaired area. The BAF results for all fish within each TMDL watershed were then evaluated using the three following scenarios to determine PCB endpoints: 1) scenario one was based on using all species of recreational interest with a sample size ≥ 8 ; 2) the second scenario was based on using the Advisory species regardless of the sample size; and 3) the final scenario was based on Advisory species with a sample size ≥ 8 . Except for the Jackson River, the selected endpoints were based on a central tendency value (i.e., arithmetic mean) of the BAF results from scenario 3. Each endpoint served as a threshold when running model allocation scenarios and was used concurrently with the application a process to account for long-term average exposure. Note that all endpoint values have been set to two significant figures to be consistent with the application of DEQ's WQS.

All site-specific endpoints for the Maury River, Upper James River, and Lower James River are more protective than the state WQC of 580 pg/L, as indicated in Table A 2. The site-specific endpoint for the Jackson River was greater than the WQC, therefore the WQC was selected as the TMDL endpoint for the Jackson River. The resulting TMDL endpoints from all fish species collected in the stream ranged in concentration from 52 pg/L to 580 pg/L.

A.4 Conclusion

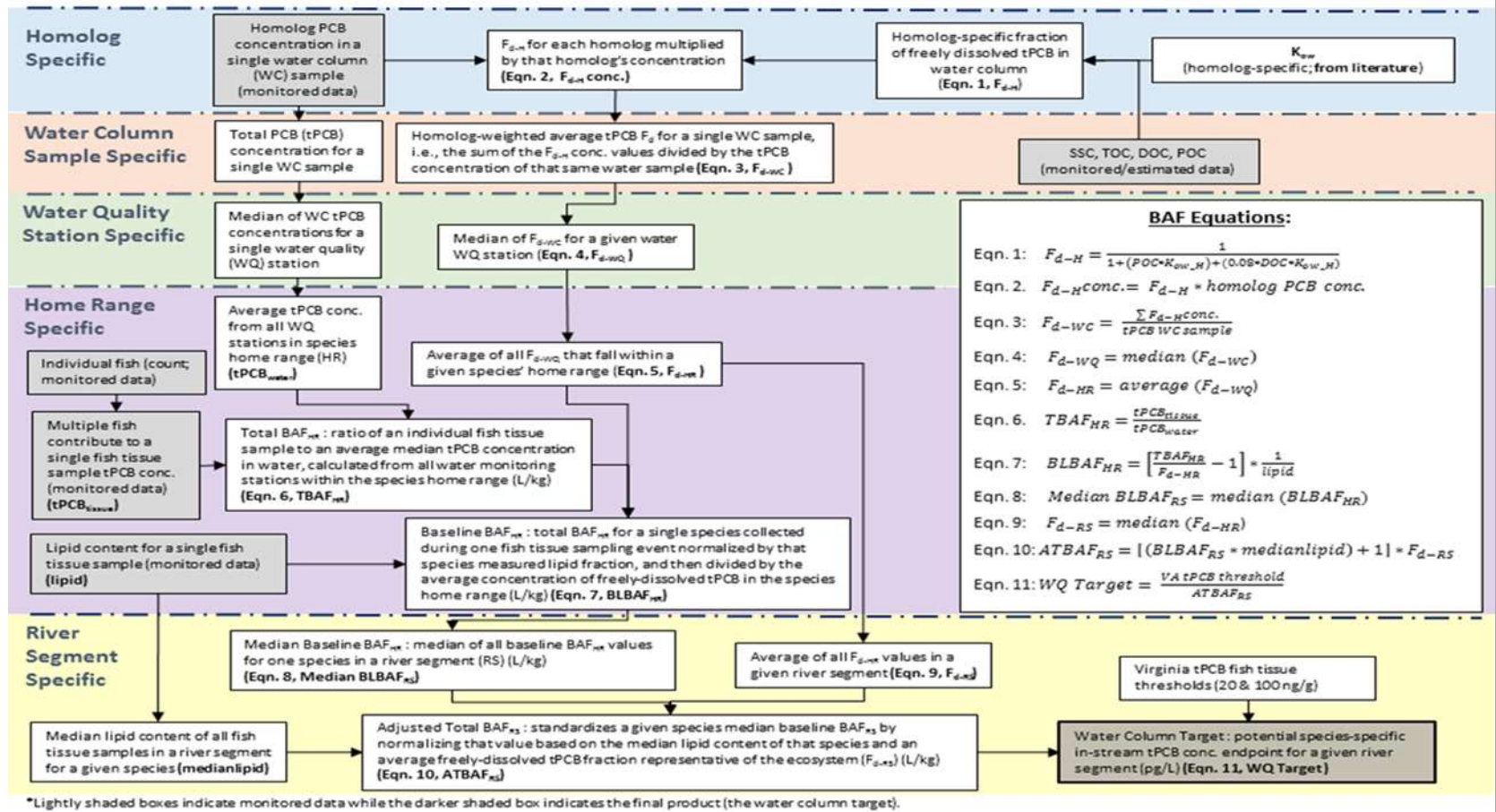
The water column tPCB endpoint for the Jackson River is the PCB WQC of 580 pg/L. Endpoints for the Maury, and Upper and Lower James were calculated using the BAF approach (Error! Reference source not found.).

Table A-2. PCB Endpoints for impaired segments of the James River study area

Impaired Segment	PCB Water Quality TMDL Endpoint (pg/L)
Jackson River	580
Maury River	400
Upper James River	120
Lower James River	52

A.5 BAF Flow Chart

BAF Flow Chart (Revised)



A.6 References

- DEQ. 2021a. Guidance Memo No. GM21-2002. 2022 Water Quality Assessment Guidance Manual. Prepared by Virginia Department of Environmental Quality, Division of Water Planning, April 2021.
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- USEPA (U. S. Environmental Protection Agency). 2003. Methodology for deriving ambient water quality criteria for the protection of human health (2000). EPA-822-R-03-030. Technical support document volume 2: development of national bioaccumulation factors. Office of Water, Washington, DC. December 2003.
- USEPA-IRIS (U.S. Environmental Protection Agency Integrated Risk Information System). 1997. Polychlorinated biphenyls (PCBs). CASRN 1336-36-3. Office of Water, Washington, DC. June 1997.

Appendix B: Observed Water Quality Data Inventory

B.1 United States Geological Survey (USGS) Streamflow Gages

Table B-1. USGS streamflow gages with complete datasets used for the Hydrology Calibration.

TMDL Watershed	USGS Stream Gage Station	
Jackson River	USGS 02011800	USGS 02013100
Upper James River	USGS 02016000	USGS 02024752
	USGS 02016500	USGS 02025500
	USGS 02019500	
Maury River	USGS 02021500	USGS 02024000
Lower James River	USGS 02026000	USGS 02035000
	USGS 02029000	USGS 02037500
	USGS 02034000	

B.2 Suspended Sediment Concentration (SSC) Data

B.2.1 Monitoring Stations

Table B-2. DEQ Suspended Sediment Concentration stations used for the sediment calibration.

TMDL Watershed	DEQ Water Quality SSC Stations			
Jackson River	2-JKS000.38	2-JKS006.67	2-JKS023.61	2-JKS044.14
	2-JMS302.85	2-JMS317.62	2BWL000.34	2-BKW000.40
	2-JMS345.73	2AJMS334.47	2BJMS255.91	2-BKW005.95
	2-JMS309.13	2-JMS229.14	2-FSG000.85	2-IVA000.22
Upper James River	2-CAT000.34	2BJMS248.90	2-FSG003.36	2BJMS263.24
	2-CRG001.20	2-BCR000.20	2-JMS258.54	2-JMS270.84
	2-MRY000.46 2-MRY015.80			
Maury River	2-JMS189.31	2-RVN001.64	2-JMS127.50	2-TKO003.42
	2BJMS214.35	2-RRN002.19	2-JMS111.17	2-JMS140.00
	2-BUF002.10	2-RRS003.12	2-JMS117.35	2-RDD000.19
	2-JMS157.28	2-RVN033.65	2-FIN000.81	2-RDD001.57
	2BSLT000.73	2-RVN039.58	2-JMS123.23	2-PWT000.57
	2-HRD000.36	2BJMS119.35	2-LIY001.73	2-PWT003.98

B.2.2 Jackson River

Table B-3. Observed SSC (mg/L) Data for the Jackson River TMDL Watershed.

Subwatershed*	Date	Station	Observed SSC (mg/L)
JKS-01	7/19/2017	2-JKS000.38	2.54
JKS-01	2/8/2018	2-JKS000.38	58.10
JKS-01	9/17/2018	2-JKS000.38	99.40
JKS-01	12/7/2018	2-JKS000.38	3.21
JKS-03	2/8/2018	2-JKS006.67	62.50
JKS-14	7/19/2017	2-JKS023.61	1.74
JKS-14	2/8/2018	2-JKS023.61	15.50
JKS-14	9/17/2018	2-JKS023.61	15.40
JKS-14	12/7/2018	2-JKS023.61	7.16
JKS-17	7/19/2017	2-JKS044.14	2.14
JKS-17	2/8/2018	2-JKS044.14	1.69
JKS-17	9/17/2018	2-JKS044.14	1.48
JKS-17	12/7/2018	2-JKS044.14	1.64

*Subwatershed designation for the Jackson River (JKS).

B.2.3 Maury River

Table B-4. Observed SSC (mg/L) Data for the Maury River TMDL Watershed.

Subwatershed*	Date	Station	Observed SSC (mg/L)
MRY-01	7/20/2017	2-MRY000.46	2.02
MRY-01	2/8/2018	2-MRY000.46	123.00
MRY-01	6/4/2018	2-MRY000.46	7.51
MRY-01	4/3/2019	2-MRY000.46	1.07
MRY-09	7/20/2017	2-MRY015.80	1.44
MRY-09	2/8/2018	2-MRY015.80	62.10
MRY-09	6/4/2018	2-MRY015.80	6.86
MRY-09	4/3/2019	2-MRY015.80	0.46

*Subwatershed designation for the Maury River (MRY).

B.2.4 Upper James River

Table B-5. Observed SSC (mg/L) Data for the Upper James River TMDL Watershed.

Subwatershed*	Date	Station	Observed SSC (mg/L)
CRG-13	9/17/2018	2AJMS334.47	134.00
MJF-07	9/17/2018	2-BCR000.20	815.00
MJF-06	9/17/2018	2BJMS248.90	144.00
MJF-06	2/7/2019	2BJMS248.90	1.66
MJF-10	9/17/2018	2BJMS255.91	160.00
MJF-10	2/7/2019	2BJMS255.91	1.70
MJF-20	7/19/2017	2BJMS263.24	2.11
MJF-20	2/8/2018	2BJMS263.24	33.30
MJF-20	9/17/2018	2BJMS263.24	172.00
MJF-20	2/7/2019	2BJMS263.24	2.04
MJF-25	2/7/2019	2BJMS273.86	1.46
MJF-14	2/8/2018	2-BKW000.40	27.80
MJF-14	9/17/2018	2-BKW000.40	281.00
MJF-14	2/7/2019	2-BKW000.40	3.37
MJF-16	9/17/2018	2-BKW005.95	340.00
MJF-09	9/17/2018	2BWL000.34	124.00
CAT-10	2/8/2018	2-CAT000.34	122.00
CRG-01	2/8/2018	2-CRG001.20	145.00
CRG-01	9/17/2018	2-CRG001.20	35.50
MJF-11	2/8/2018	2-FSG000.85	8.69
MJF-11	9/17/2018	2-FSG000.85	358.00
MJF-11	2/7/2019	2-FSG000.85	1.63
MJF-12	9/17/2018	2-FSG003.36	266.00
MJF-12	2/7/2019	2-FSG003.36	8.50
MJF-15	9/17/2018	2-IVA000.22	184.00
MJF-01	7/19/2017	2-JMS229.14	2.40
MJF-01	2/8/2018	2-JMS229.14	35.90
MJF-01	9/17/2018	2-JMS229.14	438.00
MJF-01	2/7/2019	2-JMS229.14	7.14
MJF-13	7/19/2017	2-JMS258.54	6.41
MJF-13	2/8/2018	2-JMS258.54	34.30
MJF-13	9/17/2018	2-JMS258.54	206.00
MJF-13	2/7/2019	2-JMS258.54	15.80
MJF-20	7/19/2017	2-JMS270.84	2.16
MJF-20	2/8/2018	2-JMS270.84	88.20
MJF-20	9/17/2018	2-JMS270.84	128.00
MJF-20	2/7/2019	2-JMS270.84	2.92
MJF-27	7/19/2017	2-JMS279.41	1.49
MJF-27	2/8/2018	2-JMS279.41	150.00

Subwatershed*	Date	Station	Observed SSC (mg/L)
MJF-27	9/17/2018	2-JMS279.41	153.00
MJF-27	2/7/2019	2-JMS279.41	2.10
CAT-03	7/19/2017	2-JMS302.85	1.81
CAT-03	2/8/2018	2-JMS302.85	160.00
CAT-03	9/17/2018	2-JMS302.85	106.00
CAT-05	2/8/2018	2-JMS309.13	185.00
CAT-05	9/17/2018	2-JMS309.13	107.00
CAT-05	12/7/2018	2-JMS309.13	0.94
CAT-08	9/17/2018	2-JMS317.62	210.00
CRG-17	7/19/2017	2-JMS345.73	1.03
CRG-17	2/8/2018	2-JMS345.73	77.80
CRG-17	9/17/2018	2-JMS345.73	106.00
CRG-17	12/7/2018	2-JMS345.73	0.83

*Subwatershed designations for major tributaries: Catawba Creek (CAT), Craig Creek (CRG), James River/Fishing Creek junction (MJF).

B.2.5 Lower James River

Table B-6. Observed SSC (mg/L) Data for the Lower James River TMDL Watershed.

Subwatershed*	Date	Station	Observed SSC (mg/L)
MJR-24	11/15/2018	2-BDC000.79	264.00
MJR-08	7/12/2017	2BJMS119.35	3.54
RKF-14	2/8/2018	2BJMS214.35	114.00
RKF-14	8/23/2018	2BJMS214.35	8.05
HSR-02	7/19/2017	2BSLT000.73	1.45
HSR-02	2/8/2018	2BSLT000.73	20.40
TYE-03	9/17/2018	2-BUF002.10	2790.00
MJR-23	10/11/2017	2-FIN000.81	34.60
MJR-21	11/15/2018	2-GEN000.51	212.00
HSR-13	10/30/2017	2-HRD000.36	50.90
MJR-01	7/13/2017	2-JMS111.17	4.35
MJR-01	2/12/2018	2-JMS111.17	683.00
MJR-01	8/29/2018	2-JMS111.17	3.56
MJR-01	11/6/2018	2-JMS111.17	162.00
MJR-04	8/29/2018	2-JMS112.33	4.64
MJR-04	11/6/2018	2-JMS112.33	196.00
MJR-05	8/28/2017	2-JMS117.35	4.26
MJR-05	2/12/2018	2-JMS117.35	393.00
MJR-05	8/30/2018	2-JMS117.35	4.20
MJR-05	11/6/2018	2-JMS117.35	116.00
MJR-09	2/12/2018	2-JMS123.23	88.60

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Observed SSC (mg/L)
MJR-18	7/12/2017	2-JMS127.50	2.78
MJR-18	10/23/2018	2-JMS127.50	5.26
MJR-18	11/6/2018	2-JMS127.50	130.00
MJR-25	2/12/2018	2-JMS140.00	284.00
MJR-25	7/19/2018	2-JMS140.00	1.48
MJR-25	11/6/2018	2-JMS140.00	23.40
MJR-35	8/28/2017	2-JMS157.28	1.28
MJR-35	2/12/2018	2-JMS157.28	161.00
MJR-35	7/19/2018	2-JMS157.28	1.83
MJR-35	11/6/2018	2-JMS157.28	112.00
RKF-02	7/19/2017	2-JMS189.31	2.12
RKF-02	2/8/2018	2-JMS189.31	36.40
RKF-02	8/23/2018	2-JMS189.31	6.16
RKF-02	4/3/2019	2-JMS189.31	1.76
MJR-16	2/12/2018	2-LIY001.73	76.40
MJR-20	6/26/2018	2-NWD002.27	4.36
MJR-20	11/15/2018	2-NWD002.27	174.00
MJR-06	6/26/2018	2-PWT000.57	8.03
MJR-06	11/15/2018	2-PWT000.57	404.00
MJR-07	6/26/2018	2-PWT003.98	2.24
MJR-07	11/15/2018	2-PWT003.98	60.00
MJR-02	6/26/2018	2-RDD000.19	4.47
MJR-02	11/15/2018	2-RDD000.19	39.90
MJR-03	6/26/2018	2-RDD001.57	1.78
MJR-03	11/15/2018	2-RDD001.57	20.30
RVN-13	6/12/2018	2-RRN002.19	86.50
RVN-13	6/27/2019	2-RRN002.19	5.68
RVN-18	6/12/2018	2-RRS003.12	34.60
RVN-18	6/27/2019	2-RRS003.12	4.16
RVN-01	10/30/2017	2-RVN001.64	252.00
RVN-01	6/12/2018	2-RVN001.64	64.45
RVN-01	6/27/2019	2-RVN001.64	6.06
RVN-08	6/12/2018	2-RVN033.65	45.40
RVN-08	6/27/2019	2-RVN033.65	2.84
RVN-11	6/12/2018	2-RVN039.58	32.90
RVN-11	6/27/2019	2-RVN039.58	4.34
MJR-11	2/12/2018	2-TKO003.42	12.50
MJR-11	11/15/2018	2-TKO003.42	7.24

*Subwatershed designations for major tributaries: Hardware and Slate Rivers (HSR), Rockfish River (RKF), Rivanna River (RVN), Tye River (TYE), James River/Reedy Creek junction (MJR).

B.3 Total Organic Carbon (TOC) / Dissolved Organic Carbon (DOC) Data

B.3.1 Monitoring Stations

Table B-7. DEQ Total Organic Carbon and Dissolved Organic Carbon Stations.

TMDL Watershed	DEQ Water Quality TOC and DOC Stations			
Jackson River	2-JKS000.38	2-JKS006.67	2-JKS023.61	2-JKS044.14
Upper James River	2AJMS334.47	2-BKW000.40	2-FSG003.36	2-JMS302.85
	2-BCR000.20	2-BKW005.95	2-IVA000.22	2-JMS309.13
	2BJMS248.90	2BWL000.34	2-JMS229.14	2-JMS317.62
	2BJMS255.91	2-CAT000.34	2-JMS258.54	2-JMS345.73
	2BJMS263.24	2-CRG001.20	2-JMS270.84	
	2BJMS273.86	2-FSG000.85	2-JMS279.41	
Maury River	2-MRY000.46 2-MRY015.80			
Lower James River	2-BDC000.79	2-GEN000.57	2-JMS157.28	2-RRN002.19
	2BJMS119.35	2-HRD000.36	2-JMS189.31	2-RRS003.12
	2BJMS214.35	2-JMS111.17	2-LIY001.73	2-RVN001.64
	2BSLT000.73	2-JMS112.33	2-NWD002.27	2-RVN033.65
	2-BUF002.10	2-JMS117.35	2-PWT000.57	2-RVN039.58
	2-DPR001.00	2-JMS123.23	2-PWT003.98	2-TKO003.42
	2-FIN000.81	2-JMS127.50	2-RDD000.19	
	2-GEN000.51	2-JMS140.00	2-RDD001.57	

B.3.2 Jackson River

Table B-8. Observed TOC (mg/L) and DOC (mg/L) Data for the Jackson River TMDL Watershed.

Subwatershed*	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
JKS-01	7/19/2017	2-JKS000.38	7.60	7.38
JKS-01	2/8/2018	2-JKS000.38	4.67	5.33
JKS-01	9/17/2018	2-JKS000.38	6.53	5.54
JKS-01	12/7/2018	2-JKS000.38	4.16	3.71
JKS-03	2/8/2018	2-JKS006.67	5.13	6.54
JKS-14	7/19/2017	2-JKS023.61	16.00	14.10
JKS-14	2/8/2018	2-JKS023.61	9.09	9.85
JKS-14	9/17/2018	2-JKS023.61	13.20	9.64
JKS-14	12/7/2018	2-JKS023.61	9.07	7.26
JKS-17	7/19/2017	2-JKS044.14	1.68	1.87

Subwatershed*	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
JKS-17	2/8/2018	2-JKS044.14	1.58	2.34
JKS-17	9/17/2018	2-JKS044.14	1.86	1.81
JKS-17	12/7/2018	2-JKS044.14	1.54	1.47

*Subwatershed designation for the Jackson River (JKS).

B.3.3 Maury River

Table B-9. Observed TOC (mg/L) and DOC (mg/L) Data for the Maury River TMDL Watershed.

Subwatershed	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
MRY-01	7/20/2017	2-MRY000.46	1.64	1.67
MRY-01	2/8/2018	2-MRY000.46	4.37	4.70
MRY-01	6/4/2018	2-MRY000.46	2.08	1.81
MRY-01	4/3/2019	2-MRY000.46	1.42	1.07
MRY-09	7/20/2017	2-MRY015.80	1.79	1.51
MRY-09	2/8/2018	2-MRY015.80	3.13	3.13
MRY-09	6/4/2018	2-MRY015.80	2.05	1.76
MRY-09	4/3/2019	2-MRY015.80	1.15	1.25

*Subwatershed designation for the Maury River (MRY).

B.3.4 Upper James River

Table B-10. Observed TOC (mg/L) and DOC (mg/L) Data for the Upper James River TMDL Watershed.

Subwatershed*	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
MJF-01	7/19/2017	2-JMS229.14	3.84	3.66
MJF-01	2/8/2018	2-JMS229.14	3.65	3.98
MJF-01	9/17/2018	2-JMS229.14	11.30	7.71
MJF-01	2/7/2019	2-JMS229.14	2.08	1.85
MJF-06	9/17/2018	2BJMS248.90	6.64	4.47
MJF-06	2/7/2019	2BJMS248.90	1.91	1.74
MJF-07	9/17/2018	2-BCR000.20	9.98	8.21
MJF-09	9/17/2018	2BWL000.34	10.70	8.74
MJF-10	9/17/2018	2BJMS255.91	6.28	3.91
MJF-10	2/7/2019	2BJMS255.91	1.78	1.65
MJF-11	2/8/2018	2-FSG000.85	6.25	6.18
MJF-11	9/17/2018	2-FSG000.85	6.65	4.56
MJF-11	2/7/2019	2-FSG000.85	1.92	1.60
MJF-12	9/17/2018	2-FSG003.36	4.99	3.90
MJF-12	2/7/2019	2-FSG003.36	2.56	1.93
MJF-13	7/19/2017	2-JMS258.54	3.51	3.44

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Subwatershed*	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
MJF-13	2/8/2018	2-JMS258.54	3.56	3.66
MJF-13	9/17/2018	2-JMS258.54	4.91	3.69
MJF-13	2/7/2019	2-JMS258.54	1.79	1.88
MJF-14	2/8/2018	2-BKW000.40	3.26	4.65
MJF-14	9/17/2018	2-BKW000.40	5.78	3.96
MJF-14	2/7/2019	2-BKW000.40	1.46	1.47
MJF-15	9/17/2018	2-IVA000.22	5.98	5.28
MJF-16	9/17/2018	2-BKW005.95	4.83	3.98
MJF-20	7/19/2017	2BJMS263.24	3.90	3.67
MJF-20	2/8/2018	2BJMS263.24	3.44	4.04
MJF-20	9/17/2018	2BJMS263.24	3.84	3.25
MJF-20	2/7/2019	2BJMS263.24	2.36	2.00
MJF-20	7/19/2017	2-JMS270.84	4.19	4.20
MJF-20	2/8/2018	2-JMS270.84	3.76	3.87
MJF-20	9/17/2018	2-JMS270.84	5.41	3.92
MJF-20	2/7/2019	2-JMS270.84	2.29	1.94
MJF-25	2/7/2019	2BJMS273.86	1.99	1.65
MJF-27	7/19/2017	2-JMS279.41	4.07	3.91
MJF-27	2/8/2018	2-JMS279.41	6.61	5.16
MJF-27	9/17/2018	2-JMS279.41	6.73	4.03
MJF-27	2/7/2019	2-JMS279.41	2.17	2.14
CAT-03	7/19/2017	2-JMS302.85	5.23	5.08
CAT-03	2/8/2018	2-JMS302.85	5.49	5.67
CAT-03	9/17/2018	2-JMS302.85	4.43	3.40
CAT-05	2/8/2018	2-JMS309.13	6.02	5.89
CAT-05	9/17/2018	2-JMS309.13	5.11	4.25
CAT-05	12/7/2018	2-JMS309.13	2.11	1.94
CAT-08	9/17/2018	2-JMS317.62	7.82	5.36
CAT-10	2/8/2018	2-CAT000.34	7.41	5.34
CRG-01	2/8/2018	2-CRG001.20	6.67	5.22
CRG-01	9/17/2018	2-CRG001.20	7.61	6.37
CRG-13	9/17/2018	2AJMS334.47	6.86	5.57
CRG-17	7/19/2017	2-JMS345.73	5.48	5.14
CRG-17	2/8/2018	2-JMS345.73	4.85	5.76
CRG-17	9/17/2018	2-JMS345.73	10.90	5.96
CRG-17	12/7/2018	2-JMS345.73	2.91	2.31

*Subwatershed designations for major tributaries: Catawba Creek (CAT), Craig Creek (CRG), James River/Fishing Creek junction (MJF).

B.3.5 Lower James River

Table B-11. Observed TOC (mg/L) and DOC (mg/L) Data for the Lower James River TMDL Watershed.

Subwatershed*	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
MJR-01	7/13/2017	2-JMS111.17	3.04	3.47
MJR-01	2/12/2018	2-JMS111.17	12.30	8.39
MJR-01	8/29/2018	2-JMS111.17	3.03	2.72
MJR-01	11/6/2018	2-JMS111.17	7.90	5.47
MJR-02	6/26/2018	2-RDD000.19	13.30	11.60
MJR-02	11/15/2018	2-RDD000.19	9.10	5.70
MJR-03	6/26/2018	2-RDD001.57	14.80	13.80
MJR-03	11/15/2018	2-RDD001.57	10.90	8.52
MJR-04	8/29/2018	2-JMS112.33	2.975	2.68
MJR-04	11/6/2018	2-JMS112.33	8.82	6.37
MJR-06	6/26/2018	2-PWT000.57	6.22	5.66
MJR-06	11/15/2018	2-PWT000.57	6.97	5.39
MJR-07	6/26/2018	2-PWT003.98	5.25	4.92
MJR-07	11/15/2018	2-PWT003.98	5.86	5.18
MJR-05	8/28/2017	2-JMS117.35	3.90	3.95
MJR-05	2/12/2018	2-JMS117.35	12.30	9.06
MJR-05	8/30/2018	2-JMS117.35	2.67	2.41
MJR-05	11/6/2018	2-JMS117.35	6.76	5.64
MJR-08	7/12/2017	2BJMS119.35	2.90	2.86
MJR-09	2/12/2018	2-JMS123.23	12.60	17.60
MJR-11	2/12/2018	2-TKO003.42	11.80	9.58
MJR-11	11/15/2018	2-TKO003.42	7.90	6.98
MJR-12	11/15/2018	2-DPR001.00	6.82	5.99
MJR-16	2/12/2018	2-LIY001.73	13.90	12.00
MJR-18	7/12/2017	2-JMS127.50	3.08	2.94
MJR-18	11/6/2018	2-JMS127.50	8.81	6.64
MJR-20	6/26/2018	2-NWD002.27	4.14	4.10
MJR-20	11/15/2018	2-NWD002.27	7.50	6.44
MJR-21	11/15/2018	2-GEN000.51	11.00	6.27
MJR-21	11/15/2018	2-GEN000.57	10.60	6.18
MJR-23	10/11/2017	2-FIN000.81	11.20	9.00
MJR-24	11/15/2018	2-BDC000.79	9.43	6.83
MJR-25	2/12/2018	2-JMS140.00	14.50	16.20
MJR-25	7/19/2018	2-JMS140.00	2.84	2.59
MJR-25	11/6/2018	2-JMS140.00	9.53	6.91
MJR-35	8/28/2017	2-JMS157.28	4.09	3.92
MJR-35	2/12/2018	2-JMS157.28	14.60	14.00
MJR-35	7/19/2018	2-JMS157.28	3.08	2.83
MJR-35	11/6/2018	2-JMS157.28	8.27	6.60

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Subwatershed*	Date	Station	Observed TOC (mg/L)	Observed DOC (mg/L)
RVN-01	10/30/2017	2-RVN001.64	8.40	5.40
RVN-01	6/12/2018	2-RVN001.64	4.04	3.77
RVN-01	6/27/2019	2-RVN001.64	2.48	2.12
RVN-08	6/12/2018	2-RVN033.65	3.40	3.14
RVN-08	6/27/2019	2-RVN033.65	2.55	2.19
RVN-11	6/12/2018	2-RVN039.58	3.39	3.28
RVN-11	6/27/2019	2-RVN039.58	2.32	1.96
RVN-13	6/12/2018	2-RRN002.19	3.90	3.90
RVN-13	6/27/2019	2-RRN002.19	2.39	2.33
RVN-18	6/12/2018	2-RRS003.12	4.44	3.25
RVN-18	6/27/2019	2-RRS003.12	2.23	2.01
HSR-02	7/19/2017	2BSLT000.73	3.33	3.10
HSR-02	2/8/2018	2BSLT000.73	6.09	5.47
HSR-13	10/30/2017	2-HRD000.36	6.38	5.41
RKF-02	7/19/2017	2-JMS189.31	3.47	3.30
RKF-02	2/8/2018	2-JMS189.31	3.28	4.12
RKF-02	8/23/2018	2-JMS189.31	3.13	2.78
RKF-02	4/3/2019	2-JMS189.31	1.45	1.32
RKF-14	2/8/2018	2BJMS214.35	4.54	5.73
RKF-14	8/23/2018	2BJMS214.35	3.14	2.80
TYE-03	9/17/2018	2-BUF002.10	12.90	8.40

*Subwatershed designations for major tributaries: Hardware and Slate Rivers (HSR), Rockfish River (RKF), Rivanna River (RVN), Tye River (TYE), James River/Reedy Creek junction (MJR).

B.4 Fish Tissue PCB Concentration Data

B.4.1 Monitoring Stations

Table B-12. DEQ Fish Tissue PCB concentration stations used for BAF and endpoint calculation.

TMDL Watershed		DEQ Fish Tissue Sampling Stations			
Jackson River	2-JKS000.38	2-JKS006.67	2-JKS022.50	2-JKS023.61	2-JKS023.88
	2-JKS047.06	2-JKS047.07	2-JKS047.08	2-JKS047.09	2-KAR000.17
Upper James River	2-JMS258.54	2-JOB000.39	2-JMS279.41	2-JMS298.70	2-JMS330.77
	2-HAZ007.16	2-JMS267.47	2-BKW006.76	2-CWP002.58	2-JMS345.73
	2-CWP002.55	2-JMS309.13	2-JMS277.30	2-JMS317.62	
Maury River	2-MRY013.00	2-MRY016.01	2-MRY001.50	2-MRY011.23	
	2-MRY000.09	2-MRY011.86	2-MRY020.82	2-MRY013.88	
Lower James River	2-JMS176.63	2-JMS157.28	2-JMS118.99	2-SHS001.00	2-JMS182.94
	2-HRD000.25	2-PNY004.08	2-JMS127.50	2-JMS140.00	2-HRD007.21
	2-RVN000.07	2-RVN001.60	2-JMS213.00	2-JMS166.50	2-HRD002.06
	2-WLS000.50	2-HRD000.34	2-PNY003.06	2-JMS189.31	2-RVN023.01
	2-JMS229.14	2-SLT000.20	2-MIN002.00	2-JMS211.77	2-RVN037.54

B.4.2 Jackson River

Table B-13. Fish Tissue PCB Concentration (ng/g or ppb) Data for the Jackson River TMDL Watershed.

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Average Fish Tissue tPCB (ng/g)
JKS-01	7/25/2005	2-JKS000.38	Rock Bass	6	5.97	2.34
JKS-03	8/24/2017	2-JKS006.67	Smallmouth Bass	6	3.42	0.00
JKS-03	8/24/2017	2-JKS006.67	Rock Bass	7	6.26	0.53
JKS-05	9/19/2001	2-KAR000.17	Stoneroller	5	8.72	4.78
JKS-05	9/19/2001	2-KAR000.17	White Sucker	7	6.64	3.01
JKS-05	9/19/2001	2-KAR000.17	Rock Bass	2	2.69	1.70
JKS-13	7/29/2005	2-JKS022.50	Carp	1	32.06	66.43
JKS-13	7/29/2005	2-JKS022.50	Carp	1	24.99	28.81
JKS-13	7/29/2005	2-JKS022.50	Carp	1	8.93	35.96
JKS-13	7/29/2005	2-JKS022.50	Carp	1	7.05	71.31
JKS-13	7/29/2005	2-JKS022.50	Rainbow Trout	2	7.04	5.36
JKS-13	7/29/2005	2-JKS022.50	Carp	3	14.82	37.48

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Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Average Fish Tissue tPCB (ng/g)
JKS-13	7/29/2005	2-JKS022.50	Rock Bass	7	2.95	1.86
JKS-13	7/29/2005	2-JKS022.50	Rock Bass	7	3.27	6.67
JKS-13	7/29/2005	2-JKS022.50	Smallmouth Bass	4	4.86	1.35
JKS-13	7/29/2005	2-JKS022.50	Redbreast	4	4.49	4.60
JKS-14	8/23/2017	2-JKS023.61	Carp	2	15.52	9.48
JKS-14	8/23/2017	2-JKS023.61	Carp	3	18.04	28.55
JKS-14	8/23/2017	2-JKS023.61	White Sucker	6	8.70	1.27
JKS-14	8/23/2017	2-JKS023.61	Largemouth Bass	3	3.32	0.65
JKS-14	8/23/2017	2-JKS023.61	Rainbow Trout	2	13.22	0.00
JKS-14	8/23/2017	2-JKS023.61	Rock Bass	8	3.64	0.00
JKS-14	8/14/1995	2-JKS023.88	Rock Bass	10	0.73	7.25
JKS-14	8/14/1995	2-JKS023.88	Carp	5	7.50	63.71
JKS-14	8/14/1995	2-JKS023.88	Redbreast	10	0.76	6.55
JKS-19	9/20/2001	2-JKS047.06	Rainbow Trout	3	6.60	7.94
JKS-19	9/20/2001	2-JKS047.06	Rock Bass	10	3.94	0.61
JKS-19	9/20/2001	2-JKS047.06	Gizzard Shad	6	9.20	1.86
JKS-19	9/20/2001	2-JKS047.06	Largemouth Bass	3	3.19	2.08
JKS-19	9/20/2001	2-JKS047.06	Carp	2	13.25	3.44
JKS-19	7/26/2005	2-JKS047.06	Rock Bass	5	4.15	0.00
JKS-19	7/26/2005	2-JKS047.06	Carp	1	20.92	0.66
JKS-19	7/26/2005	2-JKS047.06	Largemouth Bass	3	4.97	1.66
JKS-19	7/26/2005	2-JKS047.06	Bluegill Sunfish	9	3.53	0.19
JKS-19	7/26/2005	2-JKS047.07	Carp	1	17.26	0.60
JKS-19	7/26/2005	2-JKS047.08	Carp	1	16.63	0.50
JKS-19	7/26/2005	2-JKS047.09	Carp	1	14.81	0.00

*Subwatershed designation for the Jackson River (JKS).

B.4.3 Maury River

Table B-14. Fish Tissue PCB Concentration (ng/g or ppb) Data for the Maury River TMDL Watershed.

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
MRY-01	10/6/2004	2-MRY000.09	Smallmouth Bass	1	4.46	9.60
MRY-01	10/6/2004	2-MRY000.09	Smallmouth Bass	2	5.36	5.25
MRY-01	10/6/2004	2-MRY000.09	Smallmouth Bass	3	4.38	5.59
MRY-01	10/6/2004	2-MRY000.09	Smallmouth Bass	3	5.68	6.61
MRY-01	10/6/2004	2-MRY000.09	Bull Chub	3	11.62	7.60
MRY-01	10/6/2004	2-MRY000.09	Bull Chub	3	15.54	13.92
MRY-01	10/6/2004	2-MRY000.09	Bull Chub	4	11.93	13.64

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Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
MRY-01	10/6/2004	2-MRY000.09	Redbreast Sunfish	3	6.13	6.59
MRY-01	10/6/2004	2-MRY000.09	Redbreast Sunfish	4	6.83	5.89
MRY-01	7/10/2001	2-MRY001.50	Rock Bass	15	2.85	8.02
MRY-01	7/10/2001	2-MRY001.50	Northern Hogsucker	2	4.29	8.00
MRY-01	7/10/2001	2-MRY001.50	Smallmouth Bass	3	2.69	10.43
MRY-01	7/10/2001	2-MRY001.50	Stoneroller	11	7.09	3.62
MRY-01	8/23/2017	2-MRY001.50	Redbreast Sunfish	3	6.68	0.84
MRY-01	8/23/2017	2-MRY001.50	Rock Bass	14	3.64	0.72
MRY-01	8/23/2017	2-MRY001.50	Rock Bass	15	4.00	0.61
MRY-01	8/23/2017	2-MRY001.50	Flathead Catfish	1	6.12	52.58
			Yellow Bullhead			
MRY-08	7/10/2001	2-MRY011.23	Catfish	4	4.47	332.69
MRY-08	7/10/2001	2-MRY011.23	Smallmouth Bass	3	2.63	--
MRY-08	7/10/2001	2-MRY011.23	Rock Bass	15	2.66	116.77
MRY-08	7/10/2001	2-MRY011.23	Redbreast Sunfish	15	4.04	70.55
MRY-08	7/27/2005	2-MRY011.23	Rock Bass	11	5.44	14.56
MRY-08	7/27/2005	2-MRY011.23	Rock Bass	11	5.45	4.98
MRY-08	7/27/2005	2-MRY011.23	White Sucker	2	15.16	59.46
MRY-08	7/27/2005	2-MRY011.23	Carp	1	12.67	287.16
MRY-08	7/27/2005	2-MRY011.23	Carp	1	11.19	200.51
MRY-08	7/27/2005	2-MRY011.23	Carp	1	17.08	1468.77
MRY-08	7/27/2005	2-MRY011.23	Carp	1	18.46	205.63
MRY-08	7/27/2005	2-MRY011.23	Redbreast Sunfish	5	12.60	48.56
MRY-08	7/27/2005	2-MRY011.23	Green Sunfish	7	4.75	3.39
MRY-08	7/27/2005	2-MRY011.23	Black Crappie	6	3.19	0.99
MRY-08	8/22/2017	2-MRY011.23	Redbreast Sunfish	10	3.14	4.15
MRY-08	8/22/2017	2-MRY011.23	Rock Bass	12	3.58	3.99
MRY-08	8/22/2017	2-MRY011.23	Rock Bass	15	3.10	1.38
			Yellow Bullhead			
MRY-08	8/22/2017	2-MRY011.23	Catfish	4	4.68	8.31
MRY-08	8/28/2017	2-MRY011.23	Smallmouth Bass	5	4.66	12.75
MRY-08	10/6/2004	2-MRY011.86	Smallmouth Bass	3	4.79	6.74
MRY-08	10/6/2004	2-MRY011.86	Smallmouth Bass	3	5.57	8.89
MRY-08	10/6/2004	2-MRY011.86	Smallmouth Bass	4	5.25	4.37
MRY-08	10/6/2004	2-MRY011.86	Carp	1	8.24	33.23
MRY-08	10/6/2004	2-MRY011.86	Carp	1	16.18	71.53
MRY-08	10/6/2004	2-MRY011.86	Carp	1	9.52	22.99
MRY-08	10/6/2004	2-MRY011.86	Carp	1	14.02	43.73
MRY-08	10/6/2004	2-MRY011.86	Carp	1	7.84	18.22
MRY-08	10/6/2004	2-MRY011.86	Redbreast Sunfish	5	5.09	7.25
MRY-08	10/6/2004	2-MRY011.86	Redbreast Sunfish	5	4.35	5.21

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
MRY-08	8/15/1995	2-MRY013.00	Smallmouth Bass	10	0.69	8.29
MRY-08	8/15/1995	2-MRY013.00	Redbreast Sunfish	10	0.56	2.96
MRY-08	8/15/1995	2-MRY013.00	White Sucker	6	3.23	15.88
MRY-08	8/15/1995	2-MRY013.00	White Sucker	6	3.27	13.04
MRY-08	8/21/2017	2-MRY013.88	Largemouth Bass	6	6.52	145.57
MRY-08	8/21/2017	2-MRY013.88	Largemouth Bass	6	6.46	149.56
MRY-08	8/21/2017	2-MRY013.88	White Sucker	6	13.92	6.90
MRY-08	8/21/2017	2-MRY013.88	Rock Bass	7	2.66	3.15
MRY-08	8/21/2017	2-MRY013.88	Carp	3	17.62	90.38
MRY-08	6/28/2019	2-MRY013.88	Smallmouth Bass	2	5.56	8.18
MRY-08	6/28/2019	2-MRY013.88	Smallmouth Bass	5	3.68	3.55
MRY-14	7/9/2001	2-MRY016.01	Rock Bass	15	3.11	28.22
MRY-14	7/9/2001	2-MRY016.01	Smallmouth Bass	2	2.77	35.37
MRY-14	7/9/2001	2-MRY016.01	River Chub	2	2.77	–
MRY-14	7/9/2001	2-MRY016.01	Redbreast Sunfish	8	4.34	27.15
MRY-14	7/27/2005	2-MRY020.82	Rock Bass	10	5.52	3.45
MRY-14	7/27/2005	2-MRY020.82	Rock Bass	10	6.67	2.81
MRY-14	7/27/2005	2-MRY020.82	River Chub	5	6.61	6.13
MRY-14	7/27/2005	2-MRY020.82	Central Stoneroller	12	35.10	22.77
MRY-14	7/27/2005	2-MRY020.82	Smallmouth Bass	4	6.68	2.15

*Subwatershed designation for the Maury River (MRY). Lost samples are denoted by “–”.

B.4.4 Upper James River

Table B-15. Fish Tissue PCB Concentration (ng/g or ppb) Data for the Upper James River TMDL Watershed.

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Average Fish Tissue tPCB (ng/g)
CAT-03	8/9/2017	2-JMS298.70	Smallmouth Bass	6	4.74	0.00
CAT-03	8/9/2017	2-JMS298.70	Flathead Catfish	1	6.56	32.70
CAT-03	8/9/2017	2-JMS298.70	Carp	3	31.68	101.80
CAT-03	8/9/2017	2-JMS298.70	Carp	3	26.98	170.36
CAT-03	10/8/2019	2-JMS298.70	Carp	3	36.78	221.44
CAT-03	10/8/2019	2-JMS298.70	Carp	3	25.42	120.53
CAT-03	10/8/2019	2-JMS298.70	Carp	2	30.12	92.69
CAT-03	10/8/2019	2-JMS298.70	Carp	3	30.34	137.58
CAT-03	10/8/2019	2-JMS298.70	Carp	3	24.60	180.89
CAT-05	7/26/2005	2-JMS309.13	Fallfish	4	10.38	1.26
CAT-05	7/26/2005	2-JMS309.13	Rock Bass	10	6.99	2.00
CAT-05	7/26/2005	2-JMS309.13	Flathead Catfish	1	4.31	1.59
CAT-05	7/26/2005	2-JMS309.13	Smallmouth Bass	3	5.77	4.58

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Average Fish Tissue tPCB (ng/g)
CAT-05	7/26/2005	2-JMS309.13	Redbreast Sunfish	5	6.01	1.86
CAT-05	9/10/2014	2-JMS309.13	Channel Catfish	3	30.12	59.50
CAT-05	9/10/2014	2-JMS309.13	Quillback	2	6.72	8.93
CAT-05	8/11/2017	2-JMS309.13	Carp sucker	6	3.30	0.71
CAT-05	8/11/2017	2-JMS309.13	Smallmouth Bass	6	3.00	0.58
CAT-05	8/11/2017	2-JMS309.13	Smallmouth Bass	10	2.72	0.00
CAT-05	8/11/2017	2-JMS309.13	Rock Bass	10	3.04	0.00
CAT-05	8/11/2017	2-JMS309.13	Northern Hogsucker	6	5.08	0.00
CAT-05	8/11/2017	2-JMS309.13	Redbreast	8	5.16	0.00
CAT-08	9/25/2017	2-JMS317.62	Sunfish	10	3.22	0.00
CAT-08	9/25/2017	2-JMS317.62	Smallmouth Bass	10	3.34	0.00
CAT-08	9/25/2017	2-JMS317.62	Rock Bass	5	5.08	0.00
CAT-08	9/25/2017	2-JMS317.62	Northern Hogsucker	3	8.64	4.44
CAT-13	9/25/2017	2-JMS330.77	Flathead Catfish	6	4.60	1.81
CAT-13	9/25/2017	2-JMS330.77	Smallmouth Bass	10	5.08	0.53
CAT-13	9/25/2017	2-JMS330.77	Rock Bass	11	3.34	0.00
CAT-13	9/25/2017	2-JMS330.77	Northern Hogsucker	6	3.68	1.37
CRG-10	9/19/2001	2-JOB000.39	Brown Bullhead	2	3.70	2.52
CRG-10	9/19/2001	2-JOB000.39	Catfish	9	3.34	2.07
CRG-10	9/19/2001	2-JOB000.39	Redbreast	10	2.81	1.53
CRG-10	9/19/2001	2-JOB000.39	Sunfish	2	3.71	3.24
CRG-17	9/28/2017	2-JMS345.73	Rock Bass	3	4.12	11.89
CRG-17	9/28/2017	2-JMS345.73	Smallmouth Bass	11	4.32	0.59
CRG-17	9/28/2017	2-JMS345.73	Rock Bass	10	5.00	0.00
CRG-17	9/30/2019	2-JMS345.73	Northern Hogsucker	3	16.46	39.75
CRG-17	9/30/2019	2-JMS345.73	Carp	3	10.26	61.60
CRG-17	9/30/2019	2-JMS345.73	Carp	3	41.20	191.10
CRG-17	9/30/2019	2-JMS345.73	Carp	3	15.78	62.80
CWP-01	7/12/2001	2-CWP002.55	Redbreast	9	5.49	305.89
CWP-01	7/12/2001	2-CWP002.55	Sunfish	6	4.19	3.17
CWP-01	7/12/2001	2-CWP002.55	Black Jumprock Sucker	15	2.45	1.33
CWP-01	7/25/2005	2-CWP002.55	Rock Bass	10	6.61	0.87
CWP-01	7/25/2005	2-CWP002.55	Rock Bass	10	4.66	1.11
CWP-01	7/25/2005	2-CWP002.55	Rock Bass	3	5.86	3.54

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Average Fish Tissue tPCB (ng/g)
CWP-01	9/5/2017	2-CWP002.58	Rock Bass Redbreast	11	3.04	0.00
CWP-01	9/5/2017	2-CWP002.58	Sunfish	10	2.66	0.00
CWP-01	9/5/2017	2-CWP002.58	Black Jumprock	6	5.30	0.00
MJF-10	9/7/1995	2-JMS258.54	Sucker	10	0.89	5.14
MJF-10	9/7/1995	2-JMS258.54	Smallmouth Bass Redbreast	9	1.20	4.44
MJF-10	9/7/1995	2-JMS258.54	Sunfish	9	8.75	45.20
MJF-10	7/11/2001	2-JMS258.54	White Sucker	4	22.80	138.07
MJF-10	7/11/2001	2-JMS258.54	American Eel	4	5.44	301.54
MJF-10	7/11/2001	2-JMS258.54	Carp	4	18.22	190.69
MJF-10	9/6/2001	2-JMS258.54	Carp	7	4.42	re-extract
MJF-10	9/6/2001	2-JMS258.54	Bluegill Sunfish	7	4.45	4.69
MJF-10	9/6/2001	2-JMS258.54	Bluegill Sunfish	3	14.34	373.33
MJF-10	9/6/2001	2-JMS258.54	Flathead Catfish	10	19.57	178.38
MJF-10	9/6/2001	2-JMS258.54	Gizzard Shad	8	3.31	11.42
MJF-10	7/26/2005	2-JMS258.54	Smallmouth Bass	4	38.50	55.35
MJF-10	7/26/2005	2-JMS258.54	Redhorse Sucker	1	7.85	158.84
MJF-10	7/26/2005	2-JMS258.54	Flathead Catfish	1	27.76	554.07
MJF-10	7/26/2005	2-JMS258.54	Flathead Catfish	1	3.45	29.78
MJF-10	7/26/2005	2-JMS258.54	Flathead Catfish	2	13.12	17.39
MJF-10	7/26/2005	2-JMS258.54	Flathead Catfish	5	33.64	278.20
MJF-10	7/26/2005	2-JMS258.54	Gizzard Shad	3	2.86	4.48
MJF-10	7/26/2005	2-JMS258.54	Black Crappie	3	12.11	51.01
MJF-10	7/26/2005	2-JMS258.54	Channel Catfish	4	9.91	9.93
MJF-10	8/27/2014	2-JMS258.54	American Eel	3	46.86	130.62
MJF-10	8/27/2014	2-JMS258.54	Channel Catfish	5	11.86	34.67
MJF-10	8/27/2014	2-JMS258.54	Flathead Catfish	1	16.00	540.68
MJF-10	8/27/2014	2-JMS258.54	Flathead Catfish	1	5.98	133.28
MJF-10	8/27/2014	2-JMS258.54	Flathead Catfish	2	4.04	140.15
MJF-10	8/27/2014	2-JMS258.54	Quillback	3	12.90	97.01
MJF-10	8/27/2014	2-JMS258.54	Carp sucker	2	11.86	73.71
MJF-10	8/27/2014	2-JMS258.54	Quillback	2	8.54	51.78
MJF-10	8/27/2014	2-JMS258.54	Carp sucker	2	12.28	90.28
MJF-10	8/27/2014	2-JMS258.54	Carp	3	14.64	122.39
MJF-16	10/27/2005	2-BKW006.76	Carp	5	5.63	22.33
MJF-16	10/27/2005	2-BKW006.76	Redbreast Sunfish	5	5.90	10.02
MJF-16	10/27/2005	2-BKW006.76	Redbreast Sunfish	3	5.72	2.70

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Average Fish Tissue tPCB (ng/g)
MJF-16	10/27/2005	2-BKW006.76	Northern Hogsucker	3	5.16	3.11
MJF-16	10/27/2005	2-BKW006.76	Northern Hogsucker	2	4.93	1.44
MJF-18	7/11/2001	2-HAZ007.16	Smallmouth Bass	3	3.14	3.99
MJF-18	7/11/2001	2-HAZ007.16	White Sucker Redbreast	7	5.21	7.45
MJF-18	7/11/2001	2-HAZ007.16	Sunfish	14	2.46	6.37
MJF-18	7/11/2001	2-HAZ007.16	Redhorse Sucker	5	8.60	6.13
MJF-18	7/28/2005	2-HAZ007.16	Smallmouth Bass	3	4.59	1.43
MJF-18	7/28/2005	2-HAZ007.16	Northern Hogsucker	2	4.20	1.85
MJF-18	7/28/2005	2-HAZ007.16	White Sucker Redbreast	6	3.82	0.22
MJF-18	7/28/2005	2-HAZ007.16	Sunfish	10	3.34	0.00
MJF-20	9/25/2001	2-JMS267.47	Bluegill Sunfish	10	3.02	7.06
MJF-20	9/25/2001	2-JMS267.47	Spotted Bass	7	3.69	4.12
MJF-20	9/25/2001	2-JMS267.47	Carp	5	8.65	51.84
MJF-20	9/25/2001	2-JMS267.47	Channel Catfish	3	2.80	27.07
MJF-20	9/25/2001	2-JMS267.47	Channel Catfish	3	2.82	16.19
MJF-27	8/8/2017	2-JMS277.30	Smallmouth Bass	7	3.56	0.73
MJF-27	8/8/2017	2-JMS277.30	Rock Bass	4	5.08	0.60
MJF-27	8/8/2017	2-JMS277.30	Channel Catfish	3	17.26	11.13
MJF-27	8/8/2017	2-JMS277.30	Carp	3	18.96	68.03
MJF-27	10/26/2005	2-JMS279.41	Largemouth Bass	2	3.91	10.75
MJF-27	10/26/2005	2-JMS279.41	Largemouth Bass	2	3.52	1.18
MJF-27	10/26/2005	2-JMS279.41	Smallmouth Bass	2	4.53	4.10
MJF-27	10/26/2005	2-JMS279.41	Smallmouth Bass	2	4.06	4.66
MJF-27	10/26/2005	2-JMS279.41	Redhorse Sucker	3	8.32	0.99
MJF-27	10/26/2005	2-JMS279.41	Redhorse Sucker	2	17.74	6.99
MJF-27	10/26/2005	2-JMS279.41	Rock Bass	5	5.58	3.25
MJF-27	10/26/2005	2-JMS279.41	Rock Bass	5	5.48	2.27
MJF-27	9/9/2014	2-JMS279.41	American Eel	1	68.46	477.11
MJF-27	9/9/2014	2-JMS279.41	Channel Catfish	5	15.42	18.56
MJF-27	9/9/2014	2-JMS279.41	Flathead Catfish Quillback	1	2.20	54.15
MJF-27	9/9/2014	2-JMS279.41	Carpsucker	1	7.22	28.92
MJF-27	9/9/2014	2-JMS279.41	Carp	3	8.24	32.18

*Subwatershed designations for major tributaries: Catawba Creek (CAT), Craig Creek (CRG), James River/Fishing Creek junction (MJF).

B.4.5 Lower James River

Table B-16. Fish Tissue PCB Concentration (ng/g or ppb) Data for the Lower James River TMDL Watershed.

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
HSR-13	8/4/1995	2-HRD000.25	Largemouth Bass	5	0.97	10.04
HSR-13	8/4/1995	2-HRD000.25	Sunfish	10	0.57	1.58
HSR-13	8/4/1995	2-HRD000.25	Redhorse Sucker	10	2.93	9.23
HSR-13	8/6/2001	2-HRD000.34	Gizzard Shad	10	13.32	113.07
HSR-13	8/6/2001	2-HRD000.34	Redbreast Sunfish	8	2.27	4.19
HSR-13	8/6/2001	2-HRD000.34	Smallmouth Bass	5	3.01	7.97
HSR-13	8/6/2001	2-HRD000.34	White Sucker	7	8.10	15.93
HSR-13	8/10/2017	2-HRD002.06	Rock Bass	12	3.38	0.00
HSR-13	8/10/2017	2-HRD002.06	Green Sunfish	9	3.42	0.00
HSR-13	8/10/2017	2-HRD002.06	Redbreast Sunfish	5	72.32	0.00
HSR-13	8/10/2017	2-HRD002.06	American Eel	2	36.58	1.35
HSR-13	8/7/2017	2-HRD007.21	Bluegill Sunfish	6	3.82	0.00
HSR-13	8/7/2017	2-HRD007.21	Green Sunfish	5	3.74	0.00
HSR-13	8/7/2017	2-HRD007.21	American Eel	4	18.64	0.91
			Quillback			
MJR-08	3/18/2003	2-JMS118.99	Carpsucker	5	5.50	156.62
MJR-08	3/18/2003	2-JMS118.99	Redhorse Sucker	1	13.80	17.97
MJR-08	3/18/2003	2-JMS118.99	Gizzard Shad	2	20.35	207.59
MJR-08	3/18/2003	2-JMS118.99	Channel Catfish	4	22.25	28.34
MJR-08	3/18/2003	2-JMS118.99	Channel Catfish	3	15.01	18.50
MJR-08	3/18/2003	2-JMS118.99	Channel Catfish	4	15.42	16.45
MJR-08	3/18/2003	2-JMS118.99	Channel Catfish	5	6.16	18.31
MJR-08	3/18/2003	2-JMS118.99	Carp	1	30.01	177.68
MJR-08	3/18/2003	2-JMS118.99	Carp	1	42.59	661.11
MJR-08	3/18/2003	2-JMS118.99	Carp	1	15.50	194.47
MJR-08	3/18/2003	2-JMS118.99	Carp	1	8.49	74.72
MJR-08	3/18/2003	2-JMS118.99	Carp	1	19.62	124.33
MJR-08	3/18/2003	2-JMS118.99	Carp	1	26.80	429.37
MJR-08	3/18/2003	2-JMS118.99	Carp	1	20.60	129.35
MJR-08	4/25/2005	2-JMS118.99	Carp	1	17.00	–
MJR-08	4/25/2005	2-JMS118.99	Carp	1	18.88	155.91
MJR-08	4/25/2005	2-JMS118.99	Carp	1	41.48	338.31
MJR-08	4/25/2005	2-JMS118.99	Flathead Catfish	2	3.32	32.75
MJR-08	4/25/2005	2-JMS118.99	Blue Catfish	1	8.78	88.36
MJR-08	5/2/2005	2-JMS118.99	Carp	1	12.16	148.35
MJR-08	5/2/2005	2-JMS118.99	Carp	1	16.34	212.78
MJR-08	5/2/2005	2-JMS118.99	Carp	1	9.82	74.72
MJR-08	5/2/2005	2-JMS118.99	Carp	1	37.47	440.73
MJR-08	5/2/2005	2-JMS118.99	Flathead Catfish	1	16.67	870.96

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Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
MJR-08	5/2/2005	2-JMS118.99	Flathead Catfish	1	19.15	319.36
MJR-08	5/9/2005	2-JMS118.99	Gizzard Shad	10	35.73	244.84
MJR-08	5/9/2005	2-JMS118.99	Flathead Catfish	1	10.49	517.85
MJR-08	5/9/2005	2-JMS118.99	Flathead Catfish	1	5.82	493.85
MJR-08	5/8/2014	2-JMS118.99	Blue Catfish	1	31.72	408.22
MJR-08	5/8/2014	2-JMS118.99	Blue Catfish	2	5.50	155.24
MJR-08	5/8/2014	2-JMS118.99	Blue Catfish	2	6.50	164.60
MJR-08	5/8/2014	2-JMS118.99	Flathead Catfish	1	14.78	417.43
MJR-08	5/8/2014	2-JMS118.99	Flathead Catfish	1	31.52	985.42
MJR-08	5/8/2014	2-JMS118.99	Flathead Catfish	1	16.00	685.96
MJR-08	5/8/2014	2-JMS118.99	Flathead Catfish	1	15.50	538.05
MJR-08	5/8/2014	2-JMS118.99	Flathead Catfish	1	9.78	438.48
MJR-08	5/8/2014	2-JMS118.99	Carp	3	21.20	161.27
MJR-08	5/8/2014	2-JMS118.99	Carp	3	17.22	241.71
MJR-08	5/8/2014	2-JMS118.99	Gizzard Shad	10	24.98	154.61
MJR-18	7/17/2003	2-JMS127.50	Smallmouth Bass	4	3.57	2.43
MJR-18	7/17/2003	2-JMS127.50	Redbreast Sunfish	5	3.64	0.81
			Quillback			
MJR-18	7/17/2003	2-JMS127.50	Carp	4	9.12	4.36
MJR-18	7/17/2003	2-JMS127.50	Carp	3	14.54	95.57
MJR-18	7/17/2003	2-JMS127.50	Flathead Catfish	2	10.78	8.16
MJR-18	7/17/2003	2-JMS127.50	Channel Catfish	3	16.06	16.18
MJR-18	7/17/2003	2-JMS127.50	Carp	1	29.75	123.55
MJR-18	7/17/2003	2-JMS127.50	Carp	1	26.19	98.28
MJR-18	7/17/2003	2-JMS127.50	Carp	1	26.60	324.94
MJR-18	7/17/2003	2-JMS127.50	Carp	1	19.02	379.86
MJR-18	7/17/2003	2-JMS127.50	Carp	1	15.20	291.97
MJR-18	6/2/2005	2-JMS127.50	Bluegill Sunfish	10	5.84	2.51
MJR-18	6/2/2005	2-JMS127.50	Channel Catfish	3	8.84	18.93
MJR-18	6/2/2005	2-JMS127.50	Flathead Catfish	1	3.74	21.72
MJR-18	6/2/2005	2-JMS127.50	Flathead Catfish	1	10.68	382.69
MJR-18	6/2/2005	2-JMS127.50	Flathead Catfish	3	2.67	4.13
MJR-18	6/9/2014	2-JMS127.50	American Eel	5	39.34	16.80
MJR-18	6/9/2014	2-JMS127.50	Blue Catfish	1	17.12	653.01
MJR-18	6/9/2014	2-JMS127.50	Blue Catfish	2	19.70	52.58
MJR-18	6/9/2014	2-JMS127.50	Blue Catfish	3	13.58	84.12
MJR-18	6/9/2014	2-JMS127.50	Flathead Catfish	1	12.00	31.40
MJR-18	6/9/2014	2-JMS127.50	Flathead Catfish	2	6.66	21.65
MJR-18	6/9/2014	2-JMS127.50	Flathead Catfish	2	6.26	11.42
MJR-18	6/9/2014	2-JMS127.50	Flathead Catfish	2	3.00	26.62

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Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
MJR-18	6/9/2014	2-JMS127.50	Quillback	1	2.80	13.69
			Carpsucker			
MJR-18	6/9/2014	2-JMS127.50	Quillback	1	2.66	13.26
MJR-18	6/9/2014	2-JMS127.50	Carpsucker	6	19.16	113.28
MJR-25	6/4/2014	2-JMS140.00	Gizzard Shad	5	21.02	27.56
MJR-25	6/4/2014	2-JMS140.00	Channel Catfish	1	40.94	102.35
MJR-25	6/4/2014	2-JMS140.00	Blue Catfish	1	25.22	478.07
MJR-25	6/4/2014	2-JMS140.00	Blue Catfish	1	26.18	61.27
MJR-25	6/4/2014	2-JMS140.00	Blue Catfish	2	16.14	40.34
MJR-25	6/4/2014	2-JMS140.00	Carp	4	28.80	61.55
MJR-25	6/4/2014	2-JMS140.00	Carp	4	22.08	173.04
MJR-25	6/4/2014	2-JMS140.00	Carp	3	20.72	197.29
MJR-35	5/22/2001	2-JMS157.28	Smallmouth Bass	4	4.25	37.11
MJR-35	5/22/2001	2-JMS157.28	Redhorse Sucker	7	7.15	7.36
MJR-35	5/22/2001	2-JMS157.28	Channel Catfish	4	13.14	28.39
MJR-35	5/22/2001	2-JMS157.28	Carp	5	13.46	183.60
MJR-35	5/22/2001	2-JMS157.28	Redbreast Sunfish	12	3.93	4.45
MJR-35	6/9/2005	2-JMS157.28	Black Crappie	4	2.74	3.09
MJR-35	6/9/2005	2-JMS157.28	Smallmouth Bass	3	2.29	21.51
MJR-35	6/9/2005	2-JMS157.28	Channel Catfish	5	14.02	13.65
MJR-35	6/9/2005	2-JMS157.28	Channel Catfish	1	11.91	44.71
MJR-35	6/9/2005	2-JMS157.28	Flathead Catfish	3	4.13	14.56
MJR-35	6/9/2005	2-JMS157.28	Flathead Catfish	1	4.75	77.31
MJR-35	6/10/2014	2-JMS157.28	American Eel	5	35.86	17.14
MJR-35	6/10/2014	2-JMS157.28	Channel Catfish	5	11.40	50.00
MJR-35	6/10/2014	2-JMS157.28	Flathead Catfish	1	16.58	124.59
			Quillback			
MJR-35	6/10/2014	2-JMS157.28	Carpsucker	5	9.96	83.05
MJR-35	6/10/2014	2-JMS157.28	Carp	4	26.12	105.39
MJR-35	6/10/2014	2-JMS157.28	Carp	3	26.30	81.57
WIL-15	6/12/2014	2-JMS166.50	American Eel	4	34.42	17.27
WIL-15	6/12/2014	2-JMS166.50	Channel Catfish	2	12.14	7.86
WIL-15	6/12/2014	2-JMS166.50	Flathead Catfish	1	9.46	358.22
			Quillback			
WIL-15	6/12/2014	2-JMS166.50	Carpsucker	1	26.72	79.86
WIL-15	6/12/2014	2-JMS166.50	Carp	3	22.82	127.21
WIL-15	6/12/2014	2-JMS166.50	Carp	2	27.96	208.02
HSR-01	6/1/1995	2-JMS176.63	Smallmouth Bass	11	0.60	5.17
HSR-01	6/1/1995	2-JMS176.63	River Chub	10	0.93	6.59
HSR-01	6/1/1995	2-JMS176.63	Sunfish	10	0.79	3.75
HSR-01	6/16/2005	2-JMS176.63	Redbreast Sunfish	4	5.89	0.60

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
HSR-01	6/16/2005	2-JMS176.63	Flathead Catfish	1	5.22	12.55
HSR-01	6/16/2005	2-JMS176.63	Flathead Catfish	1	5.54	19.96
HSR-01	6/16/2005	2-JMS176.63	Channel Catfish	4	20.34	31.19
HSR-01	6/16/2005	2-JMS176.63	Channel Catfish	1	18.52	92.29
HSR-01	6/16/2005	2-JMS176.63	Carp	1	25.94	339.35
HSR-01	6/26/2014	2-JMS176.63	American Eel	4	46.74	19.55
HSR-01	6/26/2014	2-JMS176.63	Channel Catfish	5	8.48	4.51
HSR-01	6/26/2014	2-JMS176.63	Channel Catfish	5	9.58	4.95
HSR-01	6/26/2014	2-JMS176.63	Quillback			
HSR-01	6/26/2014	2-JMS176.63	Carp	1	3.24	15.99
HSR-01	6/26/2014	2-JMS176.63	Carp	2	25.94	286.79
RKF-01	8/14/2014	2-JMS182.94	American Eel	5	35.36	41.92
RKF-01	8/14/2014	2-JMS182.94	American Eel	12	50.34	34.98
RKF-01	8/14/2014	2-JMS182.94	Channel Catfish	5	17.20	28.68
RKF-01	8/14/2014	2-JMS182.94	Flathead Catfish	1	6.44	55.54
RKF-01	8/14/2014	2-JMS182.94	Flathead Catfish	1	7.34	61.18
RKF-01	8/14/2014	2-JMS182.94	Flathead Catfish	5	3.64	14.77
RKF-02	6/24/2014	2-JMS189.31	American Eel	8	35.98	35.73
RKF-02	6/24/2014	2-JMS189.31	American Eel	10	39.64	38.79
RKF-02	6/24/2014	2-JMS189.31	Channel Catfish	5	21.18	14.39
RKF-02	6/24/2014	2-JMS189.31	Flathead Catfish	1	5.88	116.44
RKF-02	6/24/2014	2-JMS189.31	Flathead Catfish	2	11.48	230.66
RKF-02	6/24/2014	2-JMS189.31	Flathead Catfish	1	3.28	41.52
RKF-02	6/24/2014	2-JMS189.31	Gizzard Shad	5	24.24	77.40
RKF-02	6/24/2014	2-JMS189.31	Carp	3	30.18	133.62
RKF-02	6/24/2014	2-JMS189.31	Carp	3	32.00	579.34
RKF-02	6/24/2014	2-JMS189.31	Carp	4	19.42	419.28
RKF-14	7/9/2014	2-JMS211.77	American Eel	6	45.12	19.63
RKF-14	7/9/2014	2-JMS211.77	Channel Catfish	5	13.04	18.85
RKF-14	7/9/2014	2-JMS211.77	Channel Catfish	5	29.50	19.35
RKF-14	7/9/2014	2-JMS211.77	Flathead Catfish	1	12.38	310.60
RKF-14	6/15/2005	2-JMS213.00	Flathead Catfish	1	9.25	228.28
RKF-14	6/15/2005	2-JMS213.00	Flathead Catfish	1	3.43	51.66
RKF-14	6/15/2005	2-JMS213.00	Flathead Catfish	1	5.69	29.15
RKF-14	6/15/2005	2-JMS213.00	Smallmouth Bass	2	3.51	7.19
RKF-14	6/15/2005	2-JMS213.00	Redhorse Sucker	5	34.76	81.11
RKF-14	6/15/2005	2-JMS213.00	Channel Catfish	4	23.28	8.07
RKF-14	6/15/2005	2-JMS213.00	Channel Catfish	1	15.73	113.99
TYE-17	8/22/1995	2-JMS229.14	Carp	5	7.25	688.33
TYE-17	8/22/1995	2-JMS229.14	Channel Catfish	10	4.89	28.18
TYE-17	8/22/1995	2-JMS229.14	Redbreast Sunfish	9	1.44	9.91

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
TYE-17	10/17/2001	2-JMS229.14	Channel Catfish	1	16.97	15.53
TYE-17	10/17/2001	2-JMS229.14	Smallmouth Bass	3	3.88	11.61
TYE-17	10/17/2001	2-JMS229.14	Smallmouth Bass	5	5.61	8.33
TYE-17	10/17/2001	2-JMS229.14	Redbreast Sunfish	4	5.55	1.37
TYE-17	10/17/2001	2-JMS229.14	American Eel	4	26.46	102.63
TYE-17	8/13/2014	2-JMS229.14	American Eel	8	49.26	22.16
TYE-17	8/13/2014	2-JMS229.14	American Eel	8	48.48	18.92
TYE-17	8/13/2014	2-JMS229.14	Channel Catfish	5	19.38	6.23
TYE-17	8/13/2014	2-JMS229.14	Channel Catfish	5	9.50	3.51
TYE-06	7/20/2005	2-MIN002.00	Black Crappie	10	3.25	0.15
TYE-06	7/20/2005	2-MIN002.00	Redear Sunfish	5	3.15	0.15
TYE-06	7/20/2005	2-MIN002.00	Largemouth Bass	10	2.62	0.37
TYE-06	7/20/2005	2-MIN002.00	Bluegill Sunfish	6	3.41	0.44
TYE-06	7/20/2005	2-MIN002.00	Channel Catfish	2	29.33	0.00
TYE-06	7/20/2005	2-MIN002.00	Channel Catfish	5	14.78	0.00
TYE-09	6/29/2005	2-PNY003.06	Redbreast Sunfish	7	6.44	2.32
TYE-09	6/29/2005	2-PNY003.06	Rock Bass	7	4.13	4.02
TYE-09	6/29/2005	2-PNY003.06	White Sucker	2	8.66	1.03
TYE-09	6/29/2005	2-PNY003.06	American Eel	6	27.60	12.57
TYE-09	6/19/2001	2-PNY004.08	Bluehead Chub	9	2.94	9.29
TYE-09	6/19/2001	2-PNY004.08	Northern Hogsucker	2	4.31	5.70
TYE-09	6/19/2001	2-PNY004.08	Rock Bass	7	2.74	9.77
TYE-09	6/19/2001	2-PNY004.08	Smallmouth Bass	3	3.15	13.25
TYE-09	6/19/2001	2-PNY004.08	Redbreast Sunfish	8	3.55	3.89
RVN-01	8/4/1995	2-RVN000.07	River Chub	10	1.00	4.10
RVN-01	8/4/1995	2-RVN000.07	Redbreast Sunfish	11	0.53	1.62
RVN-01	7/5/2001	2-RVN001.60	Gizzard Shad	2	7.19	16.00
RVN-01	7/5/2001	2-RVN001.60	Yellow Bullhead			
RVN-01	7/5/2001	2-RVN001.60	Catfish	3	3.39	4.11
RVN-01	7/5/2001	2-RVN001.60	Redbreast Sunfish	13	2.62	4.55
RVN-01	7/5/2001	2-RVN001.60	American Eel	12	32.25	33.87
RVN-04	10/24/2018	2-RVN023.01	Smallmouth Bass	2	4.58	3.41
RVN-04	10/24/2018	2-RVN023.01	Largemouth Bass	1	2.90	0.00
RVN-04	10/24/2018	2-RVN023.01	Largemouth Bass	1	4.08	0.00
RVN-04	10/24/2018	2-RVN023.01	Gizzard Shad	7	10.58	15.33
RVN-04	10/24/2018	2-RVN023.01	Gizzard Shad	7	9.82	31.50
RVN-04	10/24/2018	2-RVN023.01	Redbreast Sunfish	3	3.66	0.00
RVN-11	10/25/2018	2-RVN037.54	American Eel	3	51.50	8.94
RVN-11	10/25/2018	2-RVN037.54	American Eel	3	40.48	6.81
RVN-11	10/25/2018	2-RVN037.54	Redbreast Sunfish	10	3.10	0.00
RVN-11	10/25/2018	2-RVN037.54	Black Crappie	2	2.72	0.72

Subwatershed*	Date	Station	Species Common Name	No. of Fish Analyzed	Lipid Content (%)	Fish Tissue tPCB (ng/g)
TYE-06	7/20/2005	2-SHS001.00	Bluegill Sunfish	6	3.04	0.00
TYE-06	7/20/2005	2-SHS001.00	Black Crappie	10	3.93	0.00
TYE-06	7/20/2005	2-SHS001.00	Redear Sunfish	5	2.96	0.00
TYE-06	7/20/2005	2-SHS001.00	Largemouth Bass	5	2.92	0.08
HSR-02	8/6/2001	2-SLT000.20	White Sucker	6	5.87	9.78
HSR-02	8/6/2001	2-SLT000.20	Gizzard Shad	7	7.15	49.75
HSR-02	8/6/2001	2-SLT000.20	Carp	4	21.53	147.44
HSR-02	8/6/2001	2-SLT000.20	Black Crappie	5	2.93	4.76
WIL-02	8/8/1995	2-WLS000.50	White Crappie	10	0.57	1.97
WIL-02	8/8/1995	2-WLS000.50	Redbreast Sunfish	10	0.69	2.18
WIL-02	8/8/1995	2-WLS000.50	White Sucker	10	2.12	5.02

*Subwatershed designations for major tributaries: Hardware and Slate Rivers (HSR), Rockfish River (RKF), Rivanna River (RVN), James River/Reedy Creek junction (MJR), Tye River (TYE), Willis River (WIL). Lost samples are denoted by "-".

B.5 Sediment-Associated PCB Concentration Data

B.5.1 Monitoring Stations

Table B-17. DEQ sediment-associated PCB concentration stations used for the PCB calibration.

TMDL Watershed	DEQ Water Quality Sediment-Associated PCB Stations	
Jackson River	none	
Upper James River	2BJMS263.24	2-JMS309.13
	2BJMS273.86	2-JMS317.62
	2-JMS229.14	2-JMS330.77
	2-JMS258.54	2-JMS345.73
	2-JMS298.70	
Maury River	2-MRY015.80	2-MRY011.23
	2-MRY013.88	2-MRY001.50
Lower James River	2-JMS189.31	2-JMS111.17
	2-JMS157.28	2BJMS111.04
	2BJMS119.35	2-HRD007.21
	2-JMS127.50	2-HRD002.06
	2-JMS112.33	2-RVN023.01
	2-RVN039.58	2-NWD002.27
	2-RVN037.54	2-PWT000.57
	2-RVN001.64	2-PWT003.98
	2-RVN033.65	2-RDD000.48
	2-FIN000.81	2-NWD002.27

B.5.2 Maury River

Table B-18. Observed sediment-associated PCB concentration (ng/g) data for the Maury River.

Subwatershed*	Date	Station	Observed Sediment-Associated tPCB (ng/g)
MRY-01	8/23/2017	2-MRY001.50	0.50
MRY-01	4/3/2019	2-MRY000.46	1.95
MRY-07	8/22/2017	2-MRY011.23	0.50
MRY-07	8/22/2017	2-MRY011.23	0.50
MRY-08	8/21/2017	2-MRY013.88	0.50
MRY-09	7/20/2017	2-MRY015.80	0.38

*Subwatershed designation for the Maury River (MRY).

B.5.3 Upper James River

Table B-19. Observed sediment-associated PCB concentration (ng/g) data for the Upper James River.

Subwatershed*	Date	Station	Observed Sediment-Associated tPCB (ng/g)
CAT-03	8/9/2017	2-JMS298.70	0.50
CAT-06	8/11/2017	2-JMS309.13	0.50
CAT-08	9/25/2017	2-JMS317.62	0.50
CAT-13	9/25/2017	2-JMS330.77	12.12
CRG-17	9/28/2017	2-JMS345.73	0.50
MJF-01	7/19/2017	2-JMS229.14	0.63
MJF-01	7/19/2017	2-JMS229.14	1.19
MJF-13	2/7/2019	2-JMS258.54	2.84
MJF-20	7/19/2017	2BJMS263.24	0.59

*Subwatershed designations for major tributaries: Catawba Creek (CAT), Craig Creek (CRG), James River/Fishing Creek junction (MJF).

B.5.4 Lower James River

Table B-20. Observed sediment-associated PCB concentration (ng/g) data for the Lower James River.

Subwatershed*	Date	Station	Observed Sediment-Associated tPCB (ng/g)
HSR-13	8/10/2017	2-HRD002.06	0.50
HSR-13	8/7/2017	2-HRD007.21	0.50
MJR-01	12/3/2018	2BJMS111.04	1.71
MJR-01	8/29/2018	2-JMS111.17	2.19
MJR-02	8/30/2018	2-RDD000.48	47.20
MJR-04	8/29/2018	2-JMS112.33	12.39
MJR-04	8/29/2018	2-JMS112.33	3.79
MJR-06	6/26/2018	2-PWT000.57	1.37
MJR-07	6/26/2018	2-PWT003.98	1.09
MJR-08	7/12/2017	2BJMS119.35	3.47
MJR-08	7/12/2017	2BJMS119.35	3.53
MJR-18	7/12/2017	2-JMS127.50	2.47
MJR-20	6/26/2018	2-NWD002.27	0.37
MJR-23	8/22/2017	2-FIN000.81	0.37
MJR-35	7/19/2018	2-JMS157.28	2.51
RKF-02	7/19/2017	2-JMS189.31	21.66
RVN-01	8/14/2017	2-RVN001.64	0.05
RVN-04	10/24/2018	2-RVN023.01	0.50
RVN-08	6/27/2019	2-RVN033.65	0.94
RVN-11	10/25/2018	2-RVN037.54	0.50
RVN-11	10/25/2018	2-RVN039.58	0.50
RVN-11	10/25/2018	2-RVN039.58	0.50
RVN-11	6/27/2019	2-RVN039.58	0.43

*Subwatershed designations for major tributaries: Hardware and Slate Rivers (HSR), Rockfish River (RKF), Rivanna River (RVN), James River/Reedy Creek junction (MJR).

B.6 Water Column PCB Concentration Data

B.6.1 Monitoring Stations

Table B-21. DEQ water column tPCB stations used for the PCB calibration.

TMDL Watershed	DEQ Water Quality Water Column tPCB Stations					
Jackson River	2-JKS000.38	2-JKS006.67	2-JKS023.61	2-JKS044.14		
	2-JMS302.85	2-JMS317.62	2BWL M000.34	2-BKW000.40	2BJMS273.86	
	2-JMS345.73	2AJMS334.47	2BJMS255.91	2-BKW005.95	2-JMS279.41	
Upper James River	2-JMS309.13	2-JMS229.14	2-FSG000.85	2-IVA000.22		
	2-CAT000.34	2BJMS248.90	2-FSG003.36	2BJMS263.24		
	2-CRG001.20	2-BCR000.20	2-JMS258.54	2-JMS270.84		
Maury River		2-MRY000.46	2-MRY015.80			
	2-JMS189.31	2-RVN001.64	2-JMS127.50	2-TKO003.42	2-NWD002.27	
	2BJMS214.35	2-RRN002.19	2-JMS111.17	2-JMS140.00	2-JMS112.33	
Lower James River	2-BUF002.10	2-RRS003.12	2-JMS117.35	2-RDD000.19	2-GEN000.51	
	2-JMS157.28	2-RVN033.65	2-FIN000.81	2-RDD001.57	2-BDC000.79	
	2BSLT000.73	2-RVN039.58	2-JMS123.23	2-PWT000.57		
	2-HRD000.36	2BJMS119.35	2-LIY001.73	2-PWT003.98		

B.6.2 Jackson River

Table B-22. Observed water column tPCB (pg/L) data for the Jackson River TMDL Watershed.

Subwatershed*	Date	Station	Observed Water Column tPCB (pg/L)
JKS-01	7/19/2017	2-JKS000.38	133.95
JKS-01	2/8/2018	2-JKS000.38	312.26
JKS-01	9/17/2018	2-JKS000.38	668.52
JKS-01	12/7/2018	2-JKS000.38	55.26
JKS-03	2/8/2018	2-JKS006.67	262.91
JKS-14	7/19/2017	2-JKS023.61	275.02
JKS-14	2/8/2018	2-JKS023.61	296.36
JKS-14	9/17/2018	2-JKS023.61	806.40
JKS-14	12/7/2018	2-JKS023.61	195.58
JKS-17	7/19/2017	2-JKS044.14	43.35
JKS-17	2/8/2018	2-JKS044.14	76.77
JKS-17	9/17/2018	2-JKS044.14	46.58
JKS-17	12/7/2018	2-JKS044.14	67.17

*Subwatershed designation for the Jackson River (JKS).

B.6.3 Maury River

Table B-23. Observed water column tPCB (pg/L) data for the Maury River TMDL Watershed.

Subwatershed*	Date	Station	Observed Water Column tPCB (pg/L)
MRY-01	7/20/2017	2-MRY000.46	157.83
MRY-01	2/8/2018	2-MRY000.46	917.44
MRY-01	6/4/2018	2-MRY000.46	80.54
MRY-01	6/4/2018	2-MRY000.46	139.22
MRY-09	4/3/2019	2-MRY000.46	43.09
MRY-09	4/3/2019	2-MRY000.46	58.25
MRY-09	7/20/2017	2-MRY015.80	119.58
MRY-09	2/8/2018	2-MRY015.80	547.35
MRY-09	6/4/2018	2-MRY015.80	75.93
MRY-09	4/3/2019	2-MRY015.80	75.06

*Subwatershed designation for the Maury River (MRY).

B.6.4 Upper James River

Table B-24. Observed water column tPCB (pg/L) data for the Upper James River TMDL Watershed.

Subwatershed*	Date	Station	Observed Water Column tPCB (pg/L)
CRG-13	9/17/2018	2AJMS334.47	446.91
MJF-07	9/17/2018	2-BCR000.20	1,398.01
MJF-06	9/17/2018	2BJMS248.90	2,371.58
MJF-06	2/7/2019	2BJMS248.90	131.74
MJF-10	9/17/2018	2BJMS255.91	608.90
MJF-10	2/7/2019	2BJMS255.91	213.40
MJF-20	7/19/2017	2BJMS263.24	151.61
MJF-20	2/8/2018	2BJMS263.24	183.70
MJF-20	9/17/2018	2BJMS263.24	660.12
MJF-20	2/7/2019	2BJMS263.24	115.79
MJF-25	2/7/2019	2BJMS273.86	122.72
MJF-14	2/8/2018	2-BKW000.40	595.31
MJF-14	9/17/2018	2-BKW000.40	4,414.24
MJF-14	2/7/2019	2-BKW000.40	147.17
MJF-16	9/17/2018	2-BKW005.95	5,616.64
MJF-09	9/17/2018	2BWL000.34	3,965.67
CAT-10	2/8/2018	2-CAT000.34	189.90
CRG-01	2/8/2018	2-CRG001.20	246.89
CRG-01	9/17/2018	2-CRG001.20	125.47
MJF-11	2/8/2018	2-FSG000.85	2,845.14
MJF-11	9/17/2018	2-FSG000.85	8,907.23
MJF-11	2/7/2019	2-FSG000.85	305.23
MJF-12	9/17/2018	2-FSG003.36	4,511.99
MJF-12	2/7/2019	2-FSG003.36	630.03
MJF-15	9/17/2018	2-IVA000.22	592.01
MJF-01	7/19/2017	2-JMS229.14	112.07
MJF-01	2/8/2018	2-JMS229.14	337.03
MJF-01	9/17/2018	2-JMS229.14	618.39
MJF-01	2/7/2019	2-JMS229.14	118.06
MJF-13	7/19/2017	2-JMS258.54	222.03
MJF-13	2/8/2018	2-JMS258.54	614.76
MJF-13	9/17/2018	2-JMS258.54	3,215.95
MJF-13	2/7/2019	2-JMS258.54	128.36
MJF-20	7/19/2017	2-JMS270.84	106.34
MJF-20	2/8/2018	2-JMS270.84	457.17
MJF-20	9/17/2018	2-JMS270.84	600.84
MJF-20	2/7/2019	2-JMS270.84	111.16
MJF-27	7/19/2017	2-JMS279.41	86.26

Subwatershed*	Date	Station	Observed Water Column tPCB (pg/L)
MJF-27	2/8/2018	2-JMS279.41	520.03
MJF-27	9/17/2018	2-JMS279.41	829.88
MJF-27	2/7/2019	2-JMS279.41	100.06
CAT-03	7/19/2017	2-JMS302.85	66.50
CAT-03	2/8/2018	2-JMS302.85	419.85
CAT-03	9/17/2018	2-JMS302.85	240.20
CAT-05	2/8/2018	2-JMS309.13	455.24
CAT-05	9/17/2018	2-JMS309.13	238.60
CAT-05	12/7/2018	2-JMS309.13	56.93
CAT-08	9/17/2018	2-JMS317.62	396.63
CRG-17	7/19/2017	2-JMS345.73	121.13
CRG-17	2/8/2018	2-JMS345.73	167.18
CRG-17	9/17/2018	2-JMS345.73	310.93
CRG-17	12/7/2018	2-JMS345.73	63.38

*Subwatershed designations for major tributaries: Catawba Creek (CAT), Craig Creek (CRG), James River/Fishing Creek junction (MJF).

B.6.5 Lower James River

Table B-25. Observed water column tPCB (pg/L) data for the Lower James River TMDL Watershed.

Subwatershed*	Date	Station	Observed Water Column tPCB (pg/L)
MJR-24	11/15/2018	2-BDC000.79	147.27
MJR-08	7/12/2017	2BJMS119.35	109.14
RKF-14	2/8/2018	2BJMS214.35	361.68
RKF-14	8/23/2018	2BJMS214.35	112.66
HSR-02	7/19/2017	2BSLT000.73	53.55
HSR-02	2/8/2018	2BSLT000.73	121.95
TYE-03	9/17/2018	2-BUF002.10	2,104.40
MJR-23	10/11/2017	2-FIN000.81	96.82
MJR-21	11/15/2018	2-GEN000.51	164.21
HSR-13	10/30/2017	2-HRD000.36	111.34
MJR-01	7/13/2017	2-JMS111.17	131.72
MJR-01	2/12/2018	2-JMS111.17	1,628.83
MJR-01	8/29/2018	2-JMS111.17	89.13
MJR-01	11/6/2018	2-JMS111.17	584.89
MJR-04	8/29/2018	2-JMS112.33	145.83
MJR-04	11/6/2018	2-JMS112.33	336.12
MJR-05	8/28/2017	2-JMS117.35	112.26
MJR-05	2/12/2018	2-JMS117.35	880.93
MJR-05	8/30/2018	2-JMS117.35	138.49

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Subwatershed*	Date	Station	Observed Water Column tPCB (pg/L)
MJR-05	11/6/2018	2-JMS117.35	154.58
MJR-09	2/12/2018	2-JMS123.23	372.83
MJR-18	7/12/2017	2-JMS127.50	105.83
MJR-18	11/6/2018	2-JMS127.50	189.57
MJR-25	2/12/2018	2-JMS140.00	712.67
MJR-25	7/19/2018	2-JMS140.00	68.51
MJR-25	11/6/2018	2-JMS140.00	158.21
MJR-35	8/28/2017	2-JMS157.28	109.03
MJR-35	2/12/2018	2-JMS157.28	1,441.74
MJR-35	7/19/2018	2-JMS157.28	90.21
MJR-35	11/6/2018	2-JMS157.28	205.47
RKF-02	7/19/2017	2-JMS189.31	123.57
RKF-02	2/8/2018	2-JMS189.31	252.40
RKF-02	8/23/2018	2-JMS189.31	111.39
RKF-02	4/3/2019	2-JMS189.31	99.63
MJR-16	2/12/2018	2-LIY001.73	669.37
MJR-20	6/26/2018	2-NWD002.27	118.97
MJR-20	11/15/2018	2-NWD002.27	74.49
MJR-06	6/26/2018	2-PWT000.57	218.52
MJR-06	11/15/2018	2-PWT000.57	1,963.97
MJR-07	6/26/2018	2-PWT003.98	117.00
MJR-07	11/15/2018	2-PWT003.98	2,378.95
MJR-02	6/26/2018	2-RDD000.19	769.56
MJR-02	11/15/2018	2-RDD000.19	8,529.66
MJR-03	6/26/2018	2-RDD001.57	443.73
MJR-03	11/15/2018	2-RDD001.57	2,171.32
RVN-13	6/12/2018	2-RRN002.19	120.78
RVN-13	6/27/2019	2-RRN002.19	40.33
RVN-18	6/12/2018	2-RRS003.12	151.82
RVN-18	6/27/2019	2-RRS003.12	59.41
RVN-01	10/30/2017	2-RVN001.64	1,286.08
RVN-01	6/12/2018	2-RVN001.64	163.39
RVN-01	6/27/2019	2-RVN001.64	111.36
RVN-08	6/12/2018	2-RVN033.65	144.76
RVN-08	6/27/2019	2-RVN033.65	107.33
RVN-11	6/12/2018	2-RVN039.58	100.61
RVN-11	6/27/2019	2-RVN039.58	61.47
MJR-11	2/12/2018	2-TKO003.42	360.15
MJR-11	11/15/2018	2-TKO003.42	250.70

*Subwatershed designations for major tributaries: Hardware and Slate Rivers (HSR), Rockfish River (RKF), Rivanna River (RVN), Tye River (TYE), James River/Reedy Creek junction (MJR).

Appendix C: Source Assessment

C.1 Sources of PCBs

PCB sources are divided into several major categories: regulated (permitted) point sources, non-point sources that include contaminated sites, atmospheric deposition, and streambed sediments. Regulated point sources and contaminated sites are further subdivided.

C.1.1 Regulated / Permitted Point Sources

DEQ administers the Virginia Pollutant Discharge Elimination System (VPDES) Program that includes all point sources. Specific categories of point sources typically included in PCB TMDL Source Assessment studies involve municipal wastewater treatment plants (WWTP), industrial storm water general permitted facilities (ISWGP), individual industrial permitted facilities (IP), and Municipal separate storm sewer systems (MS4s) permits. Figure C-1 includes a listing of permit type and a flow matrix that is applied as specified in the calculation of baseline PCB loads and waste load allocations (WLAs).

Permit Type	Flow Used in Load Calculations
Municipal WWTPs	For Existing Load: Monthly Ave Flow (2008-2019)
	For WLA: Design Flow
Industrial Storm Water General Permits (ISWGPs)	Flow calculations based on outfall drainage acreage and impervious acreage
Individual Industrial	Process Water OR Comingled Process Water + Storm Water
	For Existing Load: Monthly Ave Flow (2008-2019)
	For WLA: Average of Daily Max Flow (2008-2019)
Storm Water	Flow calculations based on outfall drainage acreage and impervious acreage

Figure C-1. Flow matrix applicable to the different types of permits.

Municipal Wastewater Treatment Facilities

Table C-1 lists the active municipal wastewater treatment facilities in the James River study area as of December 2019 excluding those WWTPs described in Section 7.3.3 of the report, with the mean PCB concentration and TMDL endpoints used to calculate baseline PCB loads and WLAs, respectively. Equations 1 and 2 are used to derive the PCB loadings from continuously discharging outfalls such as municipal WWTPs or industrial WWTPs.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Eq. 1 $Existing\ Load\ (mg/yr) = Monthly\ Ave\ Flow\ (MGD) \times Ave.\ tPCB\ Conc.\ (pg/L) \times Conversion\ Factor$

Eq. 2 $WLA\ (mg/yr) = Design\ Flow\ (MGD) \times TMDL\ Endpoint\ (pg/L) \times Conversion\ Factor$

Where: Monthly Average Flow = Calibration period for TMDL Model

MGD = Million Gallons per Day

Conversion Factor (mg/yr) = 1.38

Table C-2 lists the municipal wastewater treatment plants that are no longer active in the James River study area. For active WWTPs where PCBs were not collected in advance of the TMDL development, default tPCB concentrations were used from a statewide dataset that are applicable to municipal outfalls (DEQ, 2016).

Table C-1. Active Municipal Wastewater Treatment Facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Mean tPCB Concentration (pg/L)	TMDL Endpoint (pg/L)
Jackson River	Covington City - Wastewater Treatment Plant	VA0025542	938.9	580
	Alleghany County - Low Moor WWTP	VA0027979	255.6	580
	Hot Springs Regional STP	VA0066303	1,707.1 ^a	580
	Alleghany Co - Lower Jackson River	VA0090671	1,707.1 ^a	580
	Regional WWTP			
Maury River	Buena Vista STP	VA0020991	1,707.1 ^a	400
	Lexington-Rockbridge Regional WQCF	VA0088161	1,707.1 ^a	400
	DOC - Augusta Correctional Center	VA0091821	250.3	400
Upper James River	Buchanan Town - Sewage Treatment Plant	VA0022225	183.3	120
	Lynchburg Regional Wastewater Treatment Plant	VA0024970	712.9	120
	Amherst Co Service Authority Ivanhoe	VA0063657	1,640.9	120
	Craig New Castle PSA WWTP Outfall 001	VA0064599	142.4	120
	Western Virginia Water Authority (WVWA) Eagle Rock WWTP Outfall 001	VA0076350	577.3	120
	Town of Glasgow WWTP	VA0083712	607.7	120
	Western Virginia Water Authority (WVWA) Glen Wilton WWTP	VA0089273	780.8	120
	James River Correction Center	VA0020681	1,707.1 ^a	52
	DOC Powhatan Correctional Center	VA0020699	1,707.1 ^a	52
	VA Correctional Center for Women	VA0020702	1,707.1 ^a	52
Lower James River	Scottsville WRRF	VA0025470	1,707.1 ^a	52
	Moore's Creek Advanced Water Resource Recovery Facility	VA0025518	1,707.1 ^a	52
	Buckingham Co Water System/Dillwyn STP	VA0027294	1,707.1 ^a	52
	Rutledge Creek WWTP	VA0031321	1,707.1 ^a	52
	DOC - Buckingham Correctional Center	VA0066460	1,707.1 ^a	52
	Glenmore WRRF	VA0086584	1,707.1 ^a	52
	Nelson County Regional STP	VA0089729	1,707.1 ^a	52
	Dutot Creek WWTP	VA0090727	17.7	52
	Oilville Wastewater Treatment Plant	VA0092428	1,707.1 ^a	52

^a Default tPCB concentration based on a statewide municipal dataset (DEQ, 2016).

Table 26. Inactive municipal wastewater treatment facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Mean tPCB Concentration (pg/L)
Jackson River	Clifton Forge Town Wastewater Treatment Plant	VA0022772	1,707.1 ^a
Lower James River	Camelot WWTP	VA0025488	1,707.1 ^a
^a Default tPCB concentration based on a statewide municipal dataset (DEQ, 2016).			

Two municipalities in the James River study area operate Combined Sewer Systems (CSSs), the City of Lynchburg and the City of Richmond. In older cities like these, the system for handling stormwater is often combined with the system for handling sewage. On most days, the sewage and stormwater are conveyed to the wastewater facility where it is treated before being discharged. However, because wastewater facilities have a maximum volume of water that can be treated over a given amount of time, during periods of heavy precipitation, the maximum volume of water that can be treated may be exceeded. When that volume is exceeded it leads to combined sewer overflows (CSOs) of untreated mixed sewage and stormwater are discharged. Both cities have entered into long-term control plans (LTCPs) that lay out the course for controlling these CSOs. Some of the LTCP activities include separating certain CSS outfalls to only discharge stormwater, adding storage capacity, and increasing treatment capacity at the wastewater facility. Given the evolving nature of these CSSs, the monthly CSO volumes for each CSS outfall over January 2008-December 2019 were used in the calculation of the baseline CSS PCB load. These flows were multiplied by a PCB concentration averaged from monitoring data at CSO outfalls during discharge events to derive the PCB load. The same concentration was multiplied by the LTCP goal overflow volume to calculate waste load allocations. The LTCP goal overflow volumes were derived independently for both the City of Lynchburg and the City of Richmond based on the models used to develop each City's LTCP. Table C-3 lists the CSSs in the James River Study Area, the area drained by each CSS, and the average annual overflow volume during the modeling period.

Table 27. Municipal Combined Sewer Systems (CSS) in the James River study area.

TMDL Watersheds	Combined Sewer System	Permit ID	Drainage Area (acres)	Average Annual Overflow (MG)	Mean tPCB Concentration (pg/L)
Upper James River	City of Lynchburg	VA0024970	1,137.4	55.2	159,265
Lower James River	City of Richmond ^a	VA0063177	11,098.9	2,240.2	11,906.68

^a Acreages and overflow values are based on the outfalls that drain into the Lower James River watershed. The outfalls that drain into the tidal portion of the James are not included.

Industrial Stormwater General Permitted Facilities (ISWGP)

Industrial Stormwater General Permitted Facilities that are receiving PCB WLAs as of December 2019 were selected by DEQ for this TMDL based on their SIC codes. The facilities regulated as an ISWGP generally have a smaller industrial footprint whereby the PCB loads are a direct function of stormwater runoff. The VPDES General Permit Regulation for Discharges of Stormwater Associated with Industrial Activity (9VAC25-151-70) formed the basis for the load derivation from these facilities. In determining the PCB concentration, an acreage-based weighted mean concentration was calculated when multiple SW outfalls existed and if available, included both actual PCB data and/or default PCB concentrations in the calculation. The PCB loads were derived by calculating the annual runoff from the facility (gal/yr), which is an attribute of the drainage areas (acres) associated with the industrial activity and impervious acreages and multiplying it by the PCB concentration at the outfall. The calculated ISWGP loads serve as a constant point source load to the model since the runoff/flow rate is an annual average, whereas the PCB load from the WWTP varies by month (DEQ, 2016). Table C-4 lists the active ISWGPs in the James River study area and the TMDL endpoint used to calculate the waste load allocation. Table C-5 lists the inactive ISWGP permits in the James River study area. As these former industrial sites are no longer permitted, residual PCBs can remain on site and be transported to the local impaired waterway. Therefore, the PCB loads originating from these sites were reallocated to the Contaminated site source category.

Table 28. Active Industrial Stormwater General Permit (ISWGP) facilities in the James River Study area

TMDL Watershed	Facility Name	Permit ID	No. of Outfalls	TMDL	
				Endpoint (pg/L)	
Jackson River	Chemtrade Solutions LLC - Covington	VAR050182	1	580	
	Material Handlings Solutions	VAR050440	6	580	
	Covington City - Peters Mountain Landfill	VAR051392	4	580	
	WestRock Virginia LLC - Low Moor	VAR052319	3	580	
	Converting Plant				
Maury River	Blue Ridge Resource Authority	VAR051408	1	400	
	Southers Auto Salvage LLC	VAR051827	4	400	
	Auto Recyclers LLC	VAR051901	1	400	
	Auto Towing and Repair LLC	VAR052111	1	400	
	City of Lexington Public Works Facility	VAR052411	2	400	
Upper James River	Virginia Auto Parts Incorporated	VAR050167	2	120	
	Candler Oil Company Incorporated	VAR050169	4	120	
	Davis-Frost Inc	VAR050172	1	120	
	Delta Star Incorporated	VAR050173	3	120	
	Crawford Oil Company Incorporated	VAR050181	1	120	
	Parker Hannifin Corporation - Powertrain Division	VAR050261	1	120	
	Flowsolve Lynchburg Operations	VAR050266	4	120	
	Schwerman Trucking Company	VAR050270	1	120	
	Hanwha Azdel	VAR050391	3	120	
	United Parcel Service Inc - Lynchburg	VAR050447	2	120	

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TMDL Watershed	Facility Name	Permit ID	No. of Outfalls	TMDL Endpoint (pg/L)
Lower James River	WestRock Converting LLC	VAR050524	7	120
	Republic Services of Lynchburg	VAR050710	2	120
	Botetourt County Landfill	VAR050712	3	120
	Cooper Steel of Virginia LLC	VAR050737	4	120
	Amherst County Landfill Permit Number 563	VAR051354	1	120
	Rolling Frito-Lay Sales LP - Lynchburg Bin	VAR051551	1	120
	International Paper Company	VAR051585	3	120
	KDC/One Lynchburg	VAR051906	5	120
	Sonoco Recycling LLC - Madison Heights	VAR051959	1	120
	Region 2000 Regional Landfill - Livestock Rd Fac	VAR051994	2	120
	Watts Petroleum Corporation - Lynchburg	VAR052022	1	120
	Banker Steel Company LLC	VAR052109	3	120
	Madison Heights Auto Parts	VAR052182	6	120
	Griffin Pipe Products Co LLC - Lynchburg	VAR052212	4	120
	Porters Properties Lynchburg LLC	VAR052226	1	120
	Foss Industrial Recycling LLC - Lynchburg	VAR052309	4	120
	Munters - Natural Bridge Station	VAR052383	2	120
	AOC Metal Works - Lynchburg	VAR052393	2	120
	BRC Investments LLC	VAR052403	2	120
	Slocum Adhesives Corporation	VAR052456	2	120
	Clear Water Manufacturing	VAR052508	1	120
	Slocum Adhesives Corporation- Carroll Ave	VAR052530	3	120
	Glad Manufacturing Company	VAR050222	2	52
	Brooks Auto Sales	VAR050630	1	52
	UPS Freight- Richmond	VAR050657	1	52
	623 Landfill	VAR050730	7	52
	United Parcel Service - Charlottesville	VAR050780	2	52
	BFI Fluvanna Transcylery	VAR050820	3	52
	M and M Service and Salvage Yard Incorporated	VAR050960	1	52
	Harry A Wright's Inc	VAR050965	1	52
	Ivy Materials Utilization Center	VAR050973	6	52
	Republic Services of Charlottesville	VAR050974	1	52
	Chesterfield Auto Parts	VAR051102	2	52
	Mullite Plant	VAR051580	1	52
	Van Der Linde Recycling	VAR051853	2	52
	Buckingham Branch Railroad	VAR051926	1	52
	County Line Auto Parts	VAR052030	2	52
	Morris Industries Incorporated	VAR052269	1	52
	Tenaska Virginia Generating Station	VAR052356	2	52
	Panorama Paydirt	VAR052458	8	52

Table 29. Inactive Industrial Stormwater General Permit (ISWGP) facilities in the James River Study Area.

TMDL Watershed	Facility Name	Permit ID	No. of Outfalls
Jackson River	Bath Co Solid Waste Transfer Stn Closed Landfill	VAR051406	3
	Gerdau - Covington	VAR051976	1
Upper James River	CR Hudgins Plating Incorporated	VAR050262	2
	LSC Communications Inc - Lynchburg	VAR050527	3
	Region 2000 Services Authority - Concord Turnpike	VAR051355	2
	DeGe Incorporated Miscellaneous Metal Fabricators	VAR051586	1
	CD Auto Recycling	VAR051763	1
	Harold Beasley Inc	VAR051902	1
	F Wayne Graves Oil Company Inc	VAR052021	2
	Former CA Recycling and National Battery Co	VAR052385	1
	Cosner Brothers Auto Parts Inc	VAR050825	6
	Greene County Transfer Station	VAR051618	3
Lower James River	CARR Service Center	VAR051730	6
	M & M Service & Salvage Yard Inc - East	VAR052274	1

Individual Industrial Permitted Facilities (IP)

The loads from IPs are calculated using a combination of the two previous methods. These facilities often feature multiple outfalls that may be one of two types, process/comingled (P/C) or stormwater (SW), where P/C includes process water outfalls and process water outfalls that are comingled with stormwater. For active IPs as of December 2019, the load from P/C outfalls were calculated similarly to municipal wastewater treatment facilities (see Equations 1 and 2 above) in which the DMR monthly average flows were multiplied by the PCB concentration at the outfall. Like the active permits, PCB load from P/C outfalls at IPs that are no longer active were calculated using the PCB concentration and the average monthly flow rate-included in the DMR for the period of permit activity between January 2008 and December 2019. The loads from SW outfalls were calculated similarly to the ISWGPs in which they were calculated as a function of facility area, runoff, and PCB concentration. Once calculated, PCB loadings at facilities where outfalls were limited to the P/C type were summed to reflect the baseline and WLA load for the combined outfalls. For those facilities that included both P/C outfalls and SW outfalls, the calculated loads were summed to yield a single baseline load and WLA. For both active and historically active SW IP outfalls, the loads were only modeled for the period of permit activity. The load from each outfall was input into the model as a point source. For both active and historically active permits, if PCB concentration data was not collected in advance of the TMDL development, default tPCB concentrations were used from a statewide dataset based on the appropriate Standard Industrial Classification (DEQ, 2016). In determining the PCB concentration for SW outfalls, an acreage-based weighted mean concentration was

calculated when multiple SW outfalls existed and if available, included both actual PCB data and/or default PCB concentrations in the calculation. **Error! Reference source not found.** lists the active IPs in the James River study area with the TMDL endpoints used to calculate waste load allocations. Outfall number, mean tPCB concentration, and whether the outfall was process/comingled, or stormwater are also listed. Table C-7 lists the IPs that are no longer active in the James River study area with the outfall number and the mean PCB concentration used to calculate historical PCB load. Similar to the ISWGP's, the PCB loads originating from these sites were reallocated to the Contaminated site source category as residual PCBs can remain on site and continue to be transported to the local impaired waterway.

Table 30. Active Individual Industrial Permitted (IP) facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Outfall #	Type of Outfall	Mean tPCB Concentration (pg/L)	TMDL Endpoint (pg/L)
Jackson River	WestRock Virginia LLC - Covington	VA0003646	003	P/C	1,532.9	580
			004	SW	429	580
			009	SW	429	580
			010	SW	429	580
			012	SW	429	580
			013	SW	429	580
			015	SW	429	580
			001	P/C	1,030.8	580
			006	P/C	125.4 ^a	580
			007	P/C	125.4 ^a	580
			008	P/C	125.4 ^a	580
			009	P/C	125.4 ^a	580
			014	P/C	125.4 ^a	580
			015	P/C	125.4 ^a	580
			030	P/C	125.4 ^a	580
Maury River	Modine Manufacturing Co - Buena Vista Mohawk Industries Inc	VA0002771 VA00004677	001	P/C	19,234.5	400
			001	P/C	560,411.0 ^a	400
			002	SW	560,411.0 ^a	400
			003	SW	560,411.0 ^a	400
			005	SW	560,411.0 ^a	400
			006	SW	560,411.0 ^a	400
			007	SW	560,411.0 ^a	400
			008	SW	560,411.0 ^a	400
			009	SW	560,411.0 ^a	400
			001	P/C	1,532.9 ^a	400
			002	P/C	1,532.9 ^a	120
			003	P/C	3,261.1	120
			005	SW	2,677.3 ^a	120
			012	SW	2,677.3 ^a	120
			014	SW	2,677.3 ^a	120
Upper James River	GP Big Island LLC	VA0003026	015	SW	2,677.3 ^a	120
			017	SW	2,677.3 ^a	120
			001	P/C	1,532.9 ^a	400
			002	P/C	1,532.9 ^a	120
			003	P/C	3,261.1	120
			005	SW	2,677.3 ^a	120
			012	SW	2,677.3 ^a	120

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TMDL Watershed	Facility Name	Permit ID	Outfall #	Type of Outfall	Mean tPCB Concentration (pg/L)	TMDL Endpoint (pg/L)
BWXT Nuclear Operations Group Inc		VA0003697	018	SW	2,677.3 ^a	120
			021	SW	2,677.3 ^a	120
			022	SW	2,677.3 ^a	120
			023	SW	2,677.3 ^a	120
			025	SW	2,677.3 ^a	120
			028	SW	2,677.3 ^a	120
			555 ^b	SW	2,677.3 ^a	120
			001	P/C	1,597.1	120
			002	SW	4,846	120
			003	SW	4,846	120
			004	SW	4,846 ^a	120
			005	SW	4,846 ^a	120
Framatome Inc - MAR		VA0004774	006	SW	4,846 ^a	120
			007	SW	4,846 ^a	120
			008	SW	4,846 ^a	120
			009	SW	4,846 ^a	120
			010	SW	4,846 ^a	120
			011	SW	4,846 ^a	120
			001	P/C	438	120
			004	P/C	2.5	120
			001	P/C	1,084.8	120
			002	SW	1,532.9 ^a	120
			003	SW	1,532.9 ^a	120
			004	SW	1,532.9 ^a	120
Greif Riverville LLC - Fibre Plant		VA0006408	005	SW	1,532.9 ^a	120
			006	SW	1,532.9 ^a	120
			007	SW	1,532.9 ^a	120
			008	SW	1,532.9 ^a	120
			009	SW	1,532.9 ^a	120
			010	SW	1,532.9 ^a	120
			011	SW	1,532.9 ^a	120
			012	SW	1,532.9 ^a	120
			001	P/C	915 ^a	120
			002	P/C	915 ^a	120
			003	P/C	915 ^a	120
			004	P/C	915 ^a	120
Roanoke Cement Co - Botetourt County		VA0072397	005	P/C	915 ^a	120
			007	P/C	915 ^a	120
			008	SW	915 ^a	120
			009	SW	915 ^a	120
			010	SW	915 ^a	120
			011	SW	915 ^a	120
			012	SW	915 ^a	120
			001	P/C	915 ^a	120
			002	P/C	915 ^a	120
			003	P/C	915 ^a	120
			004	P/C	915 ^a	120
			005	P/C	915 ^a	120
Reusens Hydroelectric Plant		VA0087114	007	SW	915 ^a	120
			011	SW	915 ^a	120
			001	P/C	2,461.4 ^a	120
			002	P/C	2,461.4 ^a	120
			003	P/C	2,461.4 ^a	120
			004	P/C	2,461.4 ^a	120
			005	P/C	2,461.4 ^a	120
			006	P/C	1,036.9	120
			007	SW	3,684.9	120
			002	P/C	67.6	52
			006	SW	2,461.4 ^a	52
			008	SW	2,461.4 ^a	52
Lower James River	Dominion - Bremono Power Station	VA0004138 ^c	001	P/C	47,347.0 ^a	52
			001	P/C	1,738.6 ^a	52
			003	P/C	1,738.6 ^a	52

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

TMDL Watershed	Facility Name	Permit ID	Outfall #	Type of Outfall	Mean tPCB Concentration (pg/L)	TMDL Endpoint (pg/L)
Jackson River	Dominion Energy - Bear Garden Generating Station	VA0090891	001	P/C	125.4 ^a	52
			002	SW	125.4 ^a	52
Upper James River	Tenaska Virginia Generating Station	VA0090905	004	P/C	125.4 ^a	52

^a Default tPCB concentration based on a statewide Standard Industrial Classification (SIC) dataset (DEQ, 2016).

^b Outfall 555 accounts for four total outfalls. These include 007, 009, 010, 013.

^c Baseline loads include six total outfalls. There were seven outfalls removed in 2020. Three of those had historical discharges and were counted in the baseline loads.

Table 31. Inactive individual industrial permitted (IP) facilities in the James River study area.

TMDL Watershed	Facility Name	Permit ID	Outfall #	Type of Outfall	Mean tPCB Concentration (pg/L)
Jackson River	CSX Transportation Inc - Clifton Forge Rail Over River Industrial Park LLC	VA0003344	001	P/C	3,063.5 ^a
		VA0003450	001	P/C	34.3 ^a
			002	P/C	34.3 ^a
Upper James River	VCI Lynchburg Foundry	VA0006262	001	P/C	14,670.6 ^a
			002	P/C	14,670.6 ^a
			003	SW	14,670.6 ^a
			004	SW	14,670.6 ^a
			005	SW	14,670.6 ^a
Lower James River	Campbell County Landfill	VA0091723	001	P/C	1,738.6 ^a
			002	P/C	1,738.6 ^a
		VA0092258	001	P/C	44.7
Lower James River	Orange Madison Cooperative Farm Service	VA0087351	001	P/C	822.1 ^a

^a Default tPCB concentration based on a statewide Standard Industrial Classification (SIC) dataset (DEQ, 2016).

In addition to the permitted facilities listed in the preceding tables, there are eleven municipal separate storm sewer systems (MS4s, **Error! Reference source not found.**) in the study area. These are municipal regions that convey impervious surface stormwater runoff from within their boundary through a permitted discharge point. MS4s are responsible for the PCB load in their runoff that is discharged through their stormwater conveyance system.

Table 32. MS4s in the James River PCB TMDL study area.

MS4 Entity	Permit Number	Service Area (acres) ^a
Albemarle County	VAR040074	14,167
Central Virginia Community College	VAR040118	32
Charlottesville City	VAR040051	5,733
Chesterfield County	VA0088609	4,678
Department of Juvenile Justice	VAR040128	51
Henrico County	VA0088617	20,835
Lynchburg City	VAR040008	7,834
Piedmont Virginia Community College	VAR040108	60
Richmond City	VA0063177	9,975
University of Virginia	VAR040073	1,198
Virginia Department of Transportation	VA0092975	6,426

^a in some areas, MS4 drainage areas may overlap.

C.1.2 Nonpoint Sources

The nonpoint PCB sources considered when developing a PCB TMDL include several subcategories of contaminated sites, atmospheric deposition and streambed sediment. Properties that are often associated with PCB contamination can include Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA) known as Superfund sites, Resource Conservation Recovery Act (RCRA) Corrective Action (CA) facilities, Brownfield sites, and sites enrolled in DEQ's Voluntary Remediation Program (VRP). Additional subcategories include sites remediated for PCBs with EPA oversight under the Toxics Substances Control Act (TSCA), railyards/railway spurs, electrical substations, and sites with possible PCB spills.

Contaminated sites and railyards were assigned a specific "contaminated" land use type that is similar hydrologically, pedologically (soil classification) and geophysically to the existing land use types (e.g., Commercial, Industrial). The sediment runoff from the "contaminated" land uses included an associated PCB load because PCBs adsorb to sediment. The contributing areas associated with the unspecified surface runoff load were not assigned specific land use types, but their sediment runoff still included a PCB load. PCB spills were modeled as direct inputs into the stream or as deposition onto the land surface. **Error! Reference source not found.** lists the nonpoint sources considered in the James River PCB TMDL.

Table 33. James River nonpoint PCB sources.

Nonpoint Sources	PCB Load
Contaminated Sites	
Volunteer Remediation Program Sites	Varies by site
Railyards and Railway Spurs	7.02 x 10 ¹⁰ pg PCB/ton of sediment
Electrical Substation	1.29 x 10 ¹² pg/PCB/ton of sediment
Pollution Response Program (PREP) Spills	Varies by Spill
Surface Sources	
Unspecified Surface Sources ¹	Varies by land use category
Atmospheric Deposition	8.90 x 10 ³ pg/m ² /year
Streambed Sediment	Varies by stream segment

¹ Unspecified surface sources represent PCB loads supported by the observed data whose specific location have yet to be identified.

Contaminated Sites

For purposes of this study, those properties and sites where PCBs have been identified as a contaminant of concern or potential concern were included. No CERCLA, RCRA Corrective Action, Brownfield or VRP sites (except the former 2.7 acre Buick Property which was fully remediated) were identified in the study as contributing PCBs and included as contaminated sites. Other categories of contaminated sites are described in the following sections.

Railyards and Railway Spurs

Railyards and railway spurs are included as PCB sources because the EPA allows continued operation of older train engine transformers that still use PCB fluids. When trains containing PCBs are idled for extended periods on unused rail lines, PCBs may leak onto the ground and contaminate the soil. A review of other PCB TMDLs developed in Virginia indicated that railyards were previously included as potential sources. The Roanoke River PCB TMDL (DEQ, 2009) included two sites as source areas: Shaffers Crossing (VPDES-permitted railyard) and Norfolk Southern 12. Shaffers Crossing was modeled as a point source, but the Norfolk Southern yard was treated as a nonpoint source. Permitted PCB point source data for the James River did not include any railyards, but analysis of satellite imagery revealed several railyards and railway spurs throughout the James River study area (**Error! Reference source not found.**). Railyards and railway spurs were modeled as nonpoint sources and were assigned specific PCB contaminated land uses and loads. Since soil tests were not conducted at most railyards and railway spurs, PCB load rates were adopted from the Roanoke River PCB TMDL.

Table 34. Contaminated sites identified as Railyards, Railway Spurs in the James River study area.

TMDL Watershed	Site Description	Receiving Body	Estimated Area (ac)
Jackson River	Railway spur 19	Jackson River	10.9
	Railway spur 20	Jackson River	196.2
	Railway spur 21	Jackson River	34.4
	Railway spur 22	Dunlap Creek, Jackson River	18.8
	Railway spur 23	Dry Run, Jackson River	10.9
	Railway spur 25	Jackson River	6.1
Maury River	Railway spur 18	Unnamed Trib to Maury River	4.7
	Railway spur 19	Maury River	5.2
	Railway spur 26	Brattons Run, Unnamed Trib to	1.7
		Calfpasture River	
Upper James River	Railway spur 8	Unnamed Tribs (3x) to James River	19.8
	Railway spur 9	James River	1.5
	Railway spur 10	Unnamed Trib to James River, James	37.3
		River, Fishing Creek	
	Railway spur 11	James River	30.5
	Railway spur 12 ^b	Fishing Creek, Unnamed Trib to	191.0
		Fishing Creek,	
	Railway spur 13	Unnamed Trib to Tomahawk Creek	3.4
	Railway spur 14	Unnamed Trib to Blackwater Creek	1.4
	Railway spur 15	James River	85.0
	Railway spur 16	Unnamed Trib to Harris Creek	2.4
	Railway spur 24	Unnamed Trib to Catawba Creek	16.7
	Rail Station 2	Unnamed Trib to Blackwater Creek	2.3
Lower James River	Norfolk Southern and	James River	40.7
	Railway Spur 10		
	Norfolk Southern	James River, Kanawha Canal	0.9
	Railway spur 1	Unnamed Trib to James River	6.5

TMDL Watershed	Site Description	Receiving Body	Estimated Area (ac)
	Railway spur 2	James River	3.4
	Railway spur 4	Unnamed Trib to James River	12.7
	Railway spur 5	Joshua Creek	2.76
	Railway spur 6	Unnamed Trib to Gold Mine Branch	1.1
	Railway spur 7	Unnamed Trib to Whispering Creek	3.2
	Railway spur 8	James River	24.4
	Railway spur 17	Unnamed Trib to Rivanna River	7.6
	Railway station 1	Unnamed Trib to Moores Creek	2.3

Railyards and railway spurs in the James River PCB TMDL study area were identified using Google Earth historical satellite imagery. Railroad lines were visually traced until a railyard or possible railway spur was identified. Key indicators of a railway spur were rail lines that diverted off the main track before ending abruptly and/or the presence of secondary and tertiary tracks. These extra rail lines were potentially used for maintenance purposes. The satellite imagery of these sites typically showed rail tie storage, indicating the possibility of railway machinery being present. If these sites were used for storage, PCBs may have leached into the soil. Locations with a large confluence of rail lines and noticeable railway activity were designated as railyards.

Several manufacturing and industrial facilities were also identified as railway spurs if it was determined from satellite imagery that rail lines and parcels of land adjacent to these rail lines were storing train cars and cargo for extended periods. The assumption is that when left stationary, trains and/or their cargo leach PCBs into the soil.

Spills and leaks by locomotives occasionally occurred when they were outside of the railyard and railway spur boundaries. Records of these incidents were recorded in DEQ's Pollution Response Program (PREP) database. These incidents were used to generate one-time loads of PCBs. Further information on PREP incidents is provided in its respective section below.

Electrical Substations

Electrical substations are part of an electrical generation, transmission, and distribution system that are used to convert voltage from high to low (or the reverse) through the use of electrical transformers. The equipment associated with this function historically contained dielectric fluids that contained high levels of PCBs. One hundred eighteen electrical substations totaling 125.53 acres were identified in the James River study area. The average area of a substation was 1.06 acres with a range from 0.02 to 9.69 acres. The applied loading rate was based on data provided by Dominion Energy and Appalachian Power for previous PCB TMDL studies (ICPRB, 2007; DEQ, 2018) and was estimated at 1.29×10^{12} (pg/ton).

Former Industrial Sites/Inactive permits

Former industrial sites that are no longer permitted under the ISWGP or IP VPDES categories, have been included in the contaminated site category as residual PCBs can remain on site long after the industrial activities have ceased. During periods of rainfall remaining PCBs can be transported off-site to the local impaired waterway and for this reason PCB loads originating from these sites were reallocated to the Contaminated site source category.

Pollution Response Program (PREP) PCB Spills

The Pollution Response Program (PREP) database is managed by DEQ and tracks pollution incidents that result in potential human health or environmental impact. Agencies, businesses, or individuals report the incidents to DEQ who dispatch personnel to investigate the report. Entries in the database may include improper liquid or solid waste disposal, leakages, sewer overflows, legal or illegal burnings, or unidentified contaminants visible in a stream. DEQ reviewed the database entries for incidents in the James River study area that occurred during the modeling period. The database was pared down to oil spills since PCBs are commonly found in oils. Database entries that noted the oil was non-PCB was ignored in the report.

In the model, PREP incidents were simulated as one-time localized events. If a duration was not provided in the PREP database, it was estimated using best professional judgement. The PREP spills were often listed as a volume. Given the fact that many of the spills were in the form of oil, it was assumed that the density of the liquid spills was 0.9 kg/L (less than the density of water). The assumed concentration of PCBs in the oil was 0.05%, which is conservative for spills from an unknown origin (DEQ, 2018). Locations of the spill incidents, in addition to the details for the estimated quantities of PCBs (mg) released from each spill incident, were included in the model. For incidents with spills of unknown quantity, the modeled PCB load was based on an estimated spill volume of one gallon.

Unspecified Surface Runoff

Unspecified surface runoff is a term that collectively accounts for PCB loadings from an uncertain origin found within regulated and non-regulated areas that drain to the James River watershed. Unspecified surface drainage includes areas adjacent to the James, Jackson and Maury Rivers and their associated tributaries that are recognized as contributing PCB loads. These areas contribute background PCBs associated with atmospheric deposition to the land surfaces as well as unknown or uncharacterized PCB contaminated sites (including past spill sites), unspecified stormwater runoff from commercial land use areas, loads from small tributaries that are not explicitly specified in the model, and unspecified point source discharges.

Sources represented by this category include PCB loads supported by the observed instream data whose specific location have yet to be identified.

C.1.3 Atmospheric Deposition

Due to their molecular stability, PCBs persist in the atmosphere after volatilization and may contaminate waterbodies through direct deposition onto the water surface or by runoff after deposition onto the land surface. Atmospheric deposition was applied on all water surfaces in the James River study area at a constant rate. Atmospheric deposition on the water surface immediately enters the water column as a freely available pollutant constituent. Since there are no available data to characterize the atmospheric deposition of tPCBs to the surface waters, Virginia Tech Biological Systems Engineering (BSE) elected to use a PCB atmospheric deposition rate of 3.0×10^6 pg/ac/month applied across the James River study area. This rate corresponds with results in the Roanoke River and New River PCB TMDLs. When PCBs are deposited onto the land surface they adsorb to soil particles but do not enter into the stream network until a precipitation event induces a runoff event that carries soils with the adsorbed PCB contamination into a stream. Atmospheric deposition to the land surface was modeled as part of the non-regulated watershed runoff.

C.1.4 Streambed Sediment

The historical discharges of PCBs into the water combined with the ability of PCBs to persist in the environment and their tendency to adsorb to sediment particles make sediment within stream channels a major source of PCBs. Due to their hydrophobic properties, PCBs adsorb to sediment particles. PCBs have a higher tendency to associate at elevated concentrations with finer sediment particles, which have more surface area and higher carbon content, such as clay and silt rather than coarser particles like sand. PCB contaminated sediment may settle to the streambed, but when disturbed the sediment may re-suspend into the water column and the soil-attached PCBs may desorb into the water. Streambed sediment sampling by DEQ has shown measurable concentrations of PCBs in James River. The sediment PCB concentrations in these observed samples were used in the James River PCB model to provide initial concentrations of PCBs associated with sediment.

C.2 References

DEQ. 2009. Roanoke River PCB TMDL Development (Virginia). Prepared for United States Environmental Protection Agency, Region 3. December 2009.

- DEQ. 2016. The Relationship between Polychlorinated Biphenyls (PCBs), VPDES Wastewater/Stormwater Facilities, Stormwater Industrial General Permitted Facilities (ISWGP), and the Standard Industrial Classification System (SIC). Virginia Department of Environmental Quality. February 2016.
- DEQ. 2018. PCB Total Maximum Daily Load Development for Reed Creek, the Upper New River, Peak Creek, Walker Creek, Stony Creek, and the Lower New River. Prepared by Department of Biological Systems Engineering, Virginia, Tech. July 2018.
- ICPRB (Interstate Commission on the Potomac River Basin). 2007. Total Maximum Daily Loads of Polychlorinated Biphenyls (PCBs) for Tidal Portions of the Potomac and Anacostia Rivers in the District of Columbia, Maryland, and Virginia. Prepared by The Interstate Commission on the Potomac River Basin (ICPRB). October 2007.

Appendix D: Hydrologic Calibration for the James River PCB TMDL Study Area

Model calibration is the process of selecting model parameters that provide an accurate representation of the watershed. In this section, we discuss the procedures followed to calibrate and validate the hydrology component of the Hydrological Simulation Program-FORTRAN (HSPF) model. Hydrologic calibrations and validations were performed for the Jackson and Maury River TMDL watersheds, while calibrations and validations were performed for multiple segments in the Upper and Lower James River TMDL watersheds. Within Appendix D each calibration segment is presented in its own section. Locations of the James River study area and flow gages are shown in Figure 2-8.

The Enhanced Expert System for calibration of HSPF (HSPEXP+) was used to aid in model calibration. HSPEXP+ uses the EXS file (*.exs") to obtain information about the calibration site, observed flow time-series dataset, simulated time-series datasets, analysis period, drainage area, storm periods, and model performance criteria. For this project, VADEQ guidance specifies the performance criteria listed in Table D-1 be used when assessing model performance during the calibration and validation periods.

Table D-1. Model performance criteria specified by DEQ.

Variable	Percent Error
Total Volume	±10%
50% Lowest Flows	±10%
10% Highest Flows	±15%
Storm Peaks	±15%
Seasonal Volume Error	±10%
Storm Volume Error	±20%

D.1 Jackson River Hydrologic Model

Observed daily flow data for the Jackson River were available from USGS monitoring station 01033100 (Dunlap Creek at Covington, VA). Daily flow data were used in the hydrologic calibration/validation. Meteorological data was obtained primarily from the Hot Springs, VA observation station (USC00444128) from National Centers for Environmental Information (NCEI).

The hydrologic calibration and validation periods were from January 1, 2000 to December 31, 2004, and January 1, 2009 to December 31, 2013, respectively. The model was

calibrated and validated using daily average flow in cubic feet per second (cfs). The HSPF model was run until the simulated and observed flow met the criteria presented in Table D-1. The final calibration parameters were within the recommended ranges found in EPA's BASINS Technical Note 6 (USEPA, 2000).

Figure D-1 and Figure D-2 show that the simulated flow for both the calibration and validation matched the observed flow well, although the model over predicted some of the peaks during both the calibration and validation periods. The agreement between the model simulated and observed flows is further illustrated in Figure D-3 and Figure D-4 for a representative year, and Figure D-5 and Figure D-6 for a representative storm. The model was able to capture representative storms, and annual flows during the calibration and validation periods.

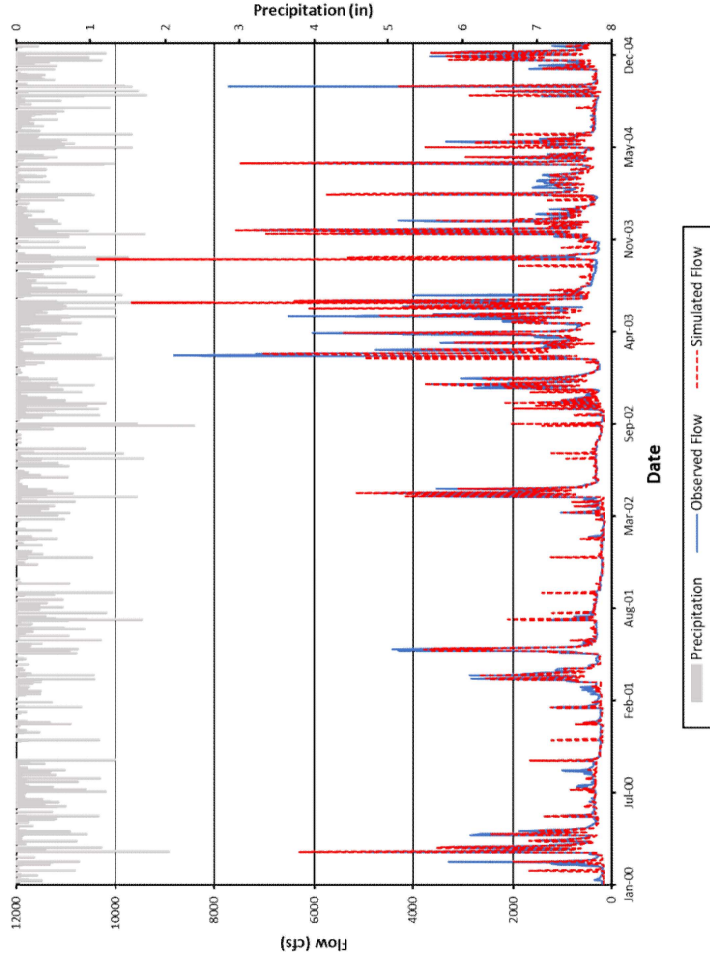


Figure D-1. Observed and simulated flows and precipitation for the Jackson River during the calibration period.

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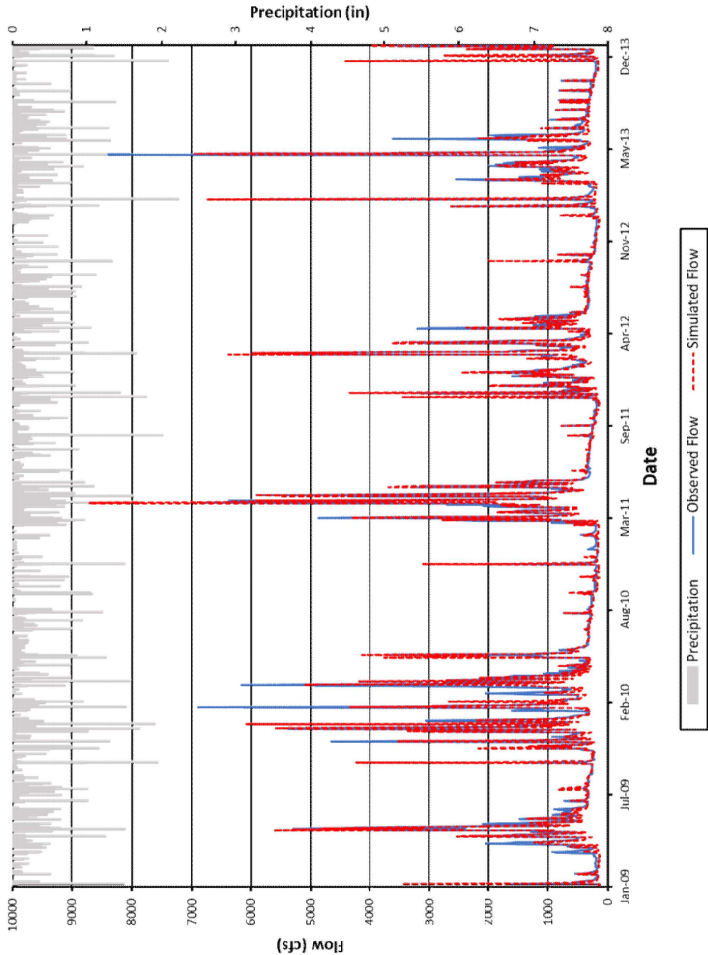


Figure D-2. Observed and simulated flows and precipitation for the Jackson River during the validation period.

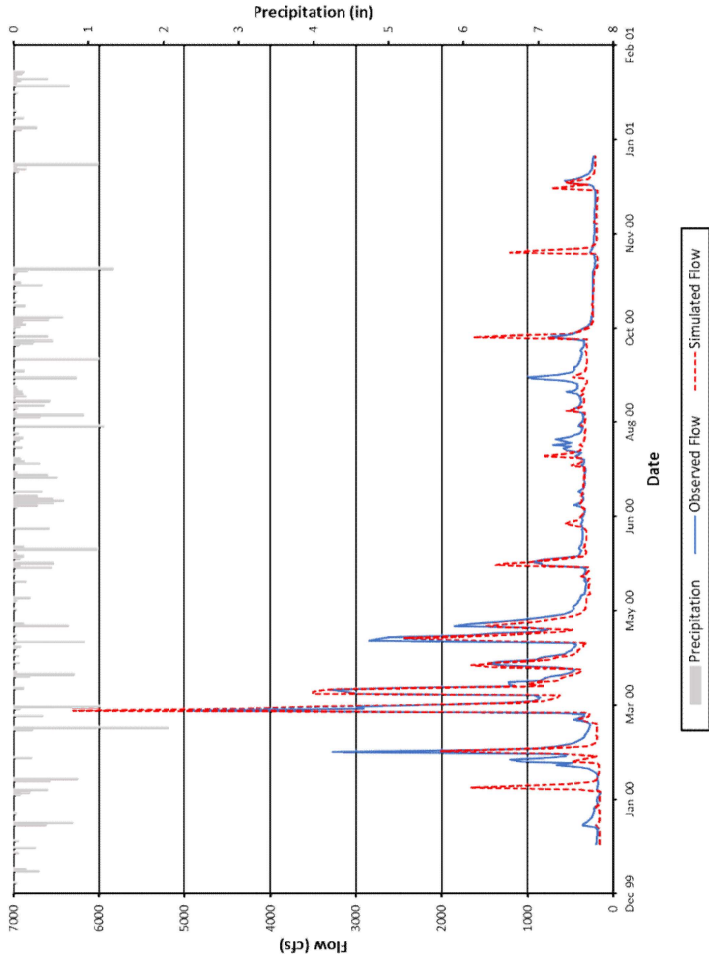


Figure D-3. Observed and simulated flows and precipitation for a representative year (2000) in the calibration period for the Jackson River.

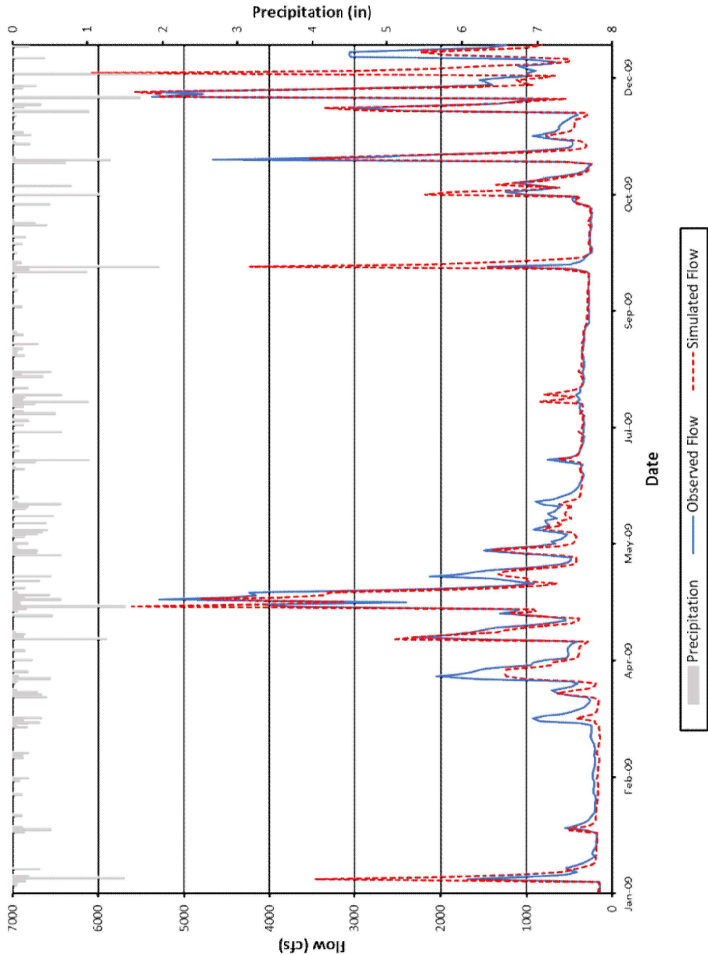


Figure D-4. Observed and simulated flows and precipitation for the Jackson River during a representative year (2009) in the validation period.

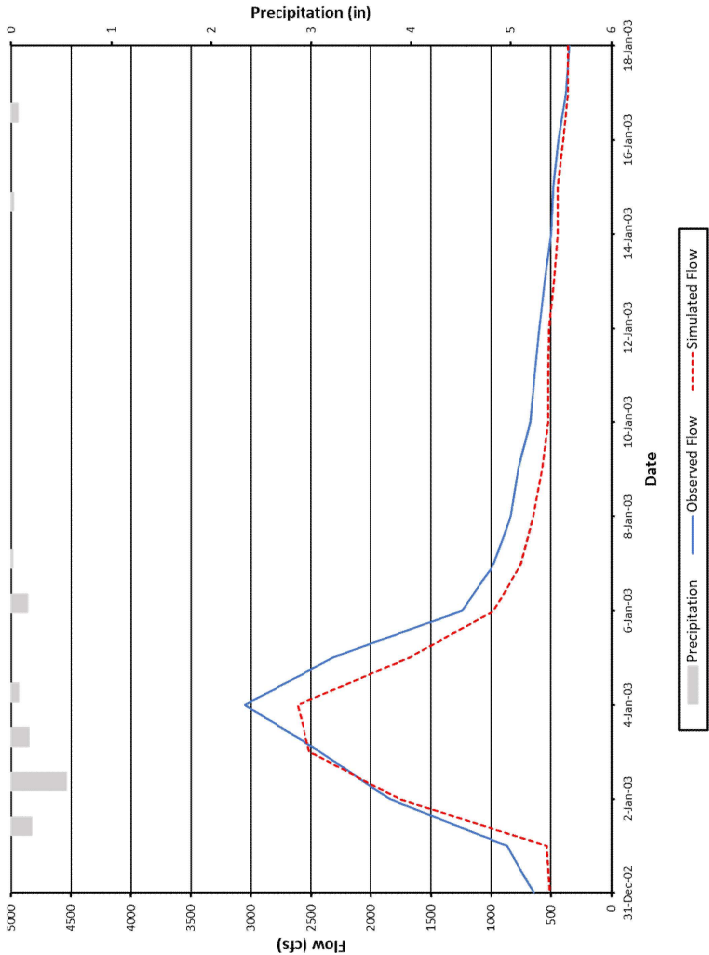


Figure D-5. Observed and simulated flows and precipitation for the Jackson River for a representative storm in the calibration period.

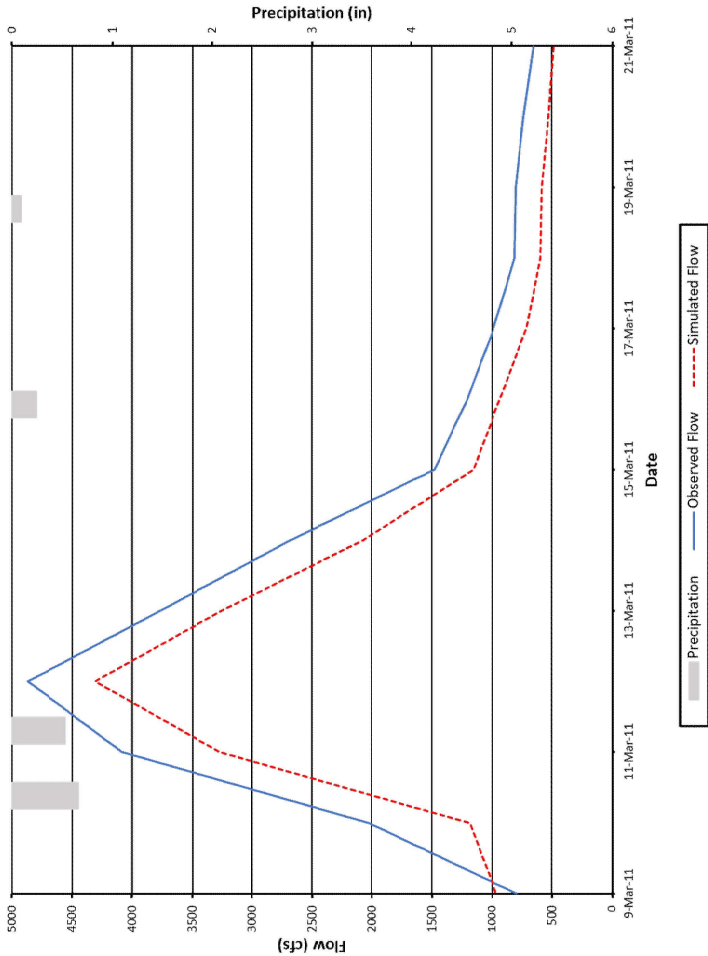


Figure D-6. Observed and simulated flows and precipitation for the Jackson River for a representative storm in the validation period.

Figure D-7 and Figure D-8 illustrate model agreement with observed data using cumulative frequency curves. The model adequately captured cumulative frequency for both calibration and validation periods.

Selected diagnostic outputs from the HSPEXP+ program is listed in Table D-2 and Table D-3. Percent errors for all the diagnostic outputs were within the allowable error criterion limits for both the calibration and validation periods.

When the observed flow data were evaluated using the Baseflow Filter program (Arnold et al., 1995), the range of baseflow indices was 0.40 to 0.62. The simulated baseflow indices are within the range of baseflow indices for the observed flow data, and the simulated indices are comparable to the observed median index. The final calibrated hydrologic parameters can be found in Table D-4.

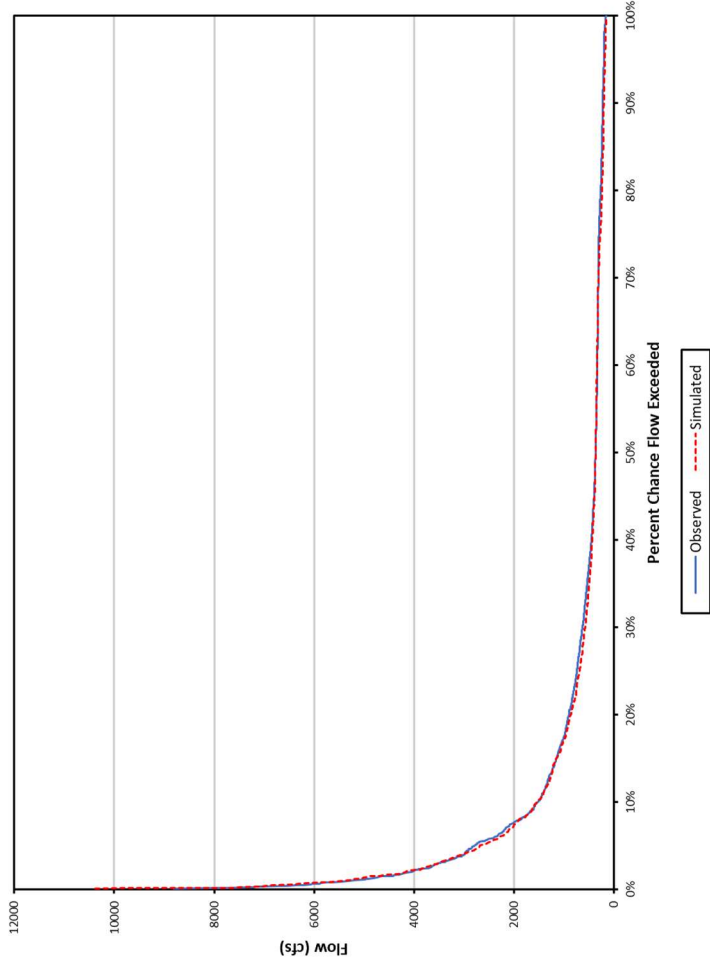


Figure D-7. Cumulative frequency curves for the calibration period for the Jackson River.

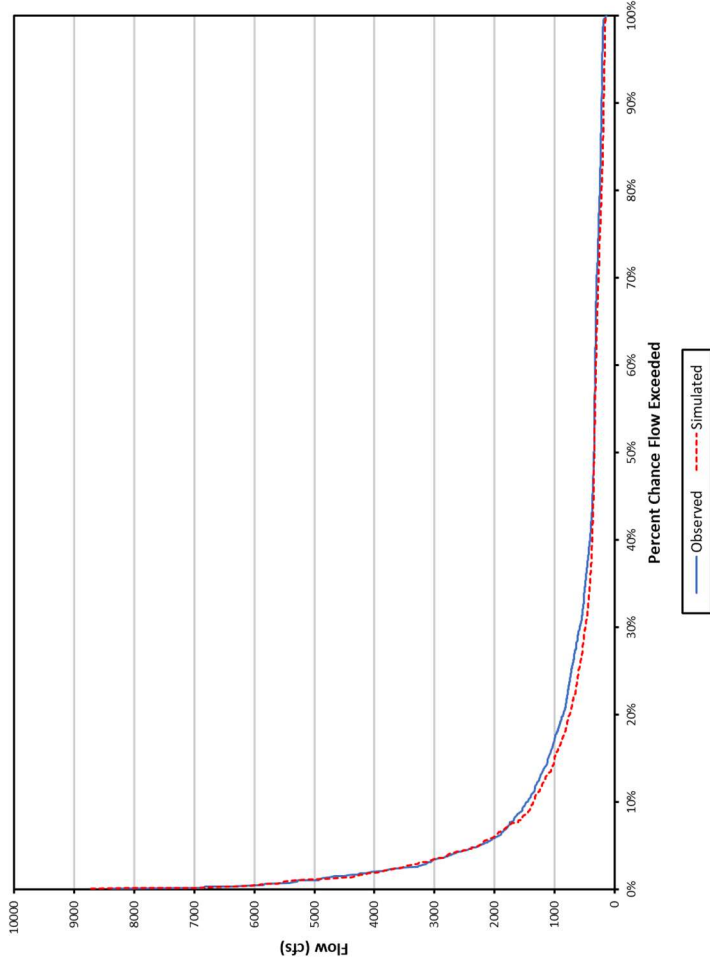


Figure D-8. Cumulative frequency curves for the validation period for the Jackson River.

Table D-2. Summary statistics for the calibration period for the Jackson River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)	79.616	81.287	-2.1	±10%
Average Annual Total Runoff (in)	15.923	16.257	-2.1	±10%
Total of Highest 10% of flows (in)	34.120	34.506	0.8	±15%
Total of Lowest 50% of flows (in)	14.853	15.369	-4.0	±10%
Total Winter Runoff (in)	18.642	19.527	-4.5	n/a
Total Summer Runoff (in)	15.981	14.769	8.2	n/a
Total Seasonal Volume Error	–	–	12.7	±20%
Storm Peaks (cfs)	1,799.3	2,104.7	-14.5	±15%
Total Storm Volume (<i>selected storms</i>) (in)	15.387	17.371	-11.4	±20%
Coefficient of Determination, r ²	0.92			

Table D-3. Summary statistics for the validation period for the Jackson River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)	71.143	76.096	-6.5	±10%
Average Annual Total Runoff (in)	14.229	15.219	-6.5	±10%
Total of Highest 10% of flows (in)	30.782	31.466	-0.2	±15%
Total of Lowest 50% of flows (in)	13.566	14.865	-9.2	±10%
Total Winter Runoff (in)	17.646	18.273	-3.4	n/a
Total Summer Runoff (in)	11.029	11.585	-4.8	n/a
Total Seasonal Volume Error	–	–	-1.4	±20%
Storm Peaks (cfs)	1,332.9	1,511.1	-11.8	±15%
Total Storm Volume (<i>selected storms</i>) (in)	11.027	12.847	-14.2	±20%
Coefficient of Determination, r ²	0.95			

Table D-4. Final calibrated parameters for the Jackson River.

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values [†]	Function of ... [‡]	Comment
PERLND (Pervious Land module)						
PWAT-PARM2 (Pervious Water Budget Hydrology Parameter Group 2)						
FOREST	Fraction forest cover	none	1.0 forest, 0.0 other	0.0 - 1.0	Forest cover	–
LZSN	Lower zone nominal soil moisture storage	inches	6.0 - 6.5	2.0 - 15.0	Soils, climate	Calibration
INFILT	Index to infiltration capacity	in/hr	0.008 - 0.191 ^a	0.001 - 0.500	Soils, land use	Calibration
LSUR	Length of overland flow	feet	23- 486 ^a	10 - 700	Topography	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.02935 - 0.45484 ^a	0.001 - 0.400	Topography	Estimated using GIS
KVARY	Groundwater recession variable	1/in	0.0	0.0 - 5.0	Baseflow recession variation	Calibration
AGWRC	Base groundwater recession	none	0.99	0.850 - 0.999	Baseflow recession	Calibration
PWAT-PARM3 (Pervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	45 - 47	32 - 48	Climate, vegetation	–

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Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values [‡]	Function of ... [‡]	Comment
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
INFEXP	Exponent in infiltration equation	none	2	1 - 3	Soils variability	Default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	1 - 3	Soils variability	Default to 2.0
DEEPPFR	Fraction of GW inflow to deep recharge	none	0.00 - 0.05	0.00 - 0.50	Geology, groundwater recharge	Calibration
BASETP	Fraction of remaining ET from baseflow	none	0.008- 0.024 ^a	0.0 - 0.2	Riparian vegetation	Calibration
AGWETP	Fraction of remaining ET from active GW	none	0.000 - 0.016 ^a	0.0 - 0.2	Marsh/wetlands extent	Calibration
PWAT-PARM4 (Pervious Water Budget Hydrology Parameter Group 4)						
CEPSC	Interception storage capacity	inches	0.05 – 0.30 ^b	0.01 - 0.40	Vegetation, type/density, land use	Calibration
UZSN	Upper zone nominal soil moisture storage	inches	0.08 – 0.45 ^b	0.05 - 2.00	Surface soil conditions, land use	Calibration
NSUR	Manning's n (roughness)	none	0.40 forest; 0.20 cropland, 0.24 pasture/hay, 0.15 res.; 0.15 comm.; and 0.10 water	0.05 - 0.50	Surface conditions, residue	Calibration
INTFW	Interflow/surface runoff partition parameter	none	1.38 – 1.78	1.0 - 10.0	Soils, topography, land use	Calibration
IRC	Interflow recession parameter	none	0.3 – 0.4	0.30 - 0.85	Soils, topography, land use	Calibration
LZETP	Lower zone ET parameter	none	0.1 – 0.58 ^b	0.1 - 0.9	Vegetation, type/density, root depth	Calibration
IMPLND (Impervious Land module)						
IWAT-PARM2 (Impervious Water Budget Hydrology Parameter Group 2)						
LSUR	Length of overland flow	feet	53.5	50 - 250	Topography, drainage system	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.15	0.001 - 0.150	Topography, drainage	Estimated using GIS
NSUR	Manning's n (roughness)	none	0.08	0.01 - 0.15	Impervious surface conditions	Default to 0.075
RETSC	Retention/interception storage capacity	inches	0.10	0.01 - 0.30	Impervious surface conditions	Default to 0.1
IWAT-PARM3 (Impervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	46	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
RCHRES (Reach/reservoir module)						
HYDR-PARM2 (Reach/Reservoir Hydrology Parameter Group 2)						
KS	Weighting factor for hydraulic routing	–	0.0	0.00 - 0.99	Channel slope, flow obstructions	Use KS = 0.5

[‡] From the EPA BASINS Technical Note 6 (USEPA, 2000).

^a Varies with land use.

^b Varies by month and with land use.

D.2 Maury River Hydrologic Model

Observed daily flow data for the Maury River were available from USGS monitoring station 02023000 near Buena Vista, VA. Daily flow data were used in the hydrologic calibration/validation. Meteorological data was obtained primarily from the Buena Vista, VA observation station (USC00441159) from National Centers for Environmental Information (NCEI).

The hydrologic calibration and validation periods were from January 1, 2009 to December 31, 2013, and January 1, 2014 to December 31, 2017, respectively. The model was calibrated and validated using daily average flow in cubic feet per second (cfs). The HSPF model was run until the simulated and observed flow met the criteria presented in Table D-1. The final calibration parameters were within the recommended ranges found in EPA's BASINS Technical Note 6 (USEPA, 2000).

Figure D-9 and Figure D-10 show that the simulated flow for both the calibration and validation matched the observed flow well, although the model over predicted some of the peaks during both the calibration and validation periods. The agreement between the model simulated and observed flows is further illustrated in Figure D-11 and Figure D-12 for a representative year, and Figure D-13 and Figure D-14 for a representative storm. The model was able to capture representative storms, and annual flows during the calibration and validation periods.

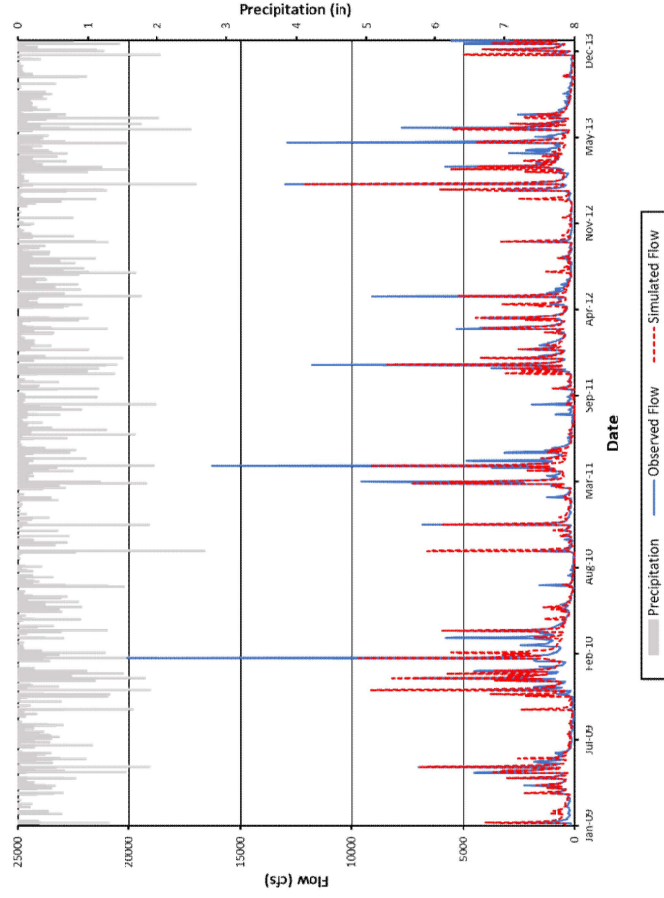


Figure D-9. Observed and simulated flows and precipitation for the Maury River during the calibration period.

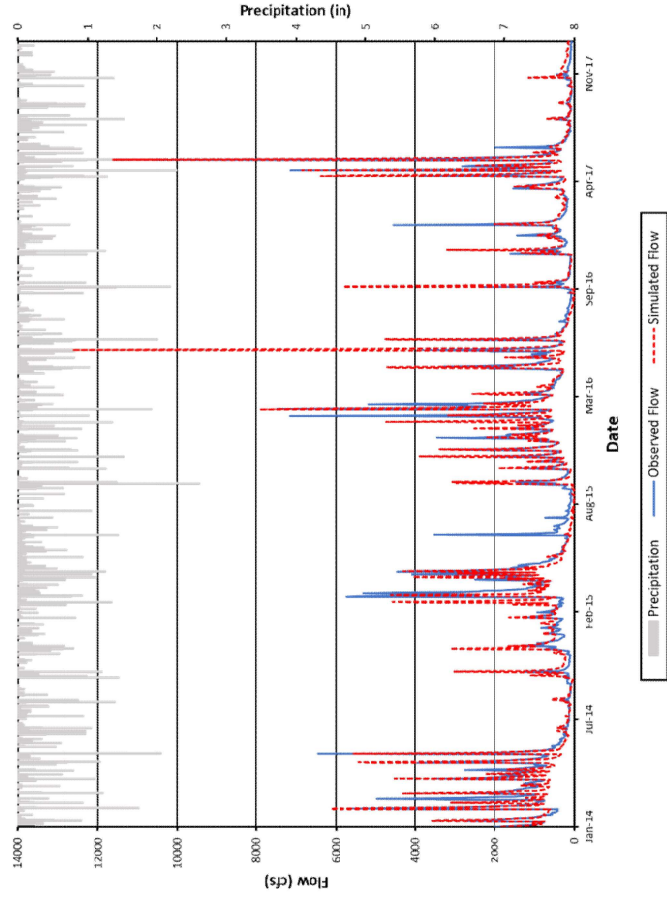


Figure D-10. Observed and simulated flows and precipitation for the Maury River during the validation period.

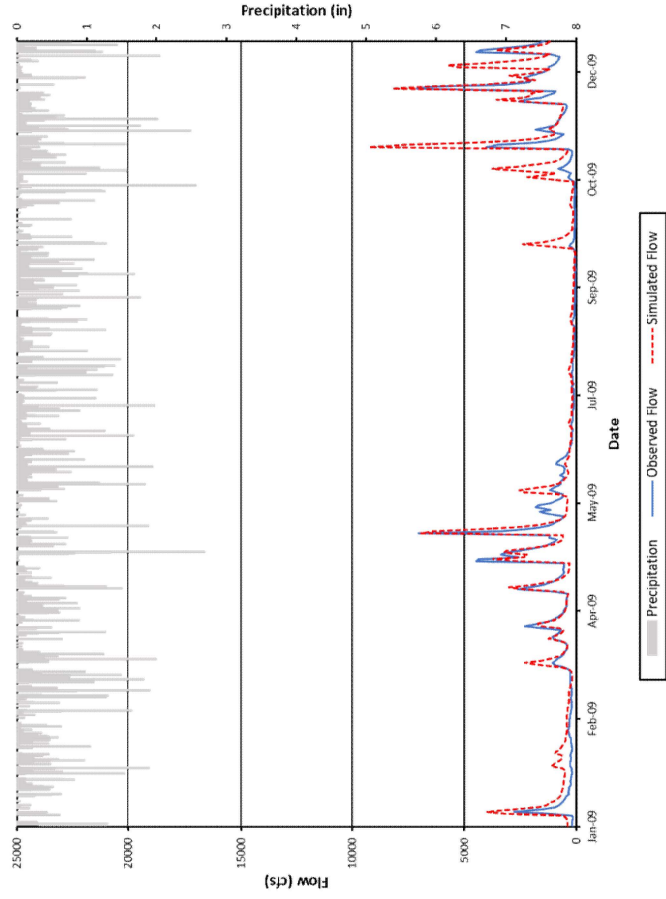


Figure D-11. Observed and simulated flows and precipitation for a representative year (2009) in the calibration period for the Maury River.

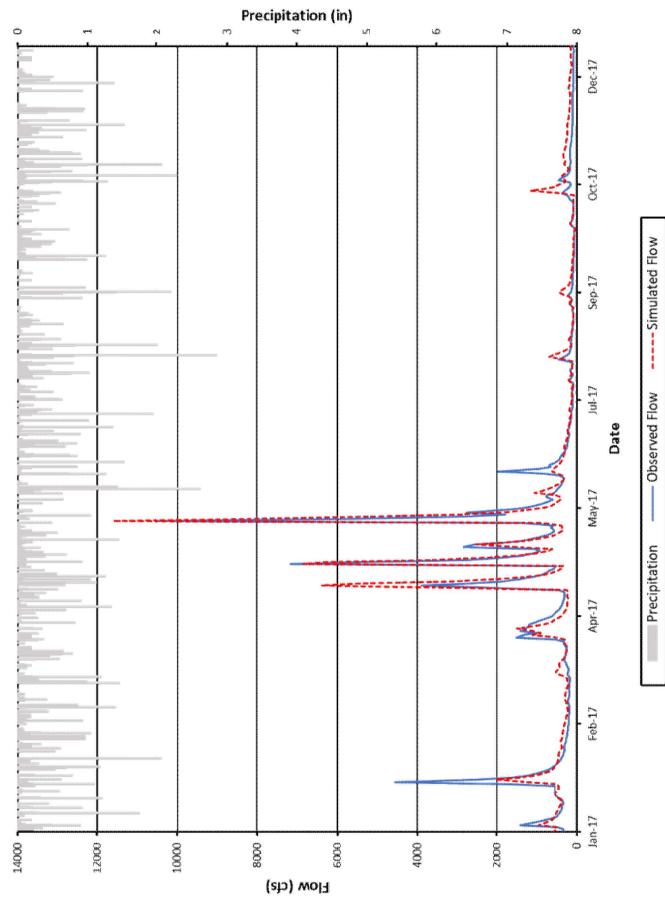


Figure D-12. Observed and simulated flows and precipitation for the Maury River during a representative year (2017) in the validation period.

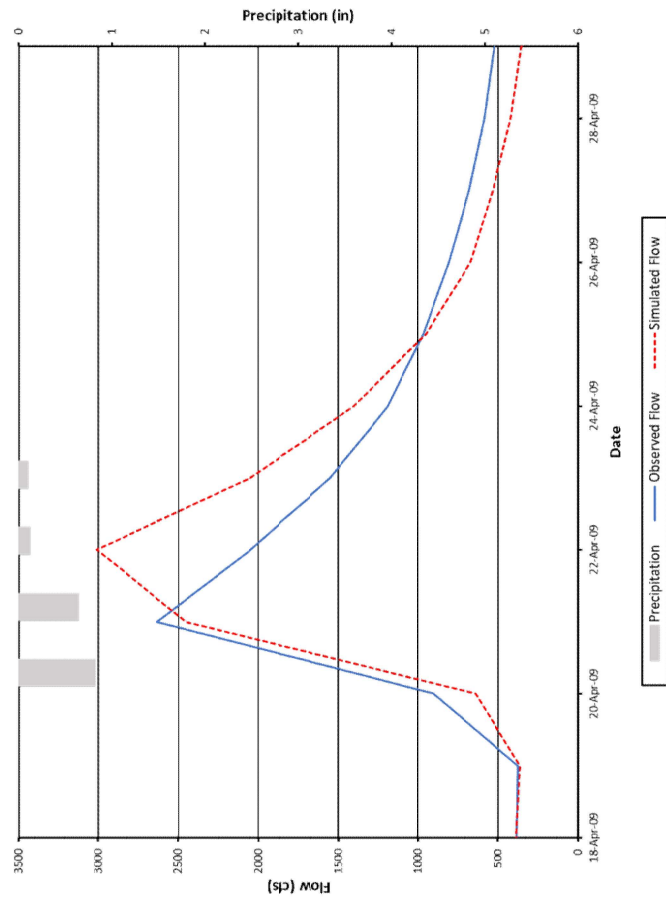


Figure D-13. Observed and simulated flows and precipitation for the Maury River for a representative storm in the calibration period.

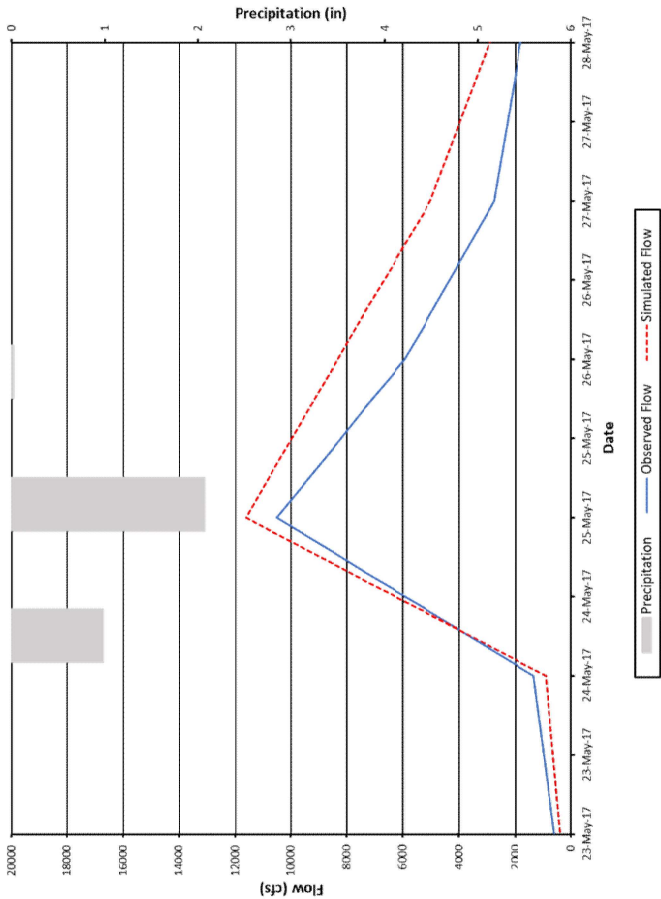


Figure D-14. Observed and simulated flows and precipitation for the Maury River for a representative storm in the validation period.

Figure D-15 and Figure D-16 illustrate model agreement with observed data using cumulative frequency curves. The model adequately captured cumulative frequency for both calibration and validation periods.

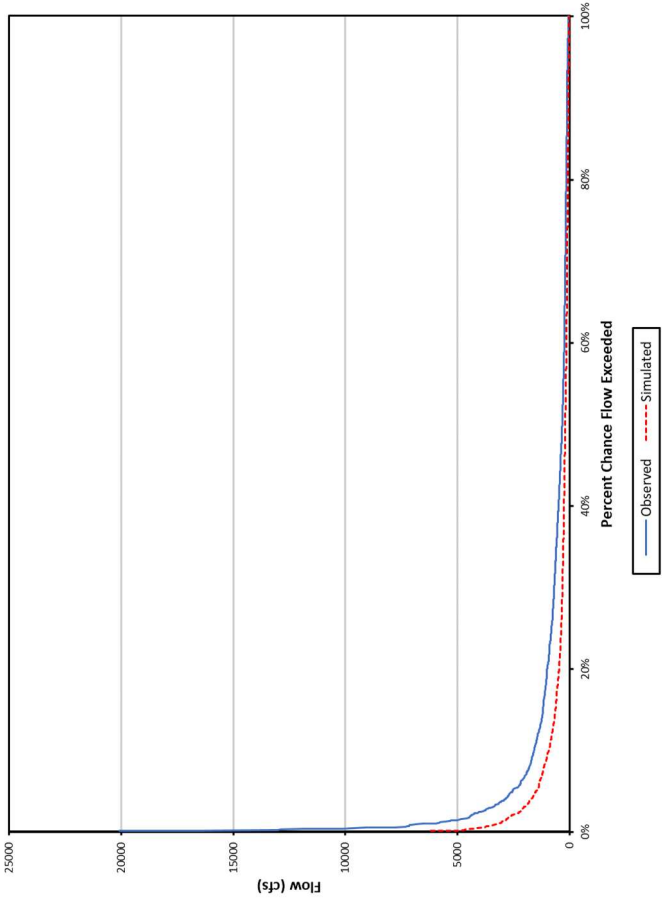


Figure D-15. Cumulative frequency curves for the calibration period for the Maury River.

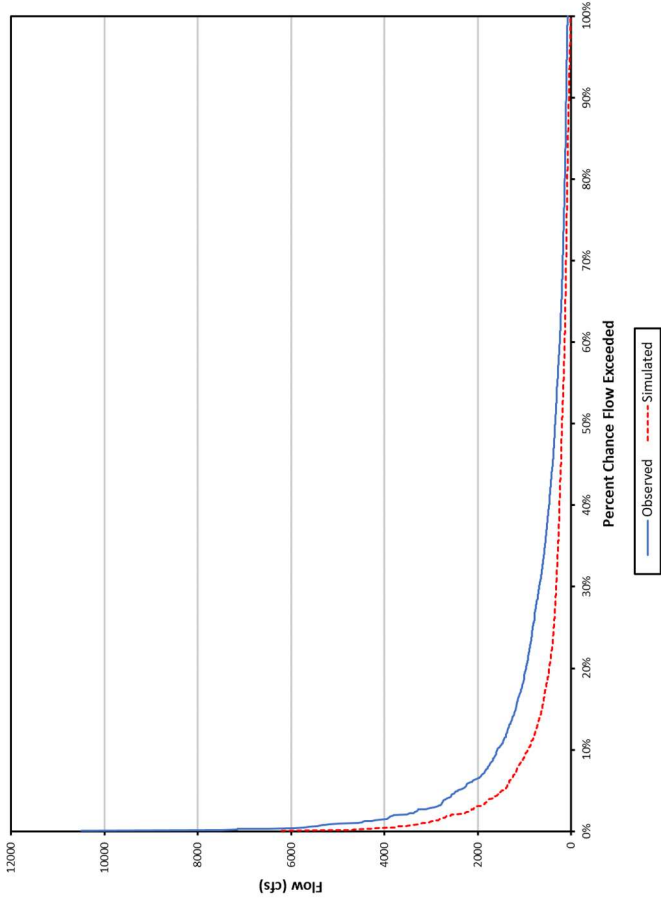


Figure D-16. Cumulative frequency curves for the validation period for the Maury River.

Selected diagnostic outputs from the HSPEXP+ program is listed in Table D-6 and Table D-7. Percent errors for all the diagnostic outputs were within the allowable error criterion limits for both the calibration and validation periods.

When the observed flow data were evaluated using the Baseflow Filter program (Arnold et al., 1995), the range of baseflow indices was 0.41 to 0.64. The simulated baseflow indices are within the range of baseflow indices for the observed flow data, and the simulated indices are comparable to the observed median index. The final calibrated hydrologic parameters can be found in Table D-8.

Table D-5. Summary statistics for the calibration period for the Maury River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)	78.751	76.061	3.5	±10%
Average Annual Total Runoff (in)	15.750	15.212	3.5	±10%
Total of Highest 10% of flows (in)	37.251	35.464	5.0	±15%
Total of Lowest 50% of flows (in)	9.649	8.996	7.3	±10%
Total Winter Runoff (in)	29.412	25.303	16.2	n/a
Total Summer Runoff (in)	8.800	9.079	-3.1	n/a
Total Seasonal Volume Error	—	—	-19.3	±20%
Storm Peaks (cfs)	3,708.1	4,260.4	-13.0	±15%
Total Storm Volume (<i>selected storms</i>) (in)	24.732	22.576	9.6	±20%
Coefficient of Determination, r^2		0.75		

Table D-6. Summary statistics for the validation period for the Maury River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)	57.161	56.074	1.9	±10%
Average Annual Total Runoff (in)	14.019	14.290	1.9	±10%
Total of Highest 10% of flows (in)	26.566	23.788	11.7	±15%
Total of Lowest 50% of flows (in)	7.050	7.194	-2.0	±10%
Total Winter Runoff (in)	19.516	18.918	3.2	n/a
Total Summer Runoff (in)	6.908	6.741	2.5	n/a
Total Seasonal Volume Error	–	–	-0.7	±20%
Storm Peaks (cfs)	2,816.8	2,821.0	-0.2	±15%
Total Storm Volume (<i>selected storms</i>) (in)	14.721	13.990	5.2	±20%
Coefficient of Determination, r^2	0.80			

Table D-7. Final calibrated parameters for the Maury River.

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values [†]	Function of ... [‡]	Comment
PERLND (Pervious Land module)						
PWAT-PARM2 (Pervious Water Budget Hydrology Parameter Group 2)						
FOREST	Fraction forest cover	none	1.0 forest, 0.0 other	0.0 - 1.0	Forest cover	–
LZSN	Lower zone nominal soil moisture storage	inches	3.2 – 4.7	2.0 - 15.0	Soils, climate	Calibration
INFILT	Index to infiltration capacity	in/hr	0.00588 – 0.24730 ^a	0.001 - 0.500	Soils, land use	Calibration
LSUR	Length of overland flow	feet	24.2 – 686.4 ^a	10 - 700	Topography	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.02781 – 0.39704 ^a	0.001 - 0.400	Topography	Estimated using GIS
KVARY	Groundwater recession variable	1/in	0.0	0.0 - 5.0	Baseflow recession variation	Calibration
AGWRC	Base groundwater recession	none	0.969 - 0.993 ^a	0.850 - 0.999	Baseflow recession	Calibration
PWAT-PARM3 (Pervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	45 - 47	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
INFEXP	Exponent in infiltration equation	none	2	1 - 3	Soils variability	Default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	1 - 3	Soils variability	Default to 2.0
DEEPPFR	Fraction of GW inflow to deep recharge	none	0.00 - 0.075	0.00 - 0.50	Geology, groundwater recharge	Calibration
BASETP	Fraction of remaining ET from baseflow	none	0.008 - 0.124 ^a	0.0 - 0.2	Riparian vegetation	Calibration
AGWETP	Fraction of remaining ET from active GW	none	0.008 – 0.195 ^a	0.0 - 0.2	Marsh/wetlands extent	Calibration
PWAT-PARM4 (Pervious Water Budget Hydrology Parameter Group 4)						
CEPSC	Interception storage capacity	inches	0.04 – 0.40 ^b	0.01 - 0.40	Vegetation, type/density, land use	Calibration

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values [‡]	Function of ... [‡]	Comment
UZSN	Upper zone nominal soil moisture storage	inches	0.03 – 0.91 ^b	0.05 - 2.00	Surface soil conditions, land use	Calibration
NSUR	Manning's n (roughness)	none	0.40 forest; 0.24 pasture/hay, 0.20 cropland, 0.15 res.; 0.15 comm.; and 0.10 water	0.05 - 0.50	Surface conditions, residue	Calibration
INTFW	Interflow/surface runoff partition parameter	none	1.0 - 1.5 ^a	1.0 - 10.0	Soils, topography, land use	Calibration
IRC	Interflow recession parameter	none	0.3 – 0.4	0.30 - 0.85	Soils, topography, land use	Calibration
LZETP	Lower zone ET parameter	none	0.1 – 0.9 ^b	0.1 - 0.9	Vegetation, type/density, root depth	Calibration
IMPLND (Impervious Land module)						
IWAT-PARM2 (Impervious Water Budget Hydrology Parameter Group 2)						
LSUR	Length of overland flow	feet	54.5	50 - 250	Topography, drainage system	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.10	0.001 - 0.150	Topography, drainage	Estimated using GIS
NSUR	Manning's n (roughness)	none	0.08	0.01 - 0.15	Impervious surface conditions	Default to 0.075
RETSC	Retention/interception storage capacity	inches	0.10	0.01 - 0.30	Impervious surface conditions	Default to 0.1
IWAT-PARM3 (Impervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	46	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
RCHRES (Reach/reservoir module)						
HYDR-PARM2 (Reach/Reservoir Hydrology Parameter Group 2)						
KS	Weighting factor for hydraulic routing	–	0.0	0.00 - 0.99	Channel slope, flow obstructions	Use KS = 0.5

[‡] from the EPA BASINS Technical Note 6 (USEPA, 2000).

^aVaries with land use.

^bVaries by month and with land use.

D.3 Upper James River Hydrologic Model

This section presents the HSPF hydrologic calibration/validation results for the Upper James River TMDL Watershed that includes: Cowpasture River, Craig Creek, Catawba Creek, portions of the James River, and Fishing Creek. Figure E-19 illustrates the location of TMDL watershed, major tributary boundaries, and reaches used in model calibration. Observed daily flow data were obtained from three USGS monitoring stations to use in the hydrologic calibration/validation for the Upper James River TMDL, USGS monitoring station 02016000 located on Cowpasture River near Clifton Forge, VA, USGS monitoring station 02019500

located on James River at Buchanan, VA, and USGS monitoring station 02026000 located on James River at Bent Creek, VA. Meteorological data were obtained primarily from the Hot Springs (USC00444128), Glasgow (USC00443375), Covington (USC00442044), Roanoke (724110 13741), and Appomattox/Lynchburg (USC00440243), VA observation stations from National Centers for Environmental Information (NCEI).

Due to the large size of the resulting hydrology calibration and validation tables and figures, only the results for the calibration/validation to the USGS monitoring station 02026000 located on James River at Bent Creek, VA are included in this Appendix. Including calibration/validation results for all USGS monitoring stations would have made the report unmanageably long. These results can be made available upon request by referring to the contact information on page ii.

The hydrologic calibration and validation periods were from January 1, 2010 to December 31, 2014, and January 1, 2004 to December 31, 2007, respectively. The model was calibrated and validated using daily average flow in cubic feet per second (cfs). The HSPF model was run until the simulated and observed flow met criteria presented in Table D-1. The final calibration parameters were within the range of recommended EPA's BASINS Technical Note 6 (USEPA, 2000).

Figure D-17 and Figure D-18 show that the simulated flow for both the calibration and validation matched the observed flow well, although the model under predicted some of the peaks during calibration period and over predicted during the validation period. The agreement with observed flows is further illustrated in Figure D-19 and Figure D-20 for a representative year, although some peaks during validation period and Figure D-21 and Figure D-22 for a representative storm. The model captured both representative storms and year flow during calibration and validation periods.

Figure D-23 and Figure D-24 illustrate model agreement with observed data using cumulative frequency curves. The model adequately captured cumulative frequency for both calibration and validation periods.

Selected diagnostic outputs from the HSPXP+ program is listed in Table D-8 and Table D-9. Percent errors for all the diagnostic outputs were within the allowable error criterion limits for both the calibration and validation periods.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

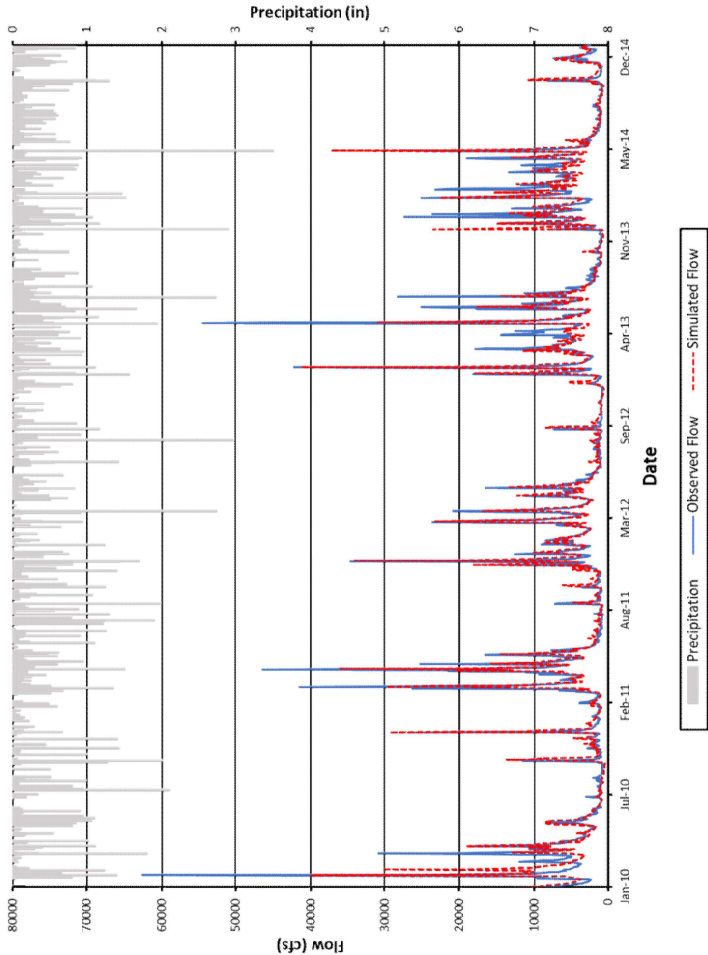


Figure D-17. Observed and simulated flows and precipitation for the James River at Bent Creek calibration period.

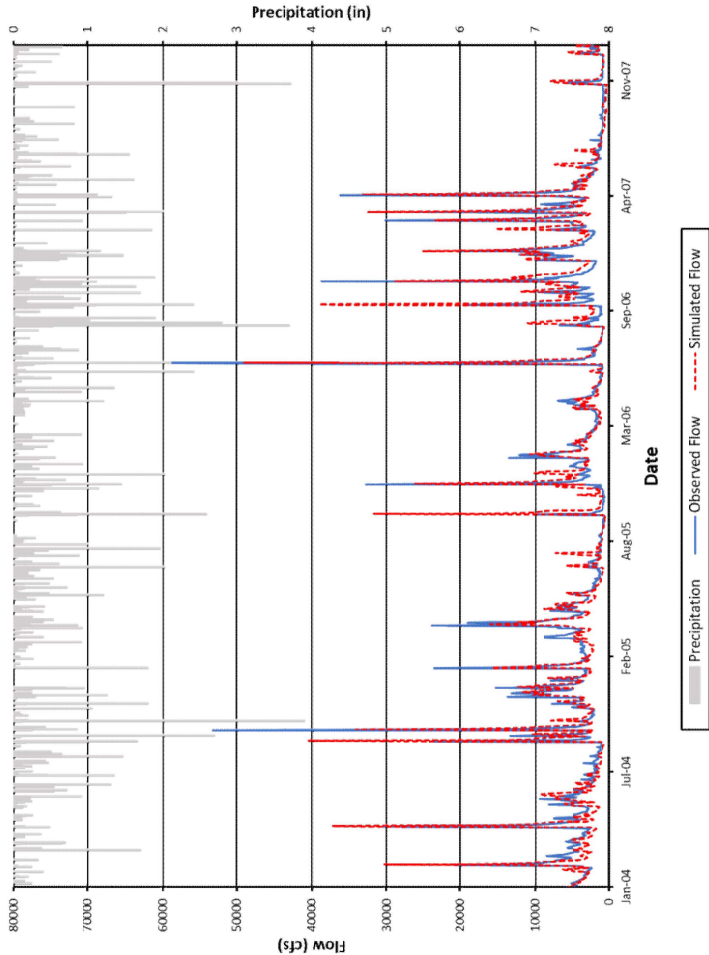


Figure D-18. Observed and simulated flows and precipitation for the James River at Bent Creek during the validation period.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

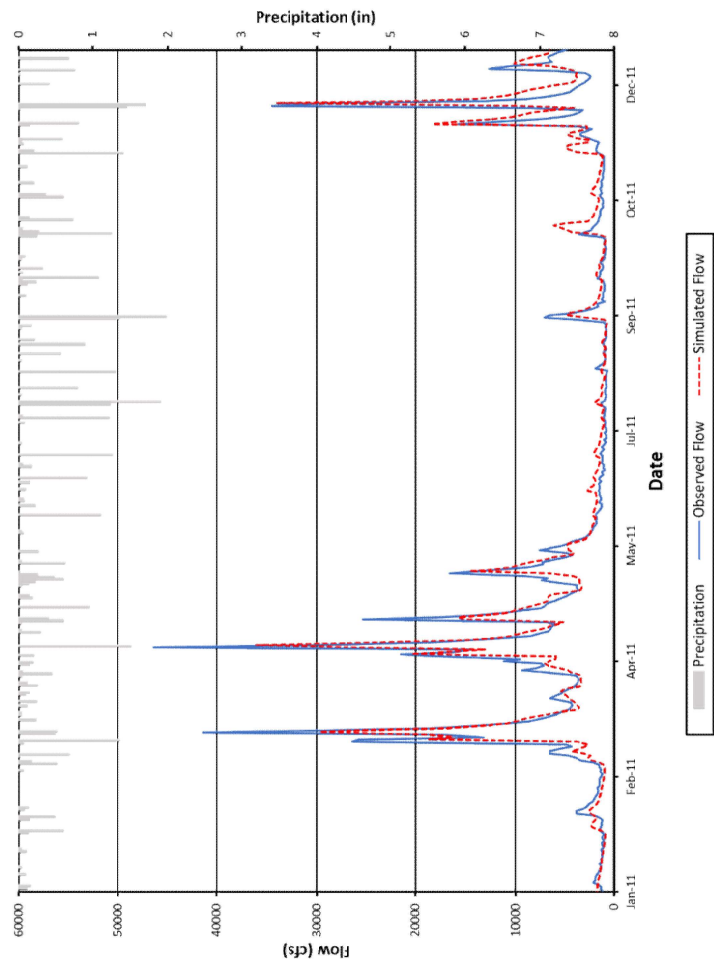


Figure D-19. Observed and simulated flows and precipitation for a representative year (2011) in the calibration period for the James River at Bent Creek.

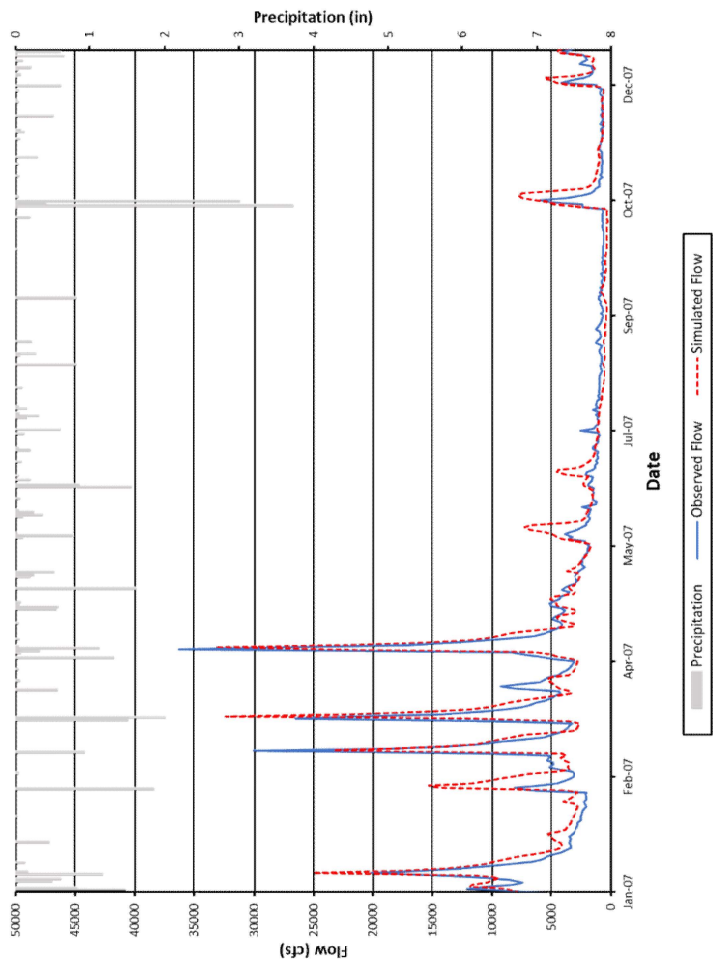


Figure D-20. Observed and simulated flows and precipitation for the James River at Bent Creek during a representative year (2007) in the validation period.

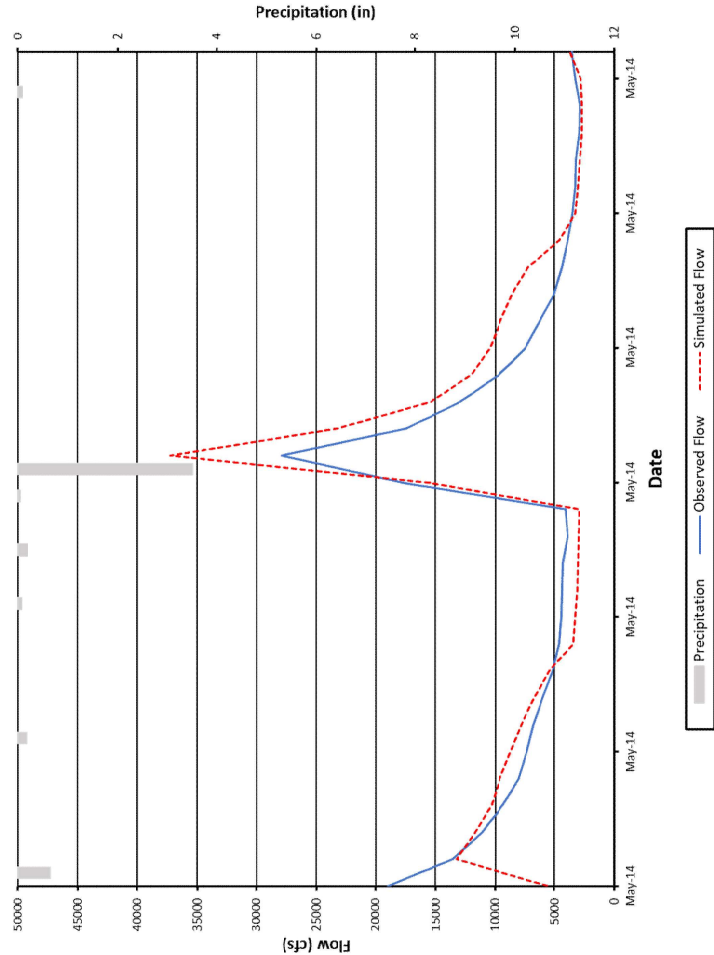


Figure D-21. Observed and simulated flows and precipitation for the James River at Bent Creek for a representative storm in the calibration period for May 2014.

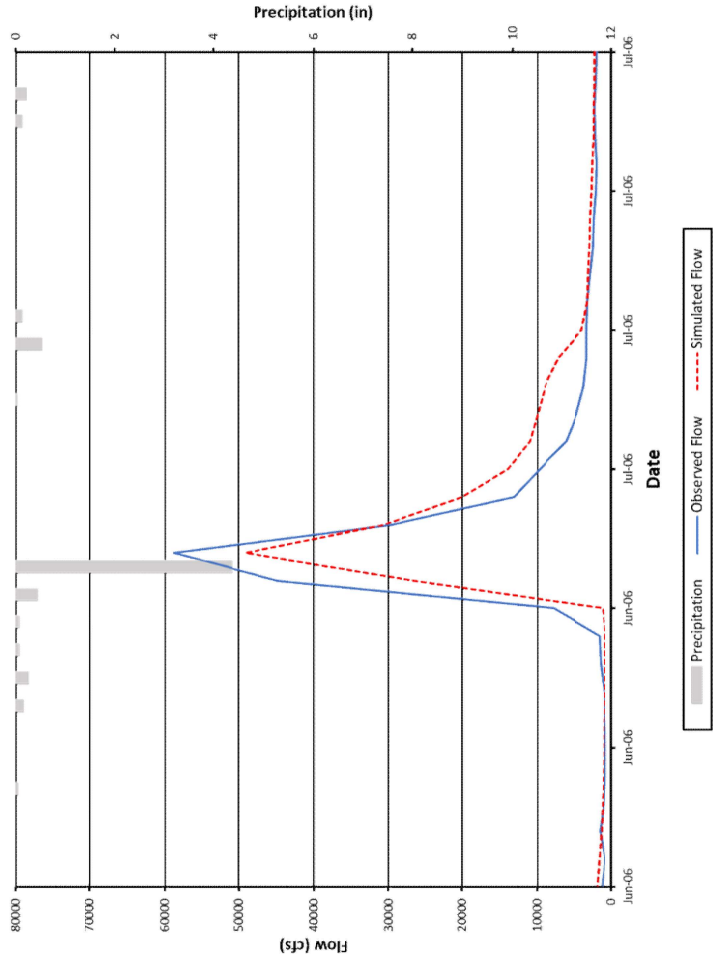


Figure D-22. Observed and simulated flows and precipitation for James River at Bent Creek for a representative storm in the validation period for June 2006.

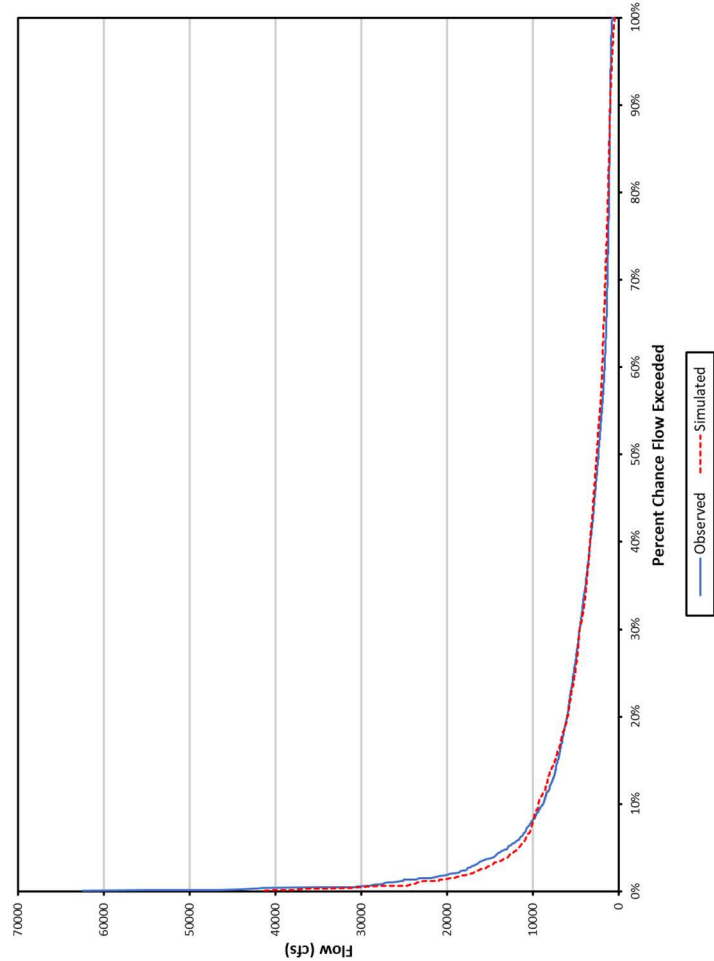


Figure D-23. Cumulative frequency curves for the calibration period for the James River at Bent Creek.

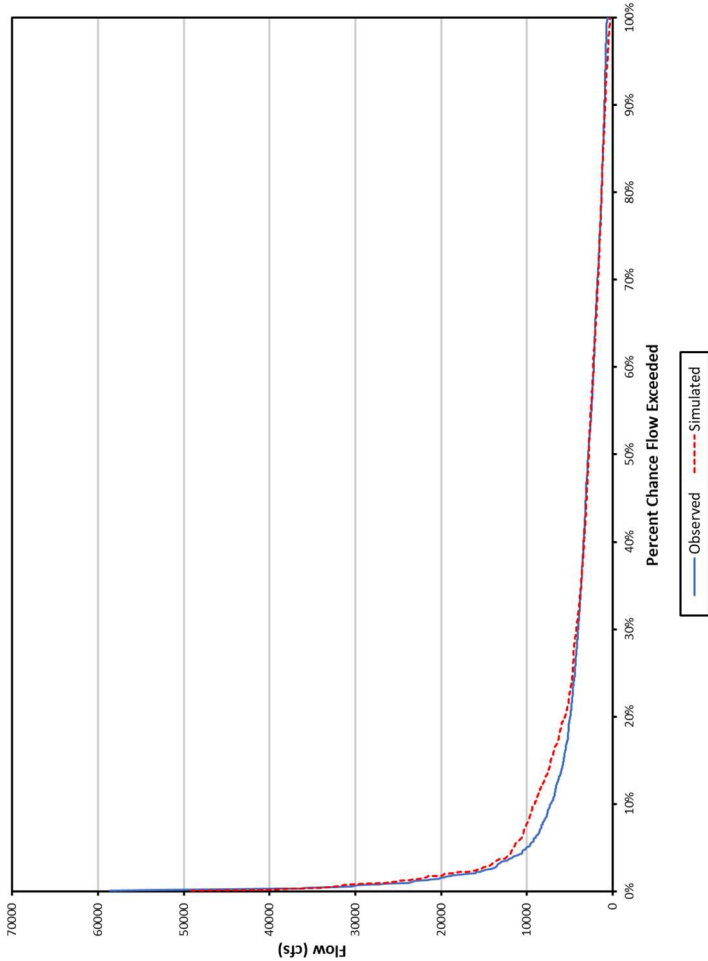


Figure D-24. Cumulative frequency curves for the validation period for the James River at Bent Creek.

Table D-8. Summary statistics for the calibration period for the James River at Bent Creek.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)	75.796	77.043	-1.6	±10%
Average Annual Total Runoff (in)	15.159	15.411	-1.6	±10%
Total of Highest 10% of flows (in)	26.071	29.032	-10.2	±15%
Total of Lowest 50% of flows (in)	13.305	12.12	9.8	±10%
Total Winter Runoff (in)	25.808	23.889	8.0	±15%
Total Summer Runoff (in)	10.275	10.670	-3.7	±20%
Total Seasonal Volume Error	–	–	-11.7	±20%
Storm Peaks (cfs)	13,124	15,296	-14.2	±15%
Total Storm Volume (<i>selected storms</i>) (in)	20.045	20.925	-4.2	±20%
Coefficient of Determination, r^2	0.89			

Table D-9. Summary statistics for the validation period for the James River at Bent Creek.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)	61,292	57,152	7.2	±10%
Average Annual Total Runoff (in)	15,323	14,883	7.2	±10%
Total of Highest 10% of flows (in)	21,456	19,530	9.9	±15%
Total of Lowest 50% of flows (in)	11,499	11,867	-3.1	±10%
Total Winter Runoff (in)	18,869	17,562	7.4	±15%
Total Summer Runoff (in)	8,921	8,733	2.2	±20%
Total Seasonal Volume Error	–	–	-5.3	±20%
Storm Peaks (cfs)	12,716	11,667	9.0	±15%
Total Storm Volume (<i>selected storms</i>) (in)	13.554	11.418	18.7	±20%
Coefficient of Determination, r^2	0.77			

When the observed flow data were evaluated using the Baseflow Filter program (Arnold *et al.*, 1995) for James River at Bent Creek, the range of baseflow indices was 0.35 to 0.62. This baseflow indices result does not include the upstream flows from Jackson and Maury Rivers which is expected to change the baseflow separation result. Therefore, the comparison between the baseflow indices for the simulated data and observed flow were not presented for the calibration and validation periods. The final calibrated hydrologic parameters can be found in Table D-10.

Table D-10. Final calibrated parameters for the James River at Bent Creek.

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values†	Function of ...‡	Comment
PERLND (Pervious Land module)						
PWAT-PARM2 (Pervious Water Budget Hydrology Parameter Group 2)						
FOREST	Fraction forest cover	none	1.0 forest, 0.0 other	0.0 - 1.0	Forest cover	–
LZSN	Lower zone nominal soil moisture storage	inches	4.5 – 5.5	2.0 - 15.0	Soils, climate	Calibration

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Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values†	Function of ...‡	Comment
INFILT	Index to infiltration capacity	in/hr	0.0507 - 0.500 ^a	0.001 - 0.500	Soils, land use	Calibration
LSUR	Length of overland flow	feet	19.47 - 1270.77 ^a	10 - 700	Topography	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.0064 - 0.3843 ^a	0.001 - 0.400	Topography	Estimated using GIS
KVARY	Groundwater recession variable	1/in	0.0	0.0 - 5.0	Baseflow recession variation	Calibration
AGWRC	Base groundwater recession	none	0.955 - 0.965 ^a	0.850 - 0.999	Baseflow recession	Calibration
PWAT-PARM3 (Pervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	45 - 47	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
INFEXP	Exponent in infiltration equation	none	2	1 - 3	Soils variability	Default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	1 - 3	Soils variability	Default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.00 - 0.20	0.00 - 0.50	Geology, groundwater recharge	Calibration
BASETP	Fraction of remaining ET from baseflow	none	0.006 - 0.050 ^a	0.0 - 0.2	Riparian vegetation	Calibration
AGWETP	Fraction of remaining ET from active GW	none	0.00 - 0.04	0.0 - 0.2	Marsh/wetlands extent	Calibration
PWAT-PARM4 (Pervious Water Budget Hydrology Parameter Group 4)						
CEPSC	Interception storage capacity	inches	0.05 - 0.40 ^b	0.01 - 0.40	Vegetation, type/density, land use	Calibration
UZSN	Upper zone nominal soil moisture storage	inches	0.20 - 0.80	0.05 - 2.00	Surface soil conditions, land use	Calibration
NSUR	Manning's n (roughness)	none	0.40 forest; 0.20 cropland, 0.24 pasture/hay; 0.15 res. and comm.; and 0.10 water	0.05 - 0.50	Surface conditions, residue	Calibration
INTFW	Interflow/surface runoff partition parameter	none	1.5 - 2.0	1.0 - 10.0	Soils, topography, land use	Calibration
IRC	Interflow recession parameter	none	0.30 - 0.40	0.30 - 0.85	Soils, topography, land use	Calibration
LZETP	Lower zone ET parameter	none	0.01 - 0.85 ^b	0.1 - 0.9	Vegetation, type/density, root depth	Calibration
IMPLND (Impervious Land module)						
IWAT-PARM2 (Impervious Water Budget Hydrology Parameter Group 2)						
LSUR	Length of overland flow	feet	53.9	50 - 250	Topography, drainage system	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.11	0.001 - 0.150	Topography, drainage	Estimated using GIS
NSUR	Manning's n (roughness)	none	0.08	0.01 - 0.15	Impervious surface conditions	Default to 0.075

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values [‡]	Function of ... [‡]	Comment
RETSC	Retention/interception storage capacity	inches	0.1	0.01 - 0.30	Impervious surface conditions	Default to 0.1
IWAT-PARM3 (Impervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	46	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
RCHRES (Reach/reservoir module)						
HYDR-PARM2 (Reach/Reservoir Hydrology Parameter Group 2)						
KS	Weighting factor for hydraulic routing		0.0	0.00 - 0.99	Channel slope, flow obstructions	Use KS = 0.5

[‡] from the EPA BASINS Technical Note 6 (USEPA. 2000).

^a Varies with land use.

^b Varies by month and with land use.

D.4 Lower James River Hydrologic Model

This section presents the HSPF hydrologic calibration/validation results for the Lower James River TMDL Watershed that include major tributary watersheds: Tye and Rockfish Rivers; Hardware, Slate, and Willis Rivers; Rivanna River, portions of the James River, and Reedy Creek. Chapter 2 provides maps illustrating the location of the Lower James River watersheds and flow gages used for hydrology calibration. Model watersheds in the Lower James River TMDL watershed are shown in Figure E-34, illustrating the location of TMDL watershed, major tributary boundaries, reaches used during model calibration. Observed daily flow data were obtained from four USGS monitoring stations to use in the hydrologic calibration/validation for the Lower James River TMDL: USGS monitoring station 02029000 located on the James River at Scottsville, VA, USGS monitoring station 02034000 located on the Rivanna River at Palmyra, VA, USGS monitoring station USGS 02035000 located on the James River at Cartersville, VA, and USGS monitoring station 02037500 located on the James River near Richmond, VA. Meteorological data were obtained primarily from the Charlottesville (USC00441593) and Crozier (USC00442142), VA observation stations from National Centers for Environmental Information (NCEI).

Due to the large size of the resulting hydrology calibration and validation tables and figures, only the results for the calibration/validation to the USGS monitoring station 02037500 located on James River near Richmond, VA are included in this Appendix. Including calibration/validation results for all USGS monitoring stations would have made the report unmanageably long. These results can be made available upon request by referring to the contact information on page ii.

The hydrologic calibration and validation periods were from January 1, 2009 to December 31, 2013, and January 1, 2014 to December 31, 2017, respectively. The model was calibrated and validated using daily average flow in cubic feet per second (cfs). The HSPF model was run until the simulated and observed flow met criteria presented in Table D-1. The final calibration parameters were within the range of recommended EPA's BASINS Technical Note 6 (USEPA, 2000).

Figure D-25 and Figure D-26 show that the simulated flow for both the calibration and validation matched the observed flow well, although the model over predicted some of the peaks during calibration period and under predicted during the validation period. The agreement with observed flows is further illustrated in Figure D-27 and Figure D-28 for a representative year, although under predicted baseflow during validation period and Figure D-29 and Figure D-30 for a representative storm. The model captured both representative storms and year flow during calibration and

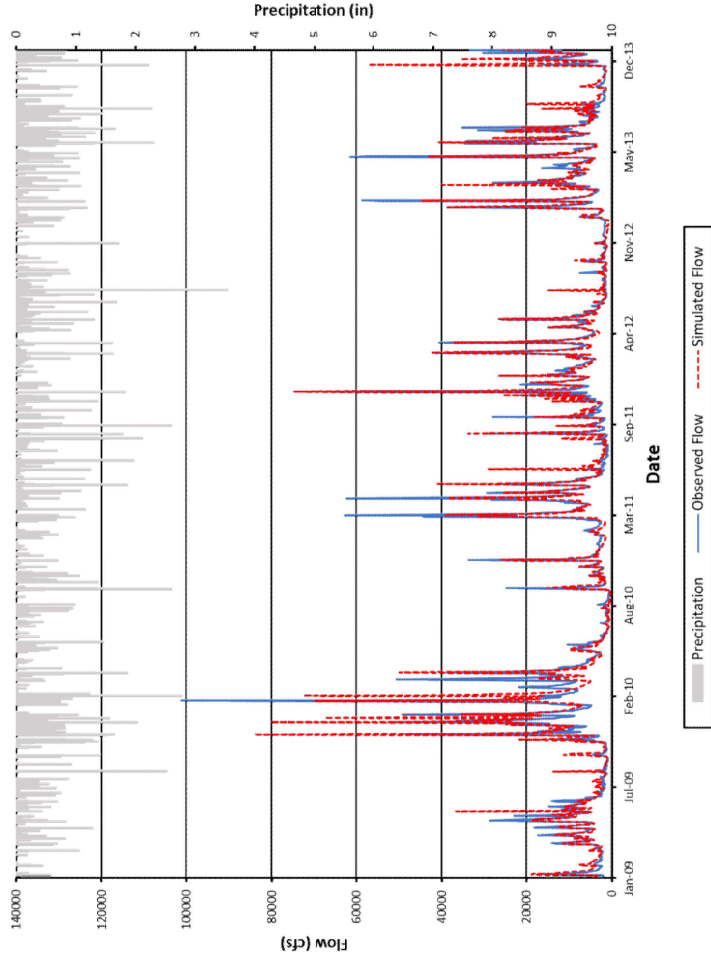


Figure D-25. Observed and simulated flows and precipitation for the James River near Richmond, VA calibration period at the outlet.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

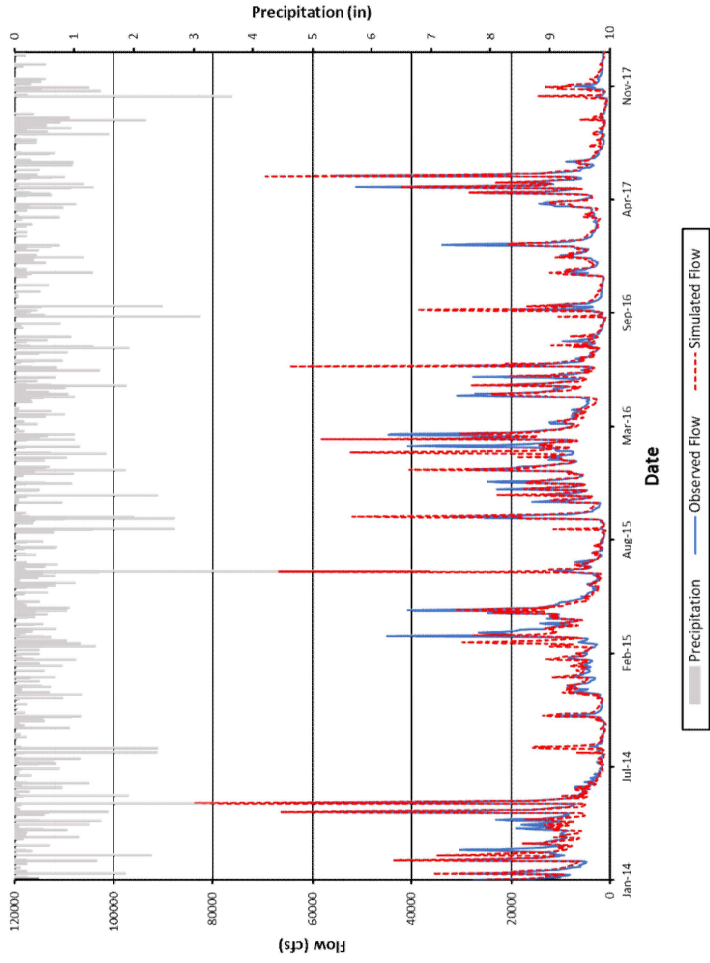


Figure D-26. Observed and simulated flows and precipitation for the James River near Richmond, VA during the validation period at the outlet.

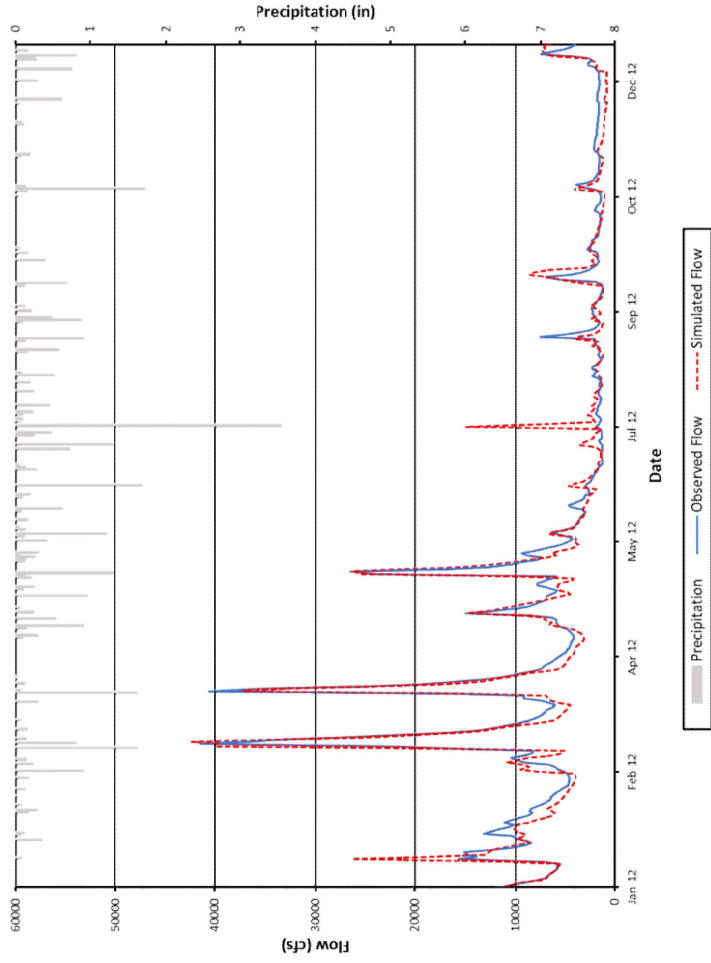


Figure D-27. Observed and simulated flows and precipitation for a representative year (2012) in the calibration period for the James River near Richmond, VA.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

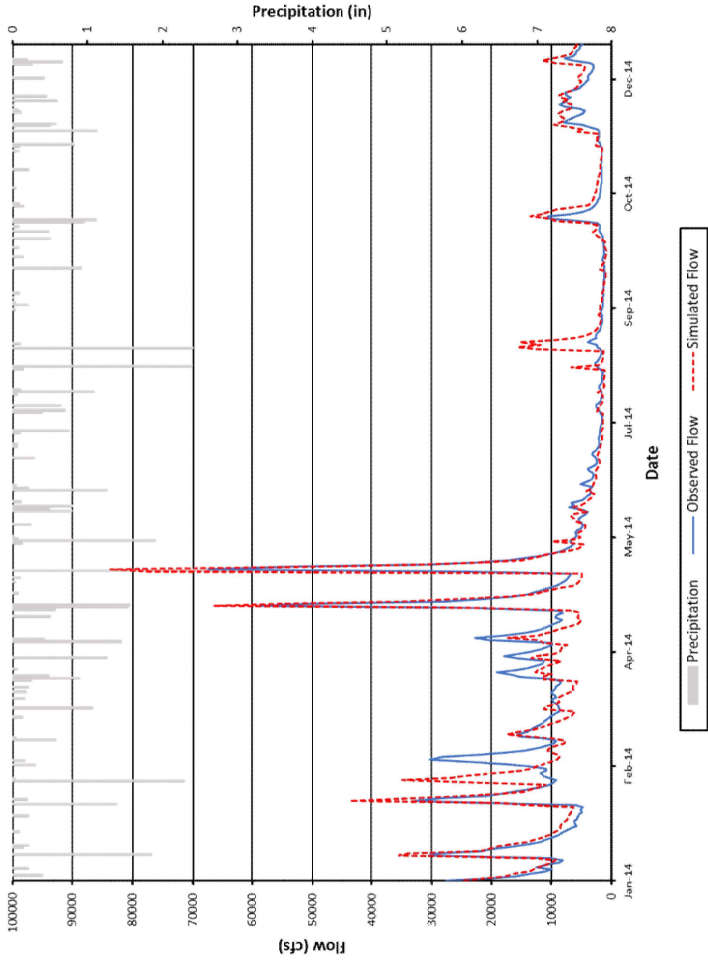


Figure D-28. Observed and simulated flows and precipitation for the James River near Richmond, VA during a representative year (2014) in the validation period.

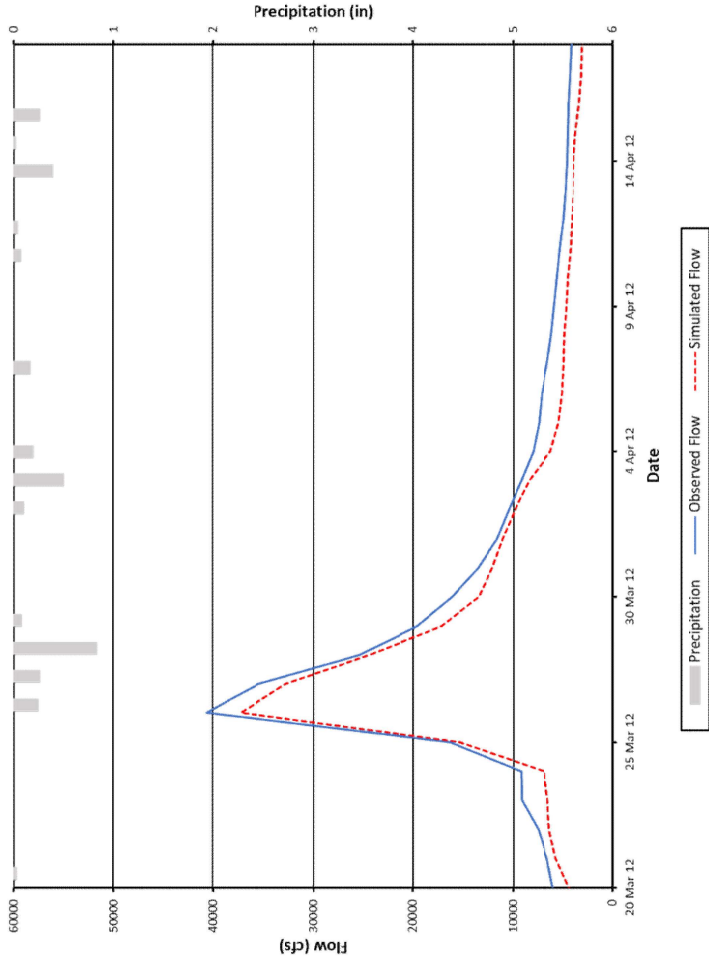


Figure D-29. Observed and simulated flows and precipitation for the James River near Richmond, VA for a representative storm in the calibration period for March 2012.

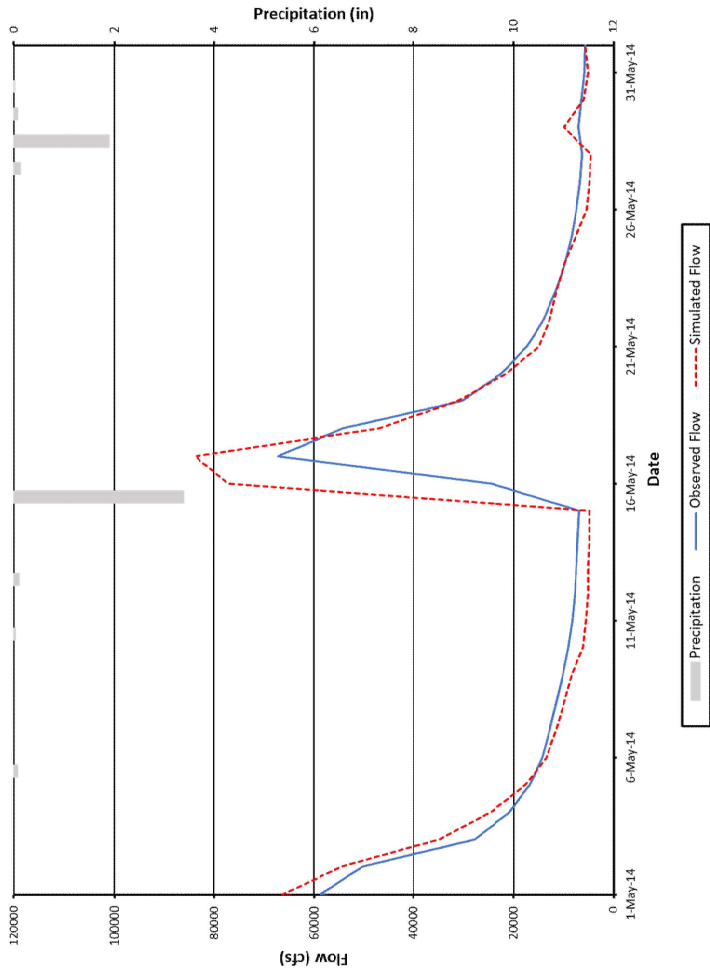


Figure D-30. Observed and simulated flows and precipitation for the James River near Richmond, VA for a representative storm in the validation period for May 2014.

Figure D-31 and Figure D-32 illustrate model agreement with observed data using cumulative frequency curves. The model adequately captured cumulative frequency for both calibration and validation periods.

Selected diagnostic outputs from the HSPEXP+ program is listed in Table D-11 and Table D-12. Percent errors for all the diagnostic outputs were within the allowable error criterion limits for both the calibration and validation periods.

When the observed flow data were evaluated using the Baseflow Filter program (Arnold et al., 1995) for the James River near Richmond, the range of baseflow indices was 0.29 to 0.58. This baseflow indices result does not include the upstream flows from James River upstream of Bent Creek, which is expected to change the baseflow separation result. Therefore, the comparison between the baseflow indices for the simulated data and observed flow were not presented for the calibration and validation periods. The final calibrated hydrologic parameters can be found in Table D-13.

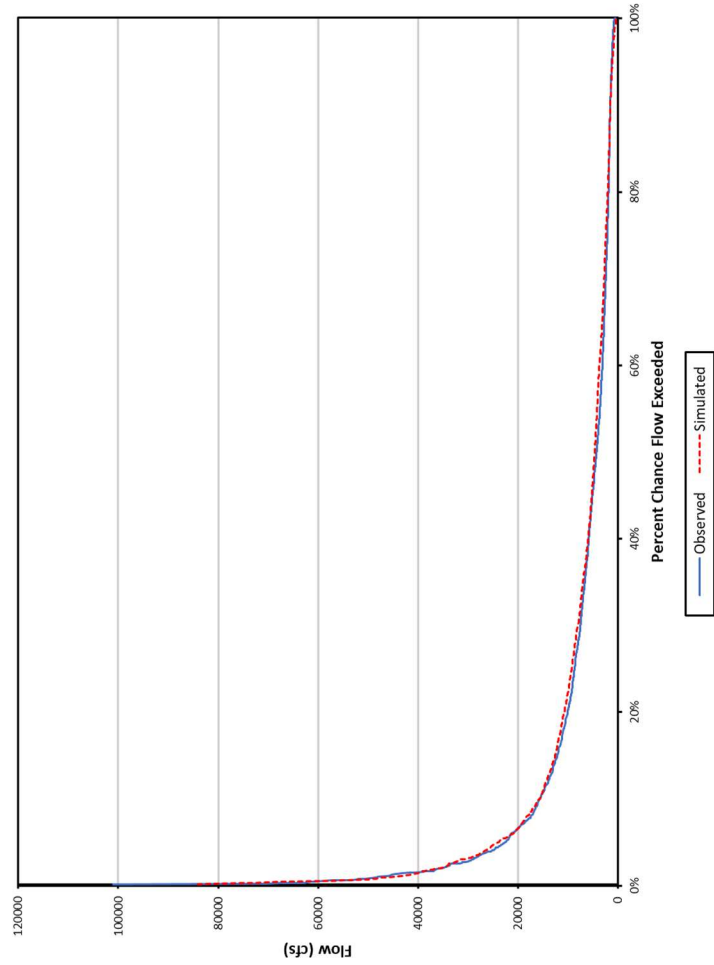


Figure D-31. Cumulative frequency curves for the calibration period for the James River near Richmond, VA.

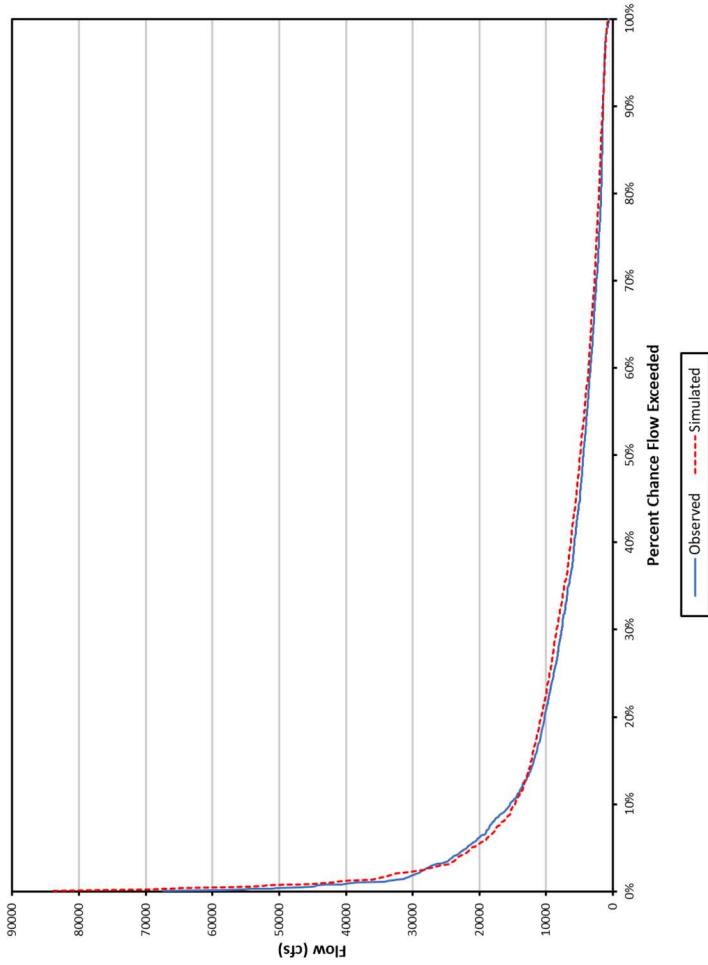


Figure D-32. Cumulative frequency curves for the validation period for the James River near Richmond, VA.

Table D-11. Summary statistics for the calibration period for the James River near Richmond, VA.

	Simulated Observed	Error (%)	Criterion
Total Runoff (in)	74.688	71.486	4.5 ±10%
Average Annual Total Runoff (in)	14.938	14.297	4.5 ±10%
Total of Highest 10% of flows (in)	27.404	26.892	1.9 ±15%
Total of Lowest 50% of flows (in)	12.550	11.399	10.0 ±10%
Total Winter Runoff (in)	26.037	23.402	11.3 ±15%
Total Summer Runoff (in)	11.327	10.200	11.1 ±20%
Total Seasonal Volume Error	–	–	-0.2 ±20%
Storm Peaks (cfs)	25,191	27,353	-7.9 ±15%
Total Storm Volume (<i>selected storms</i>) (in)	22.042	22.396	-1.6 ±20%
Coefficient of Determination, r^2	0.85		

Table D-12. Summary statistics for the validation period for the James River near Richmond, VA.

	Simulated Observed	Error (%)	Criterion
Total Runoff (in)	58.895	55.636	5.9 ±10%
Average Annual Total Runoff (in)	14.724	13.909	5.9 ±10%
Total of Highest 10% of flows (in)	20.021	19.410	2.8 ±15%
Total of Lowest 50% of flows (in)	10.522	9.452	11.3 ±10%
Total Winter Runoff (in)	19.817	17.805	11.3 ±15%
Total Summer Runoff (in)	8.951	7.636	17.2 ±20%
Total Seasonal Volume Error	–	–	5.9 ±20%
Storm Peaks (cfs)	20,646	19,781	4.4 ±15%
Total Storm Volume (<i>selected storms</i>) (in)	15.694	15.053	4.3 ±20%
Coefficient of Determination, r^2	0.88		

Table D-13. Final calibrated parameters for the James River near Richmond, VA.

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values[‡]	Function of ...[‡]	Comment
PERLND (Pervious Land module)						
PWAT-PARM2 (Pervious Water Budget Hydrology Parameter Group 2)						
FOREST	Fraction forest cover	none	1.0 forest, 0.0 other	0.0 – 1.0	Forest cover	–
LZSN	Lower zone nominal soil moisture storage	inches	7.5	2.0 – 15.0	Soils, climate	Calibration
INFILT	Index to infiltration capacity	in/hr	0.005 – 0.186 ^a	0.001 – 0.500	Soils, land use	Calibration
LSUR	Length of overland flow	feet	43.749 – 503.226 ^a	10 – 700	Topography	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.0073 – 0.193 ^a	0.001 – 0.400	Topography	Estimated using GIS
KVARY	Groundwater recession variable	1/in	0.0	0.0 – 5.0	Baseflow recession variation	Calibration
AGWRC	Base groundwater recession	none	0.850 – 0.960 ^a	0.850 – 0.999	Baseflow recession	Calibration

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Parameter	Definition	Units	FINAL CALIBRATION	Possible Range of Values [‡]	Function of ... [‡]	Comment
PWAT-PARM3 (Pervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	45 - 47	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
INFEXP	Exponent in infiltration equation	none	2	1 - 3	Soils variability	Default to 2.0
INFILD	Ratio of max/mean infiltration capacities	none	2	1 - 3	Soils variability	Default to 2.0
DEEPFR	Fraction of GW inflow to deep recharge	none	0.00 - 0.25 ^a	0.00 - 0.50	Geology, groundwater recharge	Calibration
BASETP	Fraction of remaining ET from baseflow	none	0.0 - 0.03 ^a	0.0 - 0.2	Riparian vegetation	Calibration
AGWETP	Fraction of remaining ET from active GW	none	0.00 – 0.02 ^a	0.0 - 0.2	Marsh/wetlands extent	Calibration
PWAT-PARM4 (Pervious Water Budget Hydrology Parameter Group 4)						
CEPSC	Interception storage capacity	inches	0.05 – 0.40 ^b	0.01 - 0.40	Vegetation, type/density, land use	Calibration
UZSN	Upper zone nominal soil moisture storage	inches	0.05 – 0.80 ^b	0.05 - 2.00	Surface soil conditions, land use	Calibration
NSUR	Manning's n (roughness)	none	0.40 forest; 0.20 cropland, 0.24 pasture/hay; 0.15 res. and comm.; and 0.10 water	0.05 - 0.50	Surface conditions, residue	Calibration
INTFW	Interflow/surface runoff partition parameter	none	1.0	1.0 - 10.0	Soils, topography, land use	Calibration
IRC	Interflow recession parameter	none	0.30	0.30 - 0.85	Soils, topography, land use	Calibration
LZETP	Lower zone ET parameter	none	0.10 – 0.85 ^b	0.1 - 0.9	Vegetation, type/density, root depth	Calibration
IMPLND (Impervious Land module)						
IWAT-PARM2 (Impervious Water Budget Hydrology Parameter Group 2)						
LSUR	Length of overland flow	feet	53.9	50 - 250	Topography, drainage system	Estimated using GIS
SLSUR	Slope of overland flow plane	none	0.05	0.001 - 0.150	Topography, drainage	Estimated using GIS
NSUR	Manning's n (roughness)	none	0.08	0.01 - 0.15	Impervious surface conditions	Default to 0.075
RETSC	Retention/interception storage capacity	inches	0.1	0.01 - 0.30	Impervious surface conditions	Default to 0.1
IWAT-PARM3 (Impervious Water Budget Hydrology Parameter Group 3)						
PETMAX	Temp below which ET is reduced	deg. F	46	32 - 48	Climate, vegetation	–
PETMIN	Temp below which ET is set to zero	deg. F	35	30 - 40	Climate, vegetation	–
RCHRES (Reach/reservoir module)						
HYDR-PARM2 (Reach/Reservoir Hydrology Parameter Group 2)						
KS	Weighting factor for hydraulic routing		0.0	0.00 - 0.99	Channel slope, flow obstructions	Use KS = 0.5

‡ from the EPA BASINS Technical Note 6 (USEPA. 2000).

^aVaries with land use.

^bVaries by month and with land use.

D.5 References

Arnold, J.G, P.M. Allen, R. Muttiah, and G. Bernhardt. 1995. Automated Base Flow Separation and Recession Analysis Techniques. Ground Water (33) 6: 1010-1018.

USEPA. 2000. BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters for HSPF. EPA-823-R00-012. Washington, D.C.: Office of Water, USEPA. Available at: <https://nepis.epa.gov/Exe/ZyPDF.cgi/P1004XDT.PDF?Dockey=P1004XDT.PDF>. Accessed November 1, 2021.

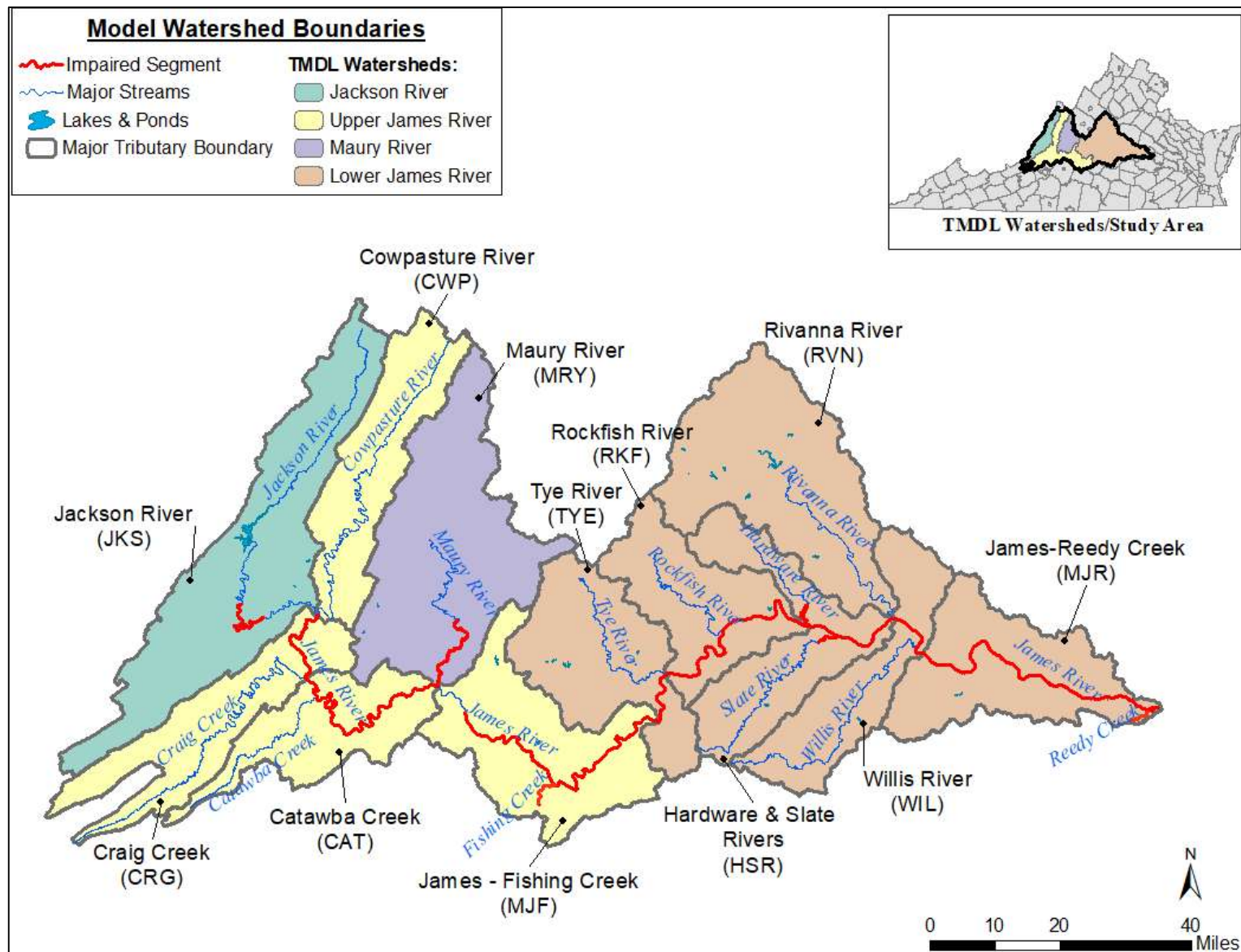
Appendix E: Sediment Calibration for the James River PCB TMDL Study Area

Sediment acts as a transport mechanism for PCBs. As part of the James River PCB TMDL development, model calibrations were performed for the coupled hydrology/water quality simulation model Hydrological Simulation Program-FORTRAN (HSPF) to predict sediment loads through the James River and its tributaries. The calibration within the James River study area includes the following TMDL watersheds: the Jackson River, Maury River, Upper and Lower James Rivers. TMDL watershed locations are illustrated in Chapter 2, and **Error! Reference source not found.** illustrates the locations of suspended sediment monitoring stations in the James River TMDL watersheds.

Due to the large size of the James River study area, sediment calibration modeling was organized and further subdivided among major tributaries within the Upper and Lower James River TMDL watersheds (Figure E-1). Major tributaries and segments within the Upper James River TMDL watershed include: Cowpasture River, Craig Creek, Catawba Creek, and James River – Fishing Creek (in the Lynchburg area). The Lower James River TMDL watershed includes: Tye River, Rockfish River, Hardware River, Slate River, Rivanna River, Willis River, and James River– Reedy Creek (in the Richmond area). The calibration results are reported for each James River TMDL watershed and calibration segment separately section by section.

The sediment calibration process was divided into two phases. Phase I addressed sediment detachment from land surfaces and loading into subwatershed stream/river reaches (water course) by comparing model-calculated loadings with published calibration targets. Phase II addressed instream total suspended sediment (SSC) concentrations within each reach. Phase II accounted for land surface loadings from Phase I and sediment deposition/scouring along stream/river beds. The outline of both calibration phases is described below, with the results for each TMDL watershed described in their respective section. During each model run, HSPF was executed using an hourly time-step interval and results are reported as daily averages.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds



E.1 Calibration Method

E.1.1 Phase I Calibration Methodology

Phase I sediment modeling used the sediment detachment and transport functionality in HSPF. The final model output for pervious land uses (e.g., cropland) was split into two sets of data: 1) the rate of sediment detachment and removal from the land surface (SOSED, tons/ac-yr), and 2) the storage of detached sediment on the land surface (DETS, tons/acre). Impervious land uses (e.g., residential) included two additional model outputs: wash-off of solids from impervious land surface (SOSLD, tons/ac-yr) and storage of solids on impervious land surface (SLDS, tons/acre).

Unlike typical water quality calibrations, there were no sediment storage or sediment removal observed data for model calibration. Measuring the quantity and removal rate of sediment on a land surface would be a laborious and expensive task, and include a high degree of uncertainty. Therefore, instead of comparing model performance against monitoring data, a “weight-of-evidence” approach was used to assess calibration sufficiency. That approach entailed calibrating the model output SOSED and SOSLD values using target ranges listed in EPA BASINS Technical Note 8, Table E-1 (USEPA, 2006). As part of the “weight-of-evidence” approach, model outputs were graphed to visualize the fluctuations in sediment storage on the land surface. The goal was to calibrate the wash off and removal rates such that sediment storage (DETS and SLDS) increased and decreased in conjunction with precipitation patterns, i.e. sediment storage totals should increase steadily before decreasing as a result of storm events. Further, DETS and SLDS totals should not continually increase or decrease over time, and significant storage reductions should be more frequent on impervious surfaces. These are sediment removal characteristics that could be reasonably expected in a watershed.

Analysis of the SOSED, SOSLD, DETS, and SLDS for each land use was performed qualitatively using time series plots to determine if the simulated sediment storage and removal values trended as expected. In the interest of consistency, and because no observed data were used, the same calibration period (January 1, 2011 to December 31, 2019) was used for the Phase I sediment calibration for all the subwatersheds. In a typical water quality calibration for a specific constituent, calibration periods would be specific to each subwatershed and monitoring station according to when observed samples were acquired. However, since no observed data were available, a uniform, multi-year calibration period that included a range of annual precipitation magnitudes was used.

Table E-1. Target **SOSED** and **SOSLD** ranges for pervious and impervious land uses (USEPA, 2006).

Pervious Land Use	Target SOSED Range (tons/ac-yr)
Forest	0.05-0.4
Pasture/Hay	0.3-1.8
Cropland	0.5-5.0
Residential	0.2-1.0
Commercial	0.2-1.0
Water	0.001-0.010
Impervious Land use	Target SOSLD Range (tons/ac-yr)
Residential	0.2-1.0
Commercial	0.2-1.0

E.1.2 Phase II Calibration Methodology

Phase II sediment modeling built upon Phase I calibration. In Phase II, HSPF was configured to output sediment bed depth (ft), sediment inflow (tons), sediment outflow (tons), deposition/scouring along the sediment bed (tons), sediment storage (tons), flow rate (cfs), shear stress (lb/ft²), and total suspended sediment concentrations (SSC, mg/L) for each calibrated reach. Once the model was run, annual averages of these outputs were examined to ensure the model did not produce unusually large or small values for sediment inflows, outflows and deposition/scouring, that bed depth remained relatively stable for the duration of the simulation, and to confirm that model output was consistent with the simulated hydrology. The Phase II calibration process entailed comparing simulated instream SSC values against observed SSC data (mg/L) provided by the Virginia Department of Environmental Quality (VADEQ). Observed total SSC is the sum of both fine SSC (suspended sediment concentration less than 62 µm, MG/L) and coarse SSC (suspended sediment concentration greater than 62 µm, MG/L). Table E-2 lists the number of VADEQ water quality stations with observed SSC data in each TMDL watershed and the number of observed samples available.

Table E-2. Number of water quality stations with observed SSC data within the James River TMDL watersheds.

TMDL Watershed	No. Water Quality Stations w/ Observed SSC Data	Total No. Observed SSC Data Samples
Jackson River	4	13
Maury River	2	8
Upper James River	22	52
Lower James River	28	59
Total	56	132

Model performance was again assessed using a “weight-of-evidence” approach, as discussed in EPA BASINS Technical Note 8 (USEPA, 2006). The Phase II calibration process focused on subwatershed reaches within each TMDL watershed where observed data were available, and the model was evaluated based on knowledge of the study area and expected behavior. BASINS Technical Note 8 recommends a graphical analysis to compare model simulated and observed data. Additionally, in other TMDL studies where observed data were sparse, 3- and 5-day calibration windows have been used both qualitatively (graphical/visual) and quantitatively to evaluate model calibration sufficiency. Calibration windows are centered (in time) on observed data (Kim *et al.*, 2007; Russo *et al.*, 2011; Liao *et al.*, 2015). Calibration windows were used here as part a “weight-of-evidence” approach to assess model sediment model calibration sufficiency.

The first Phase II model run for every calibration segment was used to generate estimates of the critical bed shear stress parameters (TAUCD and TAUCS) for each subwatershed reach. These critical shear stress values determined the shear stress threshold at which clay or silt was deposited (TAUCD) or scoured (TAUCS) from the reach bed. Since these thresholds were dependent on flow, specifically the 5%, 10%, 85% and 90% flows in a reach, it was difficult to determine their values *a priori*. Instead, the first model run was used to provide initial parameter estimates. At the end of this run, simulated shear stress and simulated flow were output as daily averages. Then, they were ranked in order of lowest flow/shear stress to highest flow/shear stress. The shear stress value corresponding to the 5% lowest flow in each reach was the deposition critical bed shear stress (TAUCD) for clay. The shear stress value corresponding to the 10% lowest flows in each reach was the deposition critical bed shear stress (TAUCD) for silt. Flows below these levels caused sediment to settle out and be deposited on the reach bed. The shear stress values corresponding to the 85% and 90% highest flows in each reach were the scour critical bed shear stress (TAUCS) for clay and silt, respectively. Flows above these levels caused sediment to scour from the reach bed. When the flow rate was between the upper and lower thresholds, no deposition or scouring occurred (i.e., sediment was transported downstream through the reach). Figure E-2 illustrates the parallel relationship between flow and shear stress with critical shear stress values denoted as horizontal lines for an example (Jackson River, reach 1).

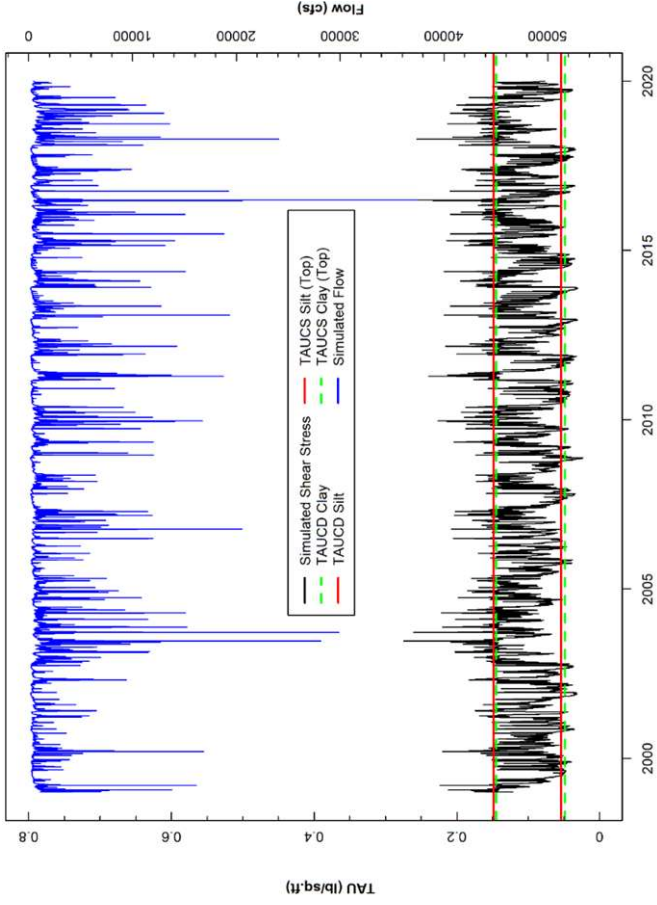


Figure E-2. Example shear stress and flow relationship with critical deposition and scour thresholds (Jackson River, reach 1).

Although TAUUCD and TAUCS are calibration parameters that were subject to change during the calibration, it was necessary to calculate initial estimates in the first model run to expedite the calibration process. In the second run, the “placeholder” TAUUCD and TAUCS values were replaced with the estimates. Then the calibration continued with all calibration parameters subject to change to achieve a sufficiently calibrated model. A table of Phase II calibration parameters and final values is included at the end of each calibration segment’s section.

Graphical Model Performance Assessment (Qualitative)

After each successful HSPF model run, the sediment outputs were plotted and analyzed to qualitatively assess model calibration sufficiency. The graphical analysis included three types of plots. A similar qualitative graphical calibration assessment approach was used in the Roanoke River PCB TMDL (DEQ, 2009) and New River PCB TMDL (DEQ, 2018).

The first type of graph used illustrates sediment concentration vs flow. In this graph, daily average simulated SSC was plotted against daily average simulated flow. Observed VADEQ SSC data were also plotted when available. A plot where most of the observed data points are encompassed by the “cloud” of simulated concentration versus flow plot data would

indicate the model is sufficiently well-calibrated. VADEQ and BSE believe that the concentration-flow plots illustrate that the model is sufficiently well calibrated.

A second type plot was used to qualitatively assess how the model performed on a given sampling date when compared to observed data. A two-part calibration graph was produced to address this need. First, observed sediment concentration data were plotted by date on the x-axis. The simulated average daily SSC for a 3-day window centered on the observed sampling date was also plotted. The maximum and minimum simulated daily SSC concentrations during the 3-day window were plotted as well. In a sufficiently well-calibrated model, a majority of the observed data points should fall within the 3-day window maximum-minimum range. When the observed data is not captured within a given 3-day window range, the model should under- and over-estimate roughly equally. Using the 3-day window to qualitatively assess model performance can aid in illustrating temporal fluctuations in the model that may cause the sediment concentrations to have a delayed or early response.

A final plot that was used to qualitatively assess model calibration was a time series plot of daily average simulated and observed SSC with daily average simulated flow plotted on a secondary axis. These plots were generated for all subwatershed reaches where observed SSC data was available. The objective of this analysis was to show that simulated SSC responded to fluctuations in simulated flow, and that simulated SSC could adequately predict observed SSC.

Three- and Five-day Window Model Performance Assessment (Quantitative)

In addition to the 3-day window qualitative, graphical assessment, 3- and 5-day calibration windows were used to quantitatively assess model performance. Again, 3-day and 5-day calibration windows were centered (in time) on observed data. Each window included an equal number of simulated data points before and after the sample date. The minimum and maximum daily simulated SSC values within the windows were determined. If the observed SSC value was between the minimum and maximum values, then that data point was considered to be “within” the window. If the observed SSC value was less than the minimum value, then it was considered to be “below” the calibration window. If the observed SSC value was greater than the maximum, then it was considered to be “above” the calibration window. It should be emphasized that 3- and 5-day windows were only generated around observed SSC sample data.

Kim *et al.* (2007) justified the use of 5-day windows for developing bacterial TMDLs in watersheds with limited observed data. Kim *et al.* (2007) stated that the goal of the calibration was to achieve at least 70% observed data points within the 5-day window. Additionally, in order

to avoid model bias, the percentage of data points above and below the window (if any) should be roughly equal.

The 3-day calibration window is 'stricter' in terms of analyzing model performance since it narrows the calibration window. Both Russo *et al.* (2011) and Liao *et al.* (2015) used 3-day calibration windows to assess bacteria model performance. Unlike the 5-day calibration window, calibration criteria for a 3-day window are not clearly defined in the literature. However, since the 3-day window is narrower, BSE believes achieving a majority of data points (i.e. ≥50%) within the 3-day calibration window demonstrates adequate evidence of model fit. Again, in order to avoid model bias, the percentage of data points above and below the 3-day calibration window maximum and minimum values should be roughly equal.

The 3- and 5-day calibration window "within", "below", and "above" statistics were calculated once per model run and included all observed SSC data available from VADEQ. During calibration, the 3-day and 5-day windows metrics were examined after each run as a primary indicator to determine if additional calibration was necessary. BSE believes it is reasonable to use both the 3- and 5-day calibration windows to quantitatively assessing sediment model performance.

E.2 Jackson River

This section presents the HSPF sediment calibration results for the Jackson River. The calibration results are summarized by Phase I and Phase II. Chapter 2 provides maps showing the location of the Jackson River subwatersheds that will be discussed as well as all observed SSC water quality stations and USGS flow gage. Figure E-3 illustrates the location of TMDL watershed, major tributary boundaries, reaches, and select monitoring stations used for comparing simulated and observed values during model calibration.

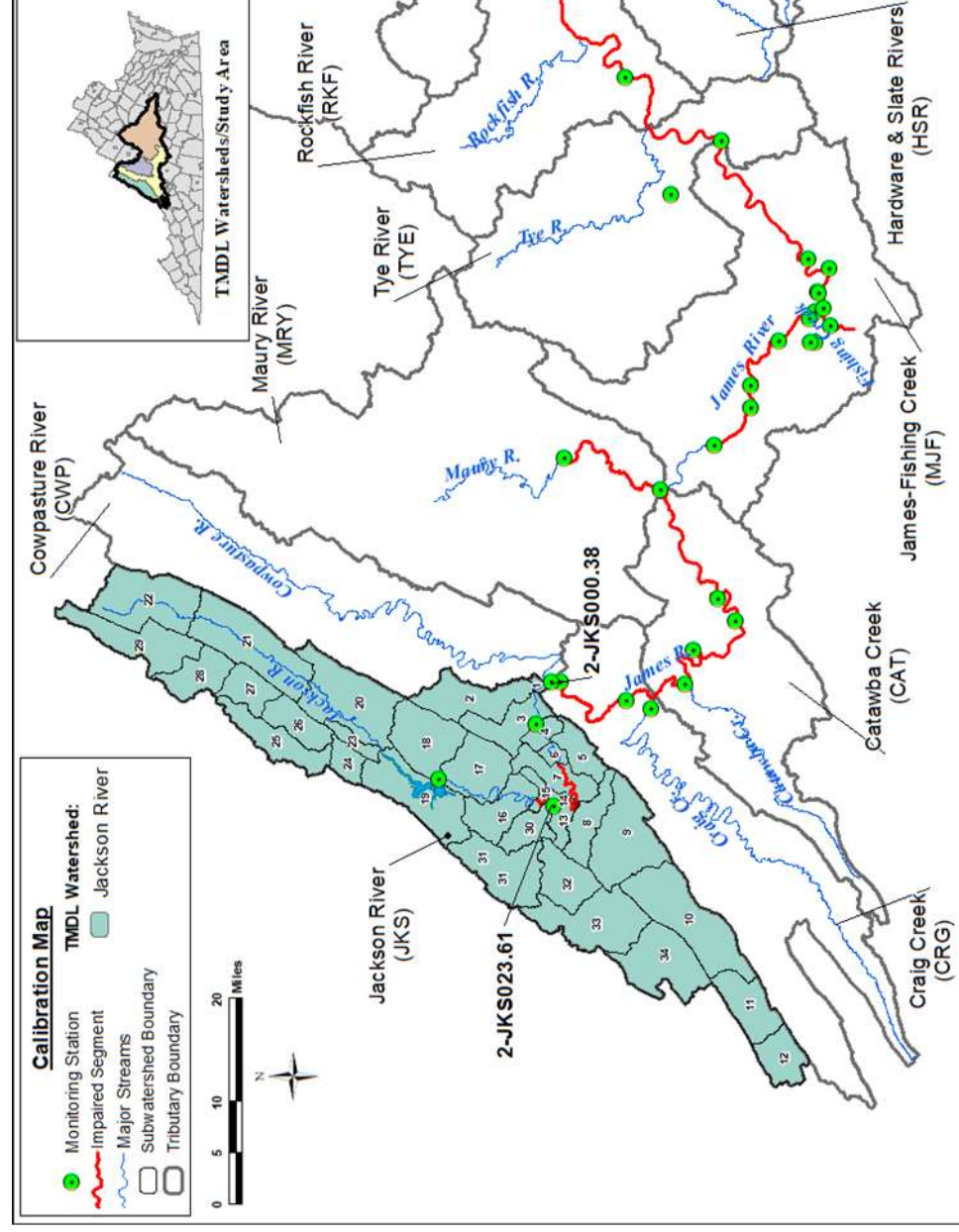


Figure E-3. Subwatersheds and monitoring stations used in calibration comparisons for the Jackson River TMDL watershed.

E.2.1 Phase I Calibration

Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Jackson River were calibrated to within the load target ranges (Table E-1) for each Jackson River subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD

calibration tables, they are not included in this Appendix; including tables would have increased report length significantly. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-4, Figure E-5, and Figure E-6 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Jackson River watershed. Other pervious land uses and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically fallowed.

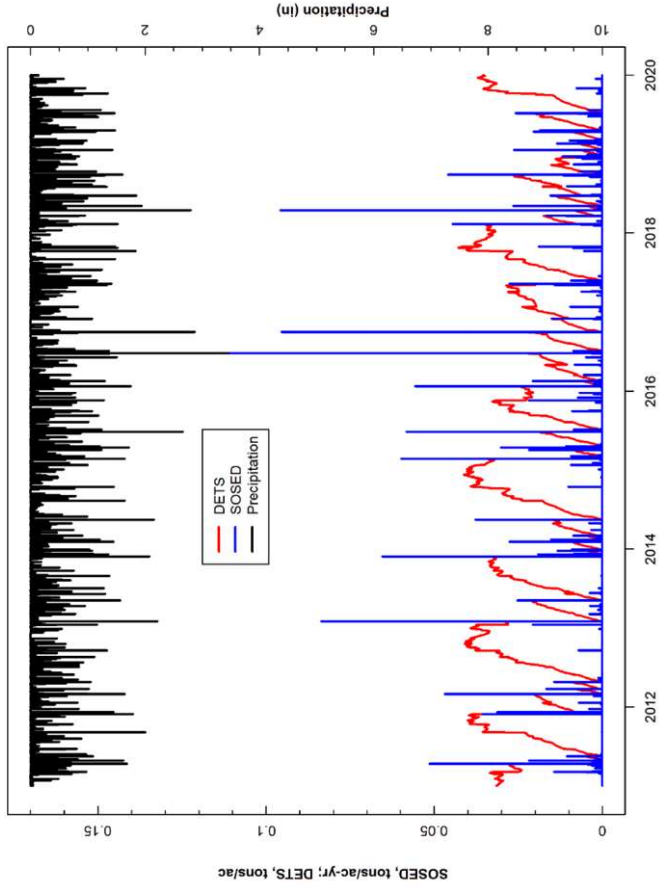


Figure E-4. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Jackson River watershed.

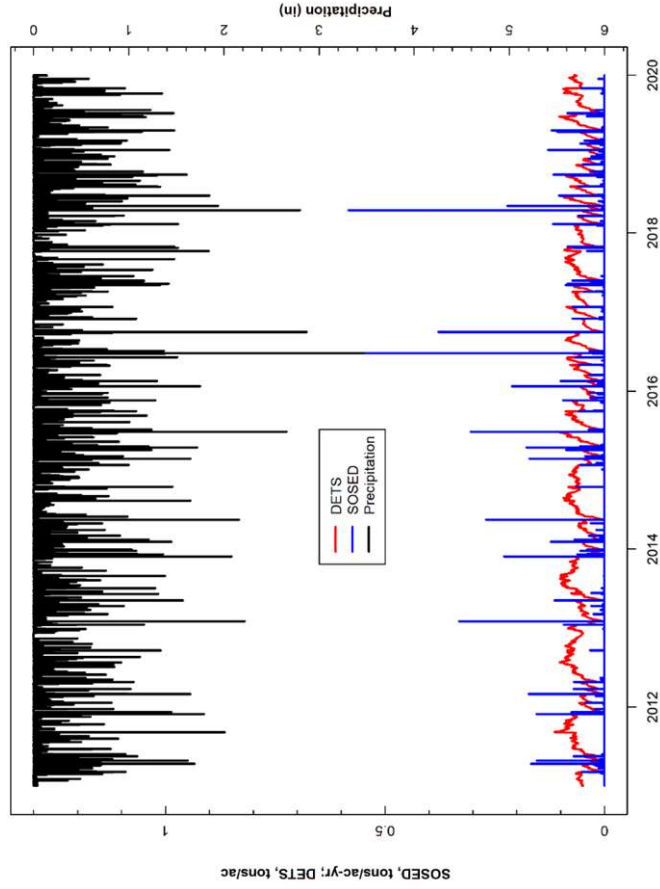


Figure E-5. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Jackson River watershed.

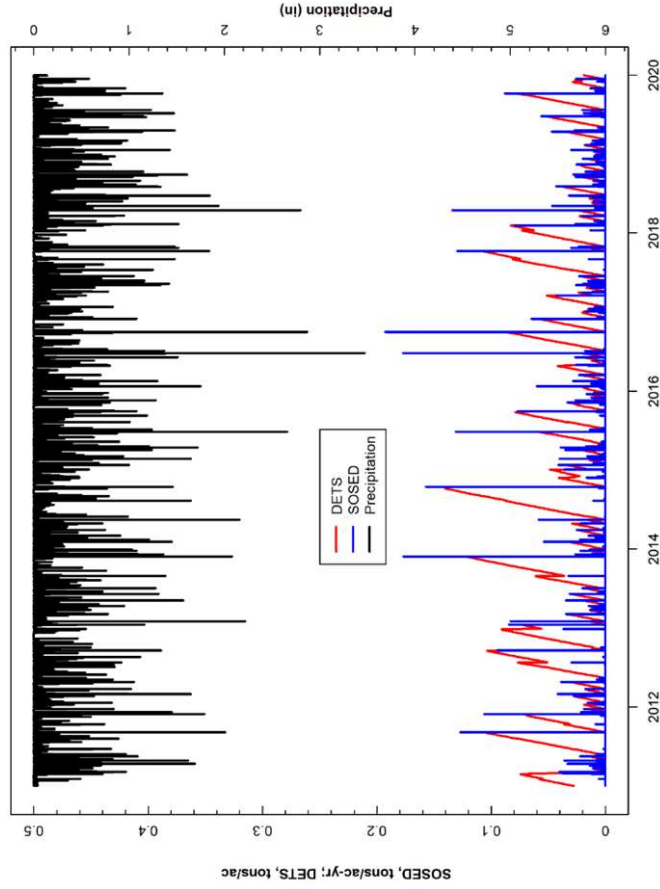


Figure E-6. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Jackson River watershed.

Impervious Land Use Calibration

Figure E-7 shows the observed precipitation (upper axis) and SOSLD and SLDS values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011

to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

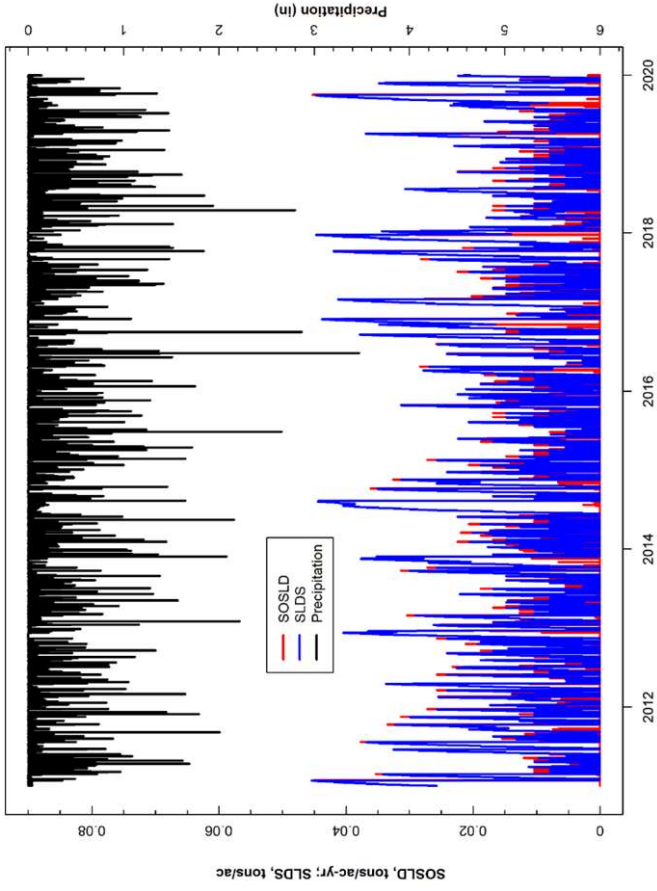


Figure E-7. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Jackson River watershed.

SOSED, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided a reasonable approximation of the behavior of sediment detachment and removal in the Jackson River calibration. Due to the large number of subwatersheds and land uses in Jackson River, Phase I graphs for the other subwatersheds are not included in this report due to

lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-3.

Table E-3. Final calibrated parameters for the Jackson River Phase I Calibration.

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	0.0-1.0	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.050 - 0.352 ^b	0.05 - 0.75	Estimated in GIS, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	3.0 for water and 2 for others	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.001 - 0.5 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.0-0.980	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 - 6.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.010 - 4.90 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.0 - 1.6	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0 - 0.5	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	1.5 - 2.5	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	1.0	0.1 - 10.0	Based on Tech. Note Recommended Values
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	1.8	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0028	0.0 - 30.0	" "
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

[#] Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segment

^b Varies with land use (data available upon request by referring to the contact information on page ii).

^c Impervious land segment.

E.2.2 Phase II Calibration

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration sufficiency metrics were analyzed after each run to determine if model calibration would continue. Although not explicitly part of the calibration evaluation process, another check that was performed after each calibration run examined the change in sediment bed depth. Bed depth was output as an annual average for each subwatershed reach. Large swings in bed depth trends were indications that the model could be encountering calculation errors and misrepresenting the subwatershed.

Graphical Model Performance Assessment (*Qualitative*)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-8 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2017 to December 31, 2018 for reach 14, the channel corresponding to subwatershed 14 in the Jackson River, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station JKS023.61 and the observed flow at the corresponding USGS flow gage on Jackson River (green triangles). The USGS flow gage closest to VADEQ station JKS023.61 with a complete flow record is USGS02013100.

Figure E-8 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases. A similar sediment concentration-flow correlation was illustrated with the simulated data.

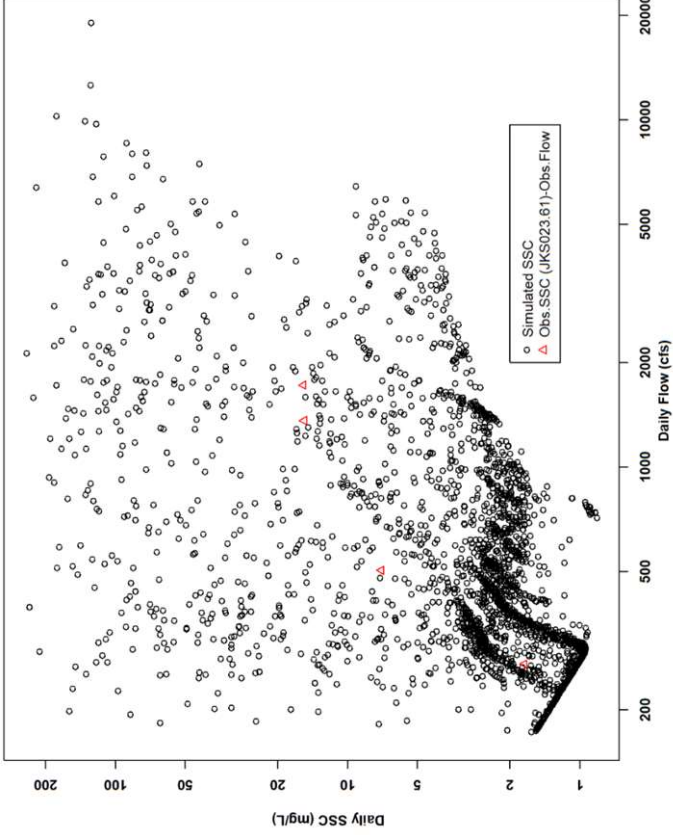


Figure E-8. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 14 in Jackson River watershed.

Figure E-9 further illustrates the model performance, with simulated and observed sediment concentrations plotted on each day that observed SSC data were collected at DEQ station JKS000.38. The performance of the 3-day window surrounding the date of the observed SSC were different for each reach in the Jackson River based on the number of SSC observed data points in each reach. The average daily simulated, and observed SSC for a 3-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 3-day window are shown. All the observed SSC data points were captured within the 3-day sediment windows by the model for reach 1 of the Jackson River watersheds.

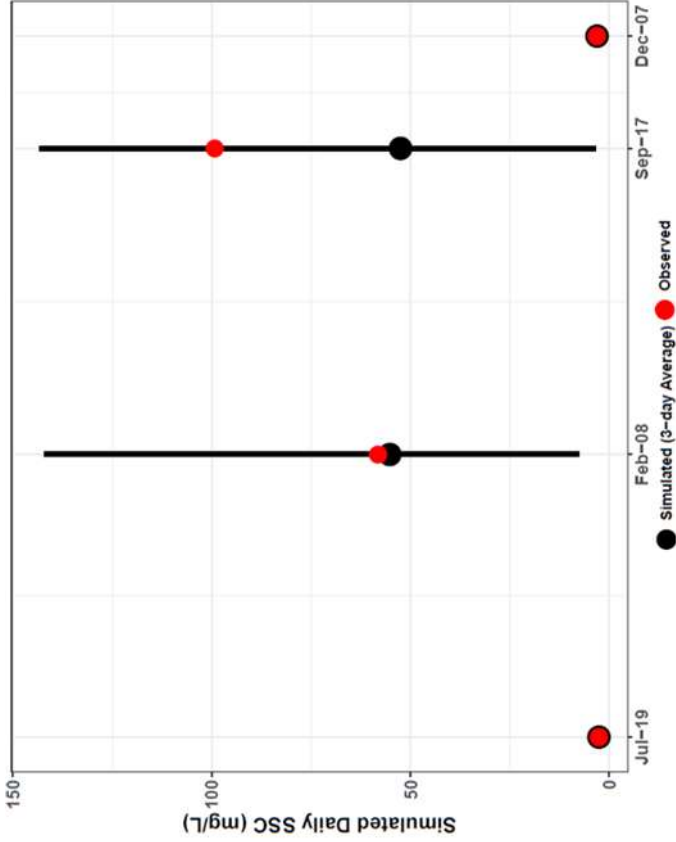


Figure E-9. Three-day window plot for sediment concentration showing the 3 and 5-day average, maximum minimum, and observed values at station JKS000.38 (Jackson River reach 1).

Figure E-10 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for subwatershed reach 1 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This time series plot is representative of the results from other Jackson River subwatershed reaches and water quality stations. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

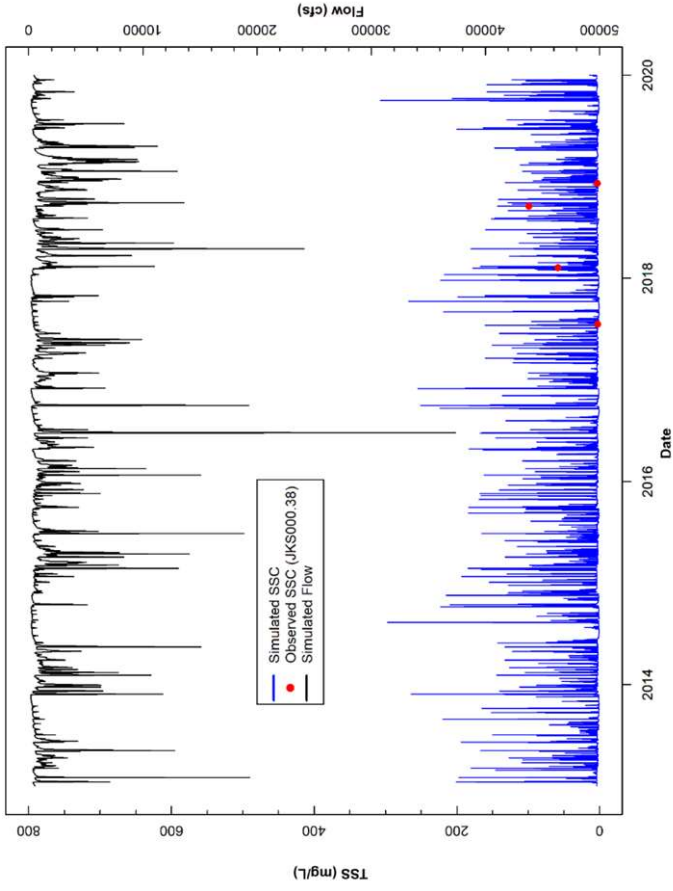


Figure E-10. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 1 in the Jackson River watershed.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-4 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Jackson River watershed. Three- and 5-day windows were only calculated around the days on which observed data is available. The 77% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim *et al.*, 2007), and the 62% of the observed data within the 3-day window is greater than the desired 50% discussed earlier. And while the model did exhibit a slight under-prediction bias as indicated by the slightly larger percentage ‘below’ values for both the 3- and 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-5.

Table E-4. Three- and five-day window calibration statistics for the Jackson River Phase II Calibration.

Statistics	Value
Number of Observed Data Points	13
Percentage within 3-day window	62%
Percentage above 3-day maximum	15%
Percentage below 3-day minimum	23%
Percentage within 5-day window	77%
Percentage above 5-day maximum	8%
Percentage below 5-day minimum	15%

Calibration Summary

Using a “weight-of-evidence” approach presented here, the conclusion is that the Jackson River watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all Jackson River watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-5. Final calibrated parameters for the Jackson River watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD#
RCHRES^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	120	5 - 1000	Estimated from ArcGIS 3D Analyst
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	7.5	0.5 - 20	Estimated from ArcGIS 3D Analyst
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.4	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.6	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.001	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Silt Parameters)						

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES ^a	CALCULATION METHOD ^a
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0005	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.0156 – 0.5544 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.1486 – 1.0820 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-05 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.0001	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.00005	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.0130- 0.54040 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.1450 – 0.91410 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-0.05 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	5 sand; 12 silt; 12 clay	n/a	Estimated
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	30% sand; 40% silt; 30% clay	n/a	Estimated

^a Acquired from EPA BASINS Technical Note 8 (2006).

^a Main stem of stream in each subwatershed.

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii).

E.3 Maury River

This section presents the HSPF sediment calibration results for the Maury River. The calibration results are summarized by Phase I and Phase II. Chapter 2 provides maps showing the location of the Maury River subwatersheds that will be discussed as well as the observed SSC water quality stations and USGS flow gage. Figure E-11 illustrates the location of TMDL watershed, major tributary boundaries, reaches, and select monitoring stations used for comparing simulated and observed values during model calibration.

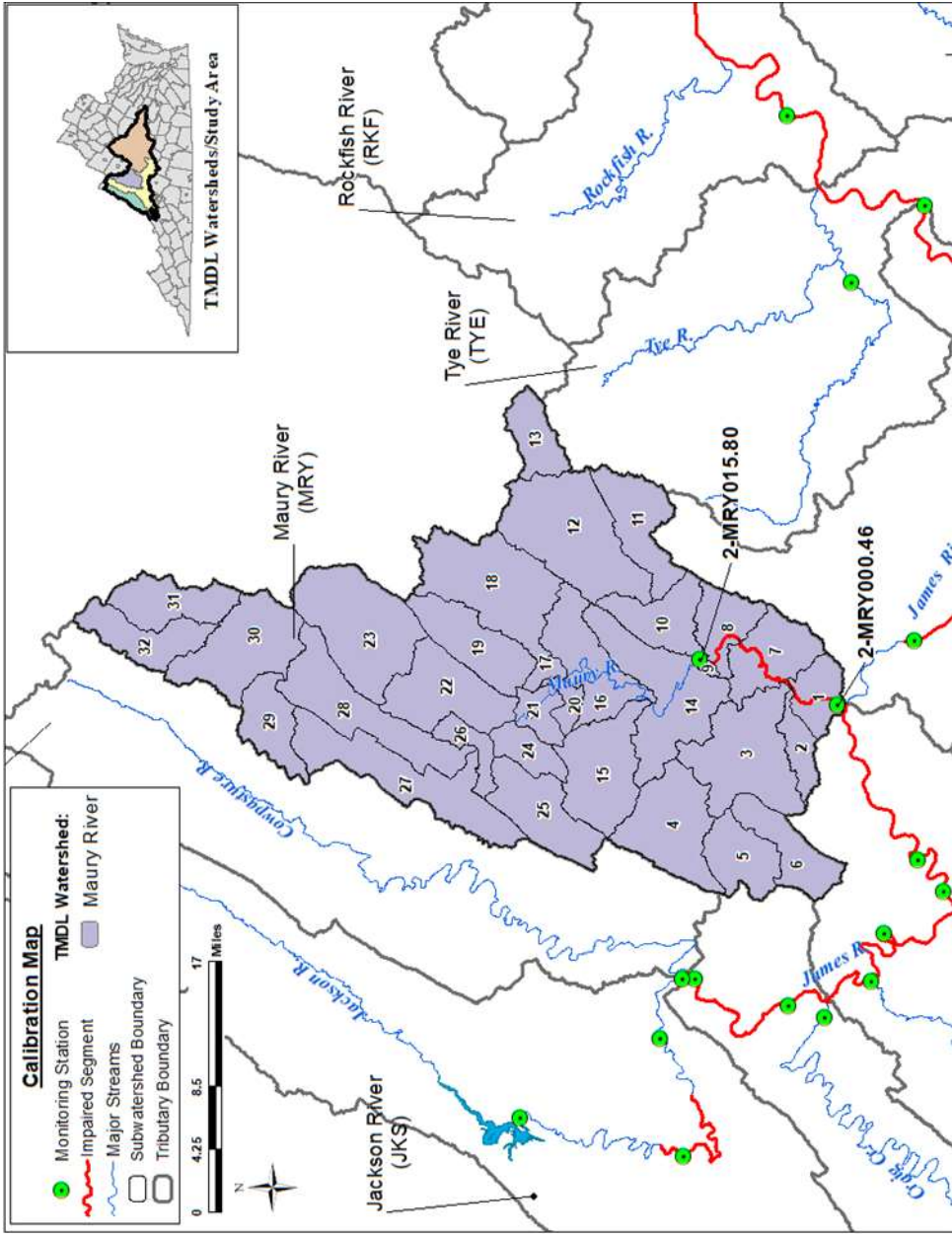


Figure E-11. Subwatersheds and monitoring stations used in calibration comparisons for the Maury River TMDL watershed.

E.3.1 Phase I Calibration

Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Maury River were calibrated to within the load target ranges (Table E-1) for each Maury River subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD calibration tables for the 32 subwatersheds, they are not included in this Appendix; including tables would have made the report unmanageably long. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-12, Figure E-13, and Figure E-14 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Maury River watershed. Other pervious land uses, and subwatersheds produced similar SOSED and DETS plots. As

expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by major storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

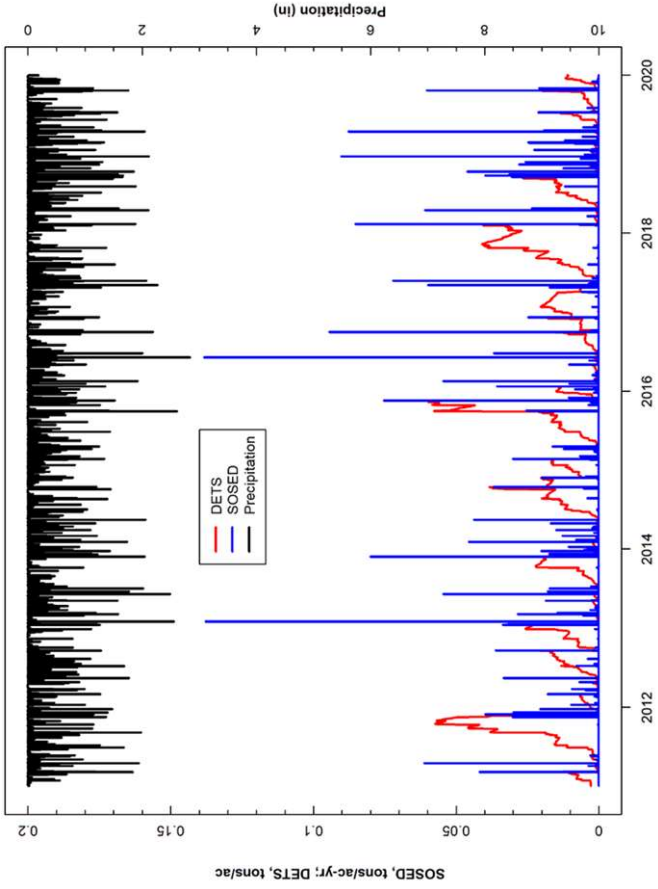


Figure E-12. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Maury River watershed.

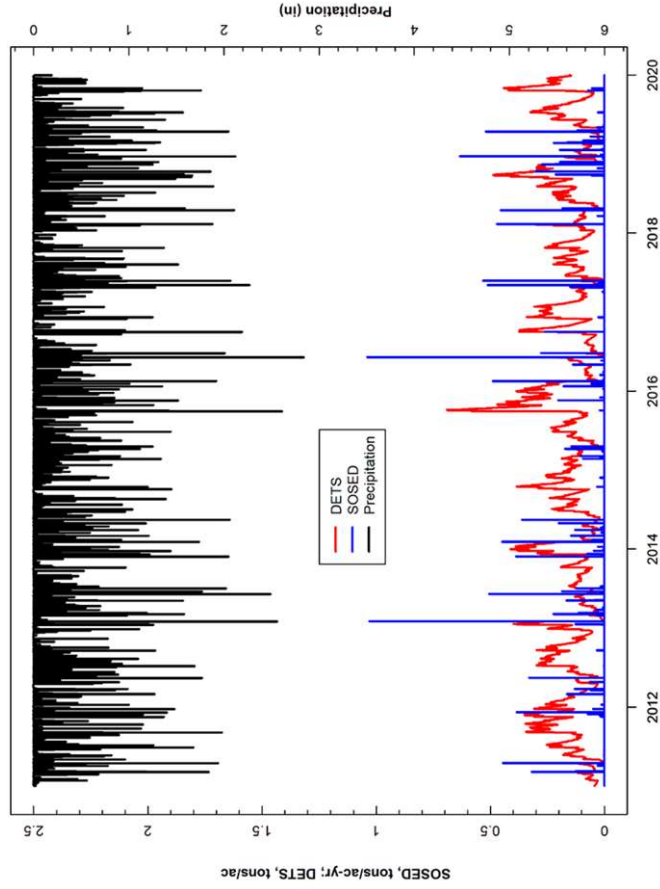


Figure E-13. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Maury River watershed.

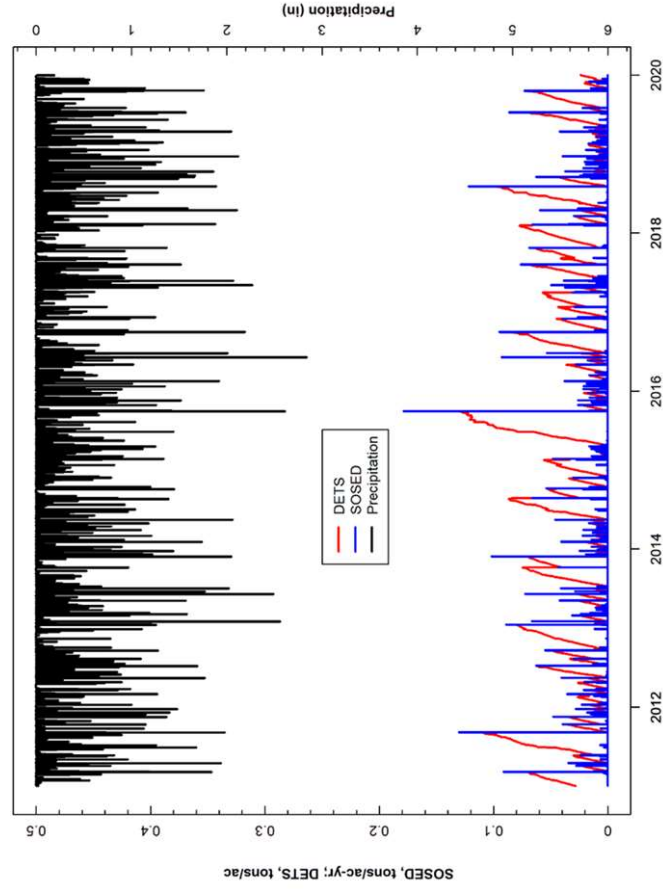


Figure E-14. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Maury River watershed.

Impervious Land Use Calibration

Figure E-15 shows the observed precipitation (upper axis) and SOSLD and SLDs values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011

to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

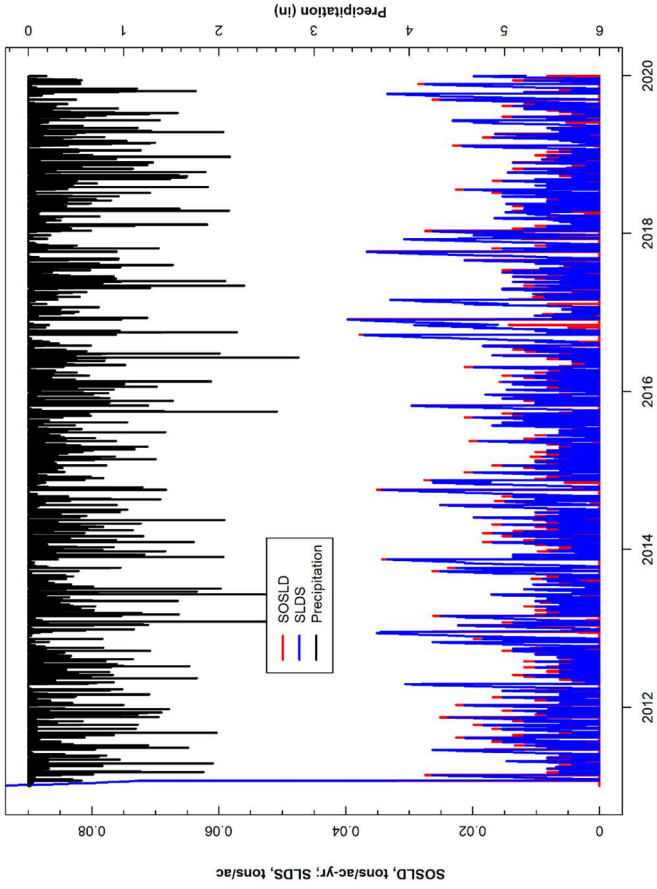


Figure E-15. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Maury River watershed

SOSED, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided a reasonable approximation of the behavior of sediment detachment and removal in the Maury River overland sediment transport calibration. Due to the large number of subwatersheds and land uses in Maury River, Phase I graphs for the other subwatersheds are not included in this

report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-6.

Table E-6. Final calibrated parameters for the Maury River Phase I Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	1	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.050 - 0.750 ^b	0.05 - 0.75	Based on Technical Note Recommended Values, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	3.0 for water bodies and 2 for others	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.001 - 0.05 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.0-0.97	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 - 2.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.1 - 9.00 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.10 - 1.20	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0 - 0.21	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	1.5-2.5	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	2.0	0.1 - 10.0	Based on Tech. Note Recommended Values
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	1.8	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0022	0.0 - 30.0	" "
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.04	0.01 - 1.0	" "

[#] Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segments

^b Varies with land use (data available upon request by referring to the contact information on page ii)

^c Impervious land segment

E.3.2 Phase II Calibration

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration efficiency metrics were analyzed after each run to determine if it's necessary to continue the model calibration procedure further.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-16 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2017 to December 31, 2019 for reach 09, the reach corresponding to subwatershed 09 in the Maury River, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station 2-MRY015.80 and the observed flow at the corresponding USGS flow gage on Maury River (Red triangles). The USGS flow gage closest to VADEQ station 2-MRY015.80 with a complete flow record is USGS02024000 (Maury River near Buena Vista).

Figure E-16 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases except for one date. On that particular date the observed SSC was very low despite the high observed flow of the river at two of the reaches. A similar sediment concentration-flow correlation was illustrated with the simulated data.

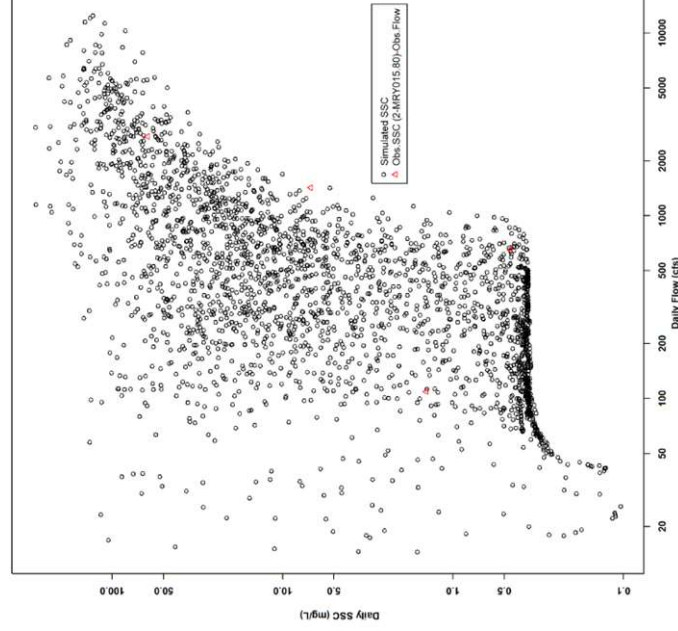


Figure E-16. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 9 in Maury River watershed.

Figure E-17 further illustrates the model performance, with simulated and observed sediment concentrations plotted on each day at which observed SSC data were collected at VADEQ station 2-MRY000.46. The average daily simulated and observed SSC for a 5-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 5-day window are shown. All the observed SSC data points were captured within the 5-day sediment windows by the model for reach 1 of the Maury River watersheds.

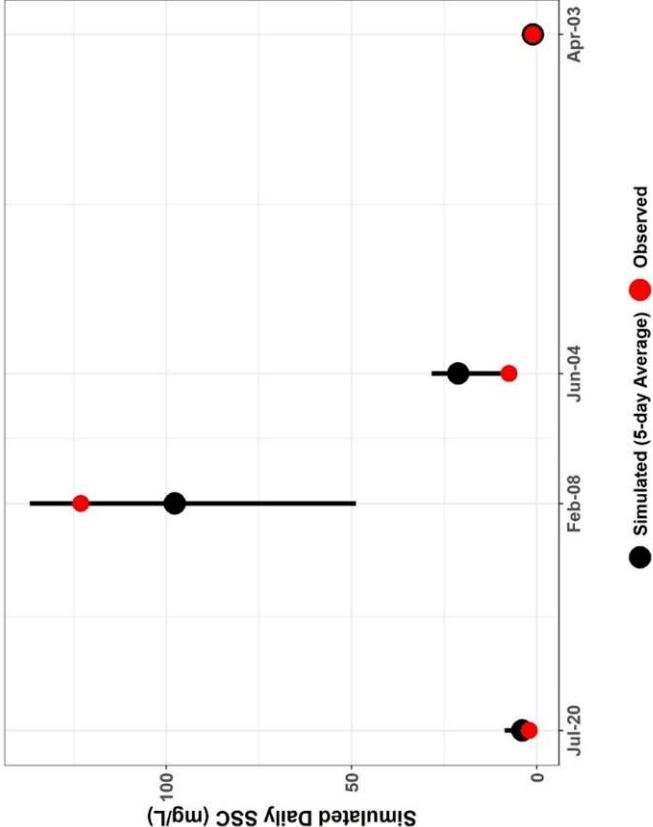


Figure E-17. Three-day window plot for sediment concentration showing the 5-day average, maximum minimum, and observed values at station 2-MRY000.46 (Maury River watershed reach 1).

Figure E-18 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for the river section within the subwatershed 1 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

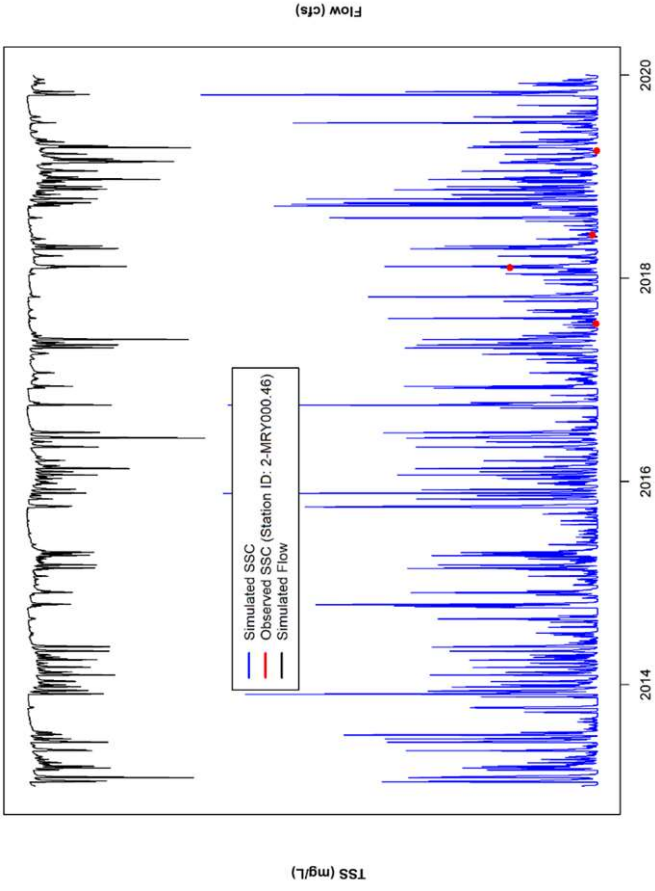


Figure E-18. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 1 in the Maury watershed.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-7 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Maury River watershed. 3- and 5-day windows were only calculated around the days on which observed data were available. The 75% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim et al., 2007), and the 50% of the observed data within the 3-day window is equal to the desired 50% discussed earlier. It is worth mentioning that for the river section within subwatershed 1 all of the four observed data points were within the 5-day window and 75% of them were within the 3-day window. And while the model over-predicted some of the SSC data as indicated by the slightly larger percentage 'below' values for the 3-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-8.

Table E-7. Three- and five-day window calibration statistics for the Maury River Phase II Calibration.

Statistics		Value
Number of Observed Data Points		8
Percentage within 3-day window		75%
Percentage above 3-day maximum		0%
Percentage below 3-day minimum		25%
Percentage within 5-day window		87.5%
Percentage above 5-day maximum		0%
Percentage below 5-day minimum		12.5%

Calibration Summary

Using a “weight-of-evidence” approach presented here, the conclusion is that the Maury River watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all Maury River watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-8. Final calibrated parameters for the Maury River watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
RCHRES^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	16	5 - 1000	Based on Technical Note Recommended Values
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	10	0.5 - 20	Based on Technical Note Recommended Values
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.1	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	4	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.05-0.125	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
SILT-CLAY-PM (Silt Parameters)						
D	Effective diameter of silt particles	Sediment properties	in	0.0005	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0004	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.01 – 0.22 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.07 – 2.77 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.1-0.2 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.001	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.005	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.9	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.01- 0.220 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.05 – 2.44 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.1-0.2 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	10 sand; 20 silt; 20 clay	n/a	Based on Tech. Note Recommended Values
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	60% sand; 20% silt; 20% clay	n/a	

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.4 Upper James River

This section presents the HSPF sediment calibration results for the Upper James River TMDL Watershed that includes: Cowpasture River, Craig Creek, Catawba Creek, portions of the James River, and Fishing Creek. The calibration results are summarized by Phase I and Phase II. Chapter 2 provides maps showing the location of the Upper James River subwatersheds that will be discussed as well as all observed SSC water quality stations and USGS flow gage.

Figure E-19 illustrates the location of TMDL watershed, major tributary boundaries, reaches,

and select monitoring stations used for comparing simulated and observed values during model calibration.

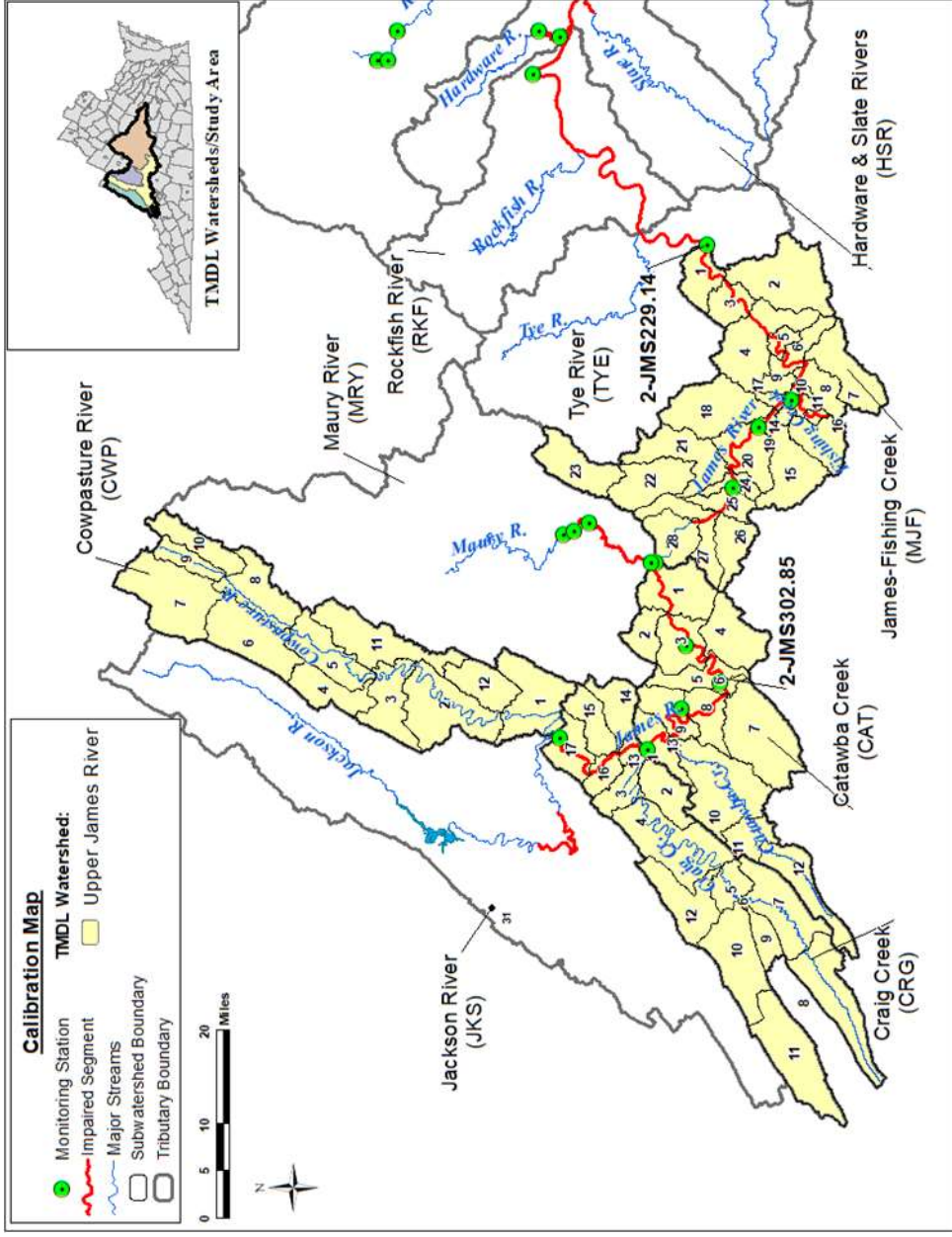


Figure E-19. Subwatersheds and monitoring stations used in calibration comparisons for the Upper James River TMDL watershed.

E.4.1 Phase I Calibration: Upper James River – Cowpasture, Catawba, Craig Creek

This section of calibration results for James River—Cowpasture, Catawba, and Craig Creeks are collectively referred to as “Upper James River”. Comparison analyses of model results for the outlet located in the James River—Catawba calibration watershed portion are discussed in the following sections. Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Upper James River were calibrated to within the load target ranges (Table E-1) for each Upper James River subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD calibration tables for the 30 subwatersheds, they are not

included in this Appendix; including tables would have made the report unmanageably long. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-20, Figure E-21, and Figure E-22 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Upper James River watershed. Other pervious land uses, and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by major storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

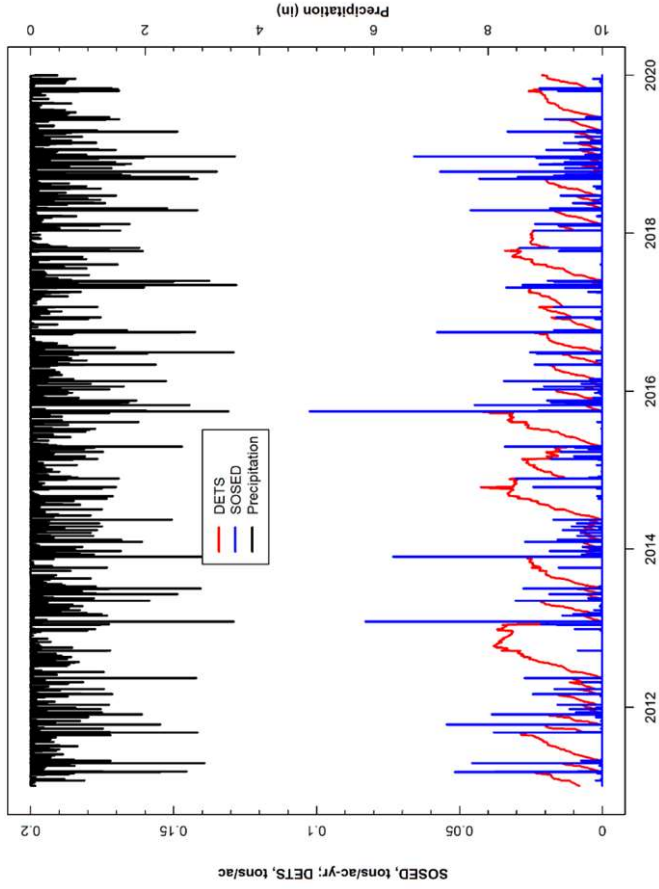


Figure E-20. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Upper James River—Catawba calibration watershed.

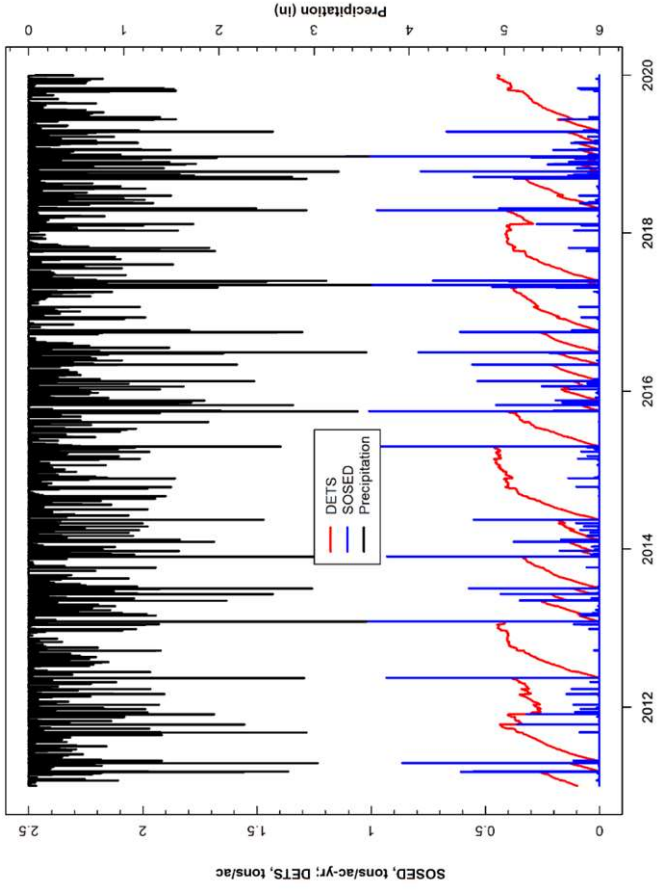


Figure E-21. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Upper James River—Catawba calibration watershed.

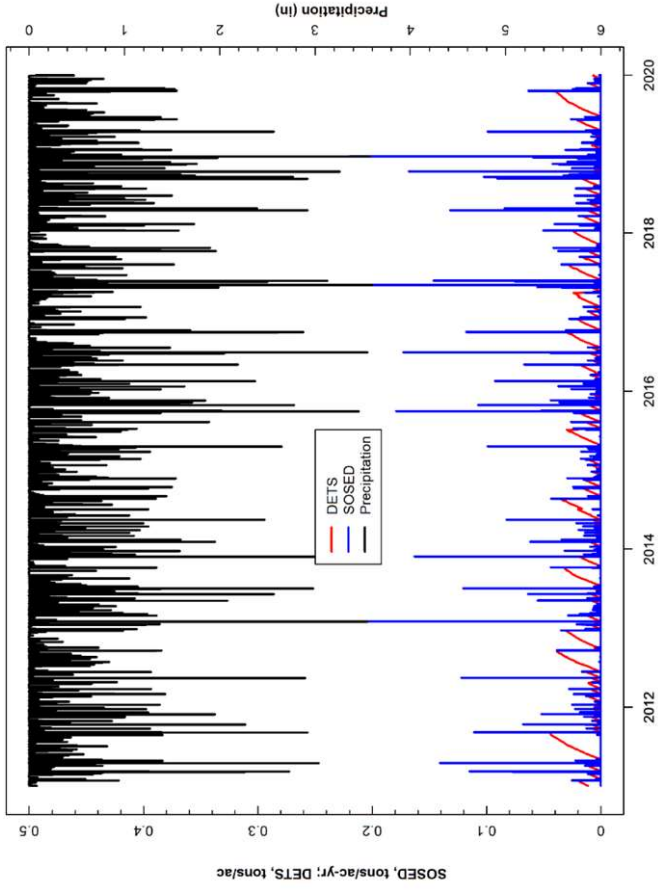


Figure E-22. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Upper James River—Catawba calibration watershed.

Impervious Land Use Calibration

Figure E-23 shows the observed precipitation (upper axis) and SOSLD and SLDS values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011

to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

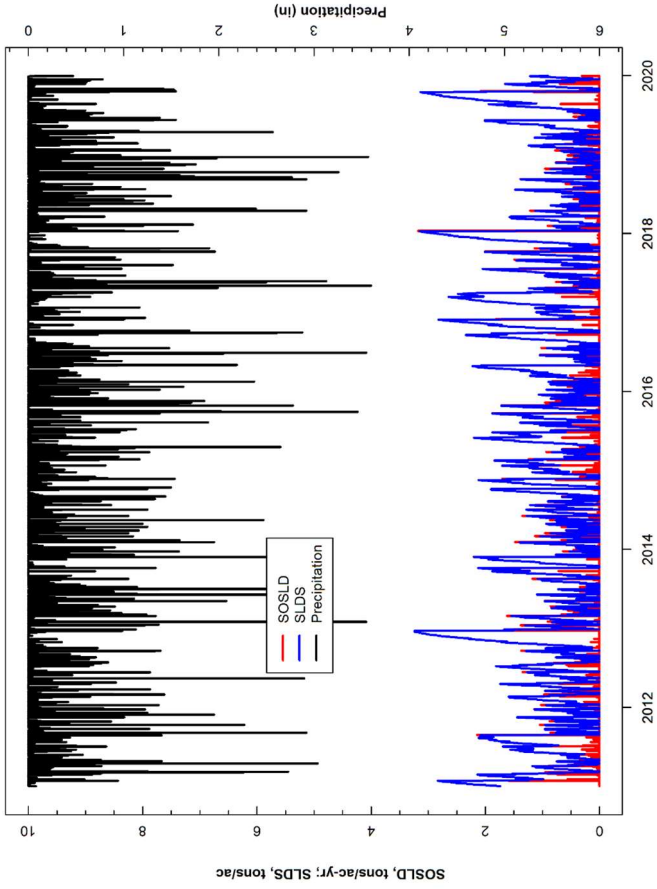


Figure E-23. Impervious Residential SOSLD, SLDs, and observed precipitation for subwatershed 1 in Upper James River—Catawba calibration watershed.

SOSLD, SOSLD, DETS, and SLDs Summary

The simulated SOSLD, SOSLD, DETS, and SLDs values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSLD (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDs (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided a reasonable approximation of the behavior of sediment detachment and removal in the Upper James River overland sediment transport calibration. Due to the large number of subwatersheds and land uses in Upper James River, Phase I graphs for the other subwatersheds are not

included in this report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-9.

Table E-9. Final calibrated parameters for the Upper James River Phase I Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	1	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.200 - 0.352 ^b	0.05 - 0.75	Based on Technical Note Recommended Values, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	2.0 - 3.05 ^b	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.01 - 0.50 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.20 - 0.97	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 - 10.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.1 - 4.5 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.0 - 2.5	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	2.0	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	1.0	0.1 - 10.0	Based on Tech. Note Recommended Values Calibrated in HSPF
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	1.8	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0032	0.0 - 30.0	" "
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

[#] Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segments

^b Varies with land use (data available upon request by referring to the contact information on page ii)

^c Impervious land segment

E.4.2 Phase II Calibration: Upper James River – Cowpasture, Catawba, Craig Creek

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration efficiency metrics were analyzed after each run to determine if it's necessary to continue the model calibration procedure further.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and sub-watersheds where observed SSC data were available. Figure E-24 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2013 to December 31, 2019 for reach 03, the reach corresponding to subwatershed 03 in the Upper James River—Catawba calibration watershed, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station 2-JMS302.85 and the observed flow at the corresponding USGS flow gage on Upper James River (Red triangles). The USGS flow gage closest to VADEQ station 2-JMS302.85 with a complete flow record is USGS02019500 (James River at Buchanan, VA).

Figure E-24 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases except for one date. On that particular date the observed SSC was very low despite the high observed flow of the river at two of the reaches. A similar sediment concentration-flow correlation was illustrated with the simulated data.

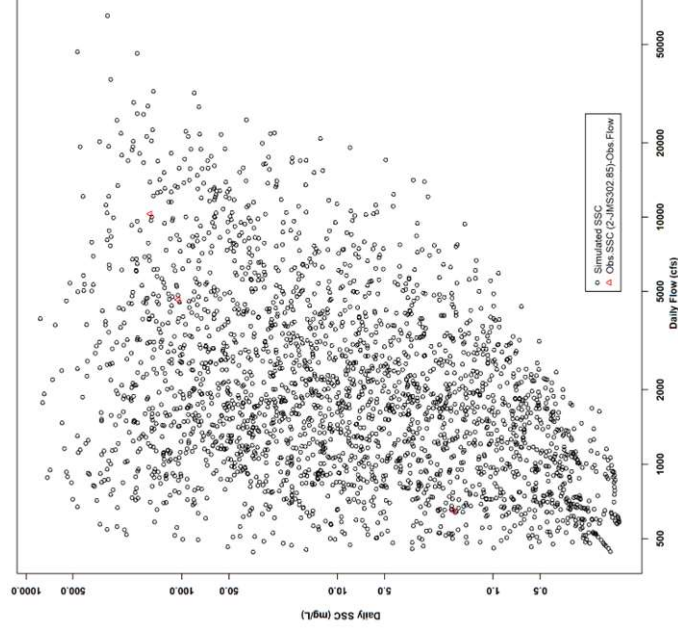


Figure E-24. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 3 in Upper James River—Catawba calibration watersheds.

Figure E-25 further illustrates the model performance. In Figure E-25 simulated and observed sediment concentrations were plotted on each day at which observed SSC data were collected at VADEQ station 2-JMS302.85. The average daily simulated and observed SSC for a 5-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 5-day window are shown. The Figure E-25 shows all the observed SSC data points were captured within the 5-day sediment windows by the model for reach 3 of the Upper James River watersheds.

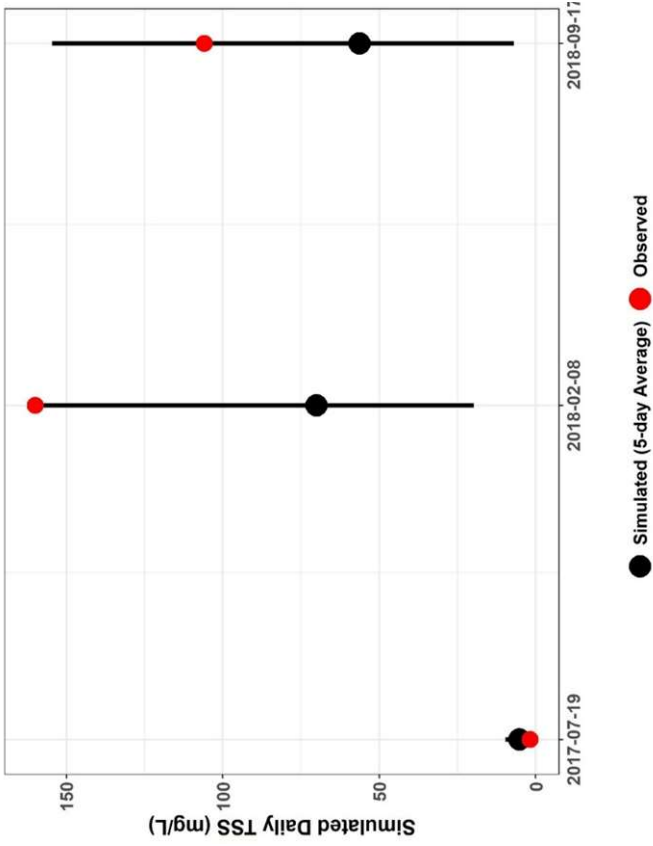


Figure E-25. Three-day window plot for sediment concentration showing the 5-day average, maximum minimum, and observed values at station 2-JMS302.85 (Upper James River—Catawba calibration watershed, reach 3).

Figure E-26 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for the river section within the subwatershed 3 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

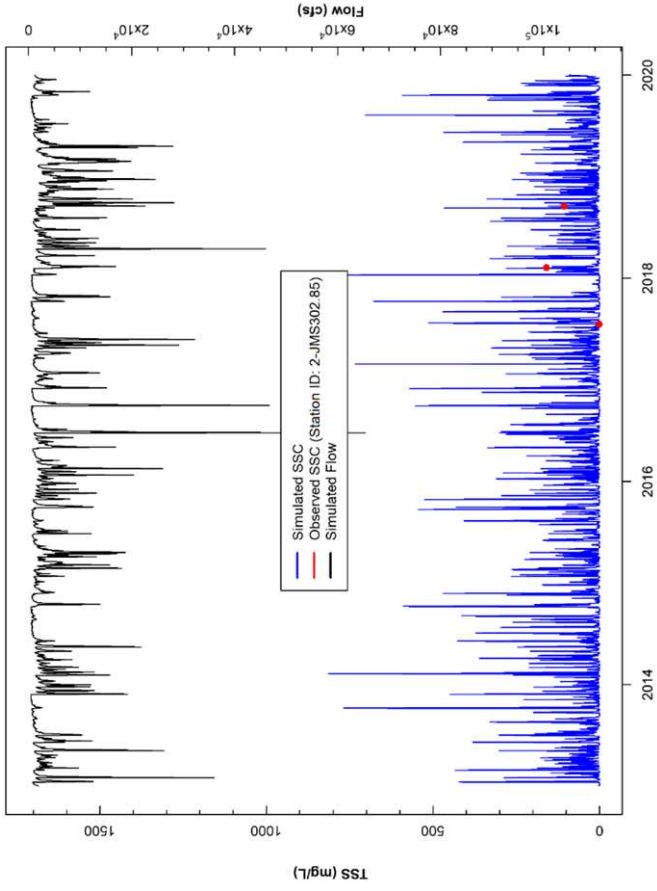


Figure E-26. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 3 in the Upper James—Catawba calibration watershed.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-10 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Upper James River watershed. 3- and 5-day windows were only calculated around the days on which observed data were available. The 80% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim et al., 2007), and the 60% of the observed data within the 3-day window is greater than the desired 50% discussed earlier. It is worth mentioning that for the river section within subwatershed 3 all of the three observed data points were within the 5-day window. And while the model under-predicted some of the SSC data as indicated by the slightly larger percentage ‘above’ values for the 3 and 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-11.

Table E-10. Three- and five-day window calibration statistics for the Upper James River Phase II Calibration.

Statistics	Value
Number of Observed Data Points	15
Percentage within 3-day window	60%
Percentage above 3-day maximum	26%
Percentage below 3-day minimum	14%
Percentage within 5-day window	80%
Percentage above 5-day maximum	20%
Percentage below 5-day minimum	0%

Calibration Summary: Upper James River –Cowpasture, Catawba, Craig Creek

Using a “weight-of-evidence” approach presented here, the conclusion is that the Upper James River watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all Upper James River watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-11. Final calibrated parameters for the Upper James River watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
RCHRES^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	13	5 - 1000	Based on Technical Note Recommended Values
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	6.5-20 ^b	0.5 - 20	Based on Technical Note Recommended Values
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.1-1.9 ^b	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.5-3.0 ^b	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.001-0.05 ^b	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	1.5-2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
SILT-CLAY-PM (Silt Parameters)						
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.002 – 0.08 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.2 – 1.00 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.001	0.00005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.001- 0.80 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.01 – 1.9 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	2 sand; 2 silt; 20 clay	n/a	Based on Tech. Note Recommended Values
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	15% sand; 65% silt; 20% clay	n/a	

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.4.3 Phase I Calibration: Upper James River – Fishing Creek

This section presents the HSPF sediment calibration results for the James River—Fishing Creek calibration segment. This is the furthest downstream modeled watershed within the Upper James River TMDL watershed (Figure E-19). The calibration results are summarized by Phase I and Phase II. Chapter 2 provides maps showing the location of the Upper James River – Fishing Creek subwatersheds that will be discussed as well as the observed SSC water quality stations and USGS flow gage.

Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Upper James River – Fishing Creek were calibrated to within the load target ranges (Table E-1) for each Upper James River – Fishing Creek subwatershed and land use. Due to the large size

of the resulting SOSED and SOSLD calibration tables for the 30 subwatersheds, they are not included in this Appendix; including tables would have made the report unmanageably long. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-27, Figure E-28, and Figure E-29 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Upper James River – Fishing Creek watershed. Other pervious land uses, and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by major storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

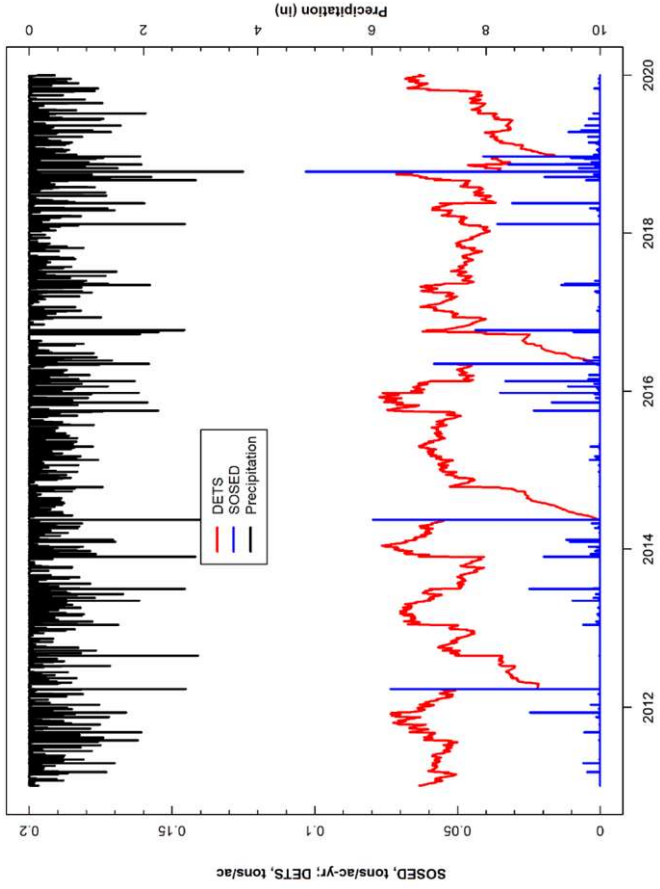


Figure E-27. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Upper James River—Fishing Creek watershed

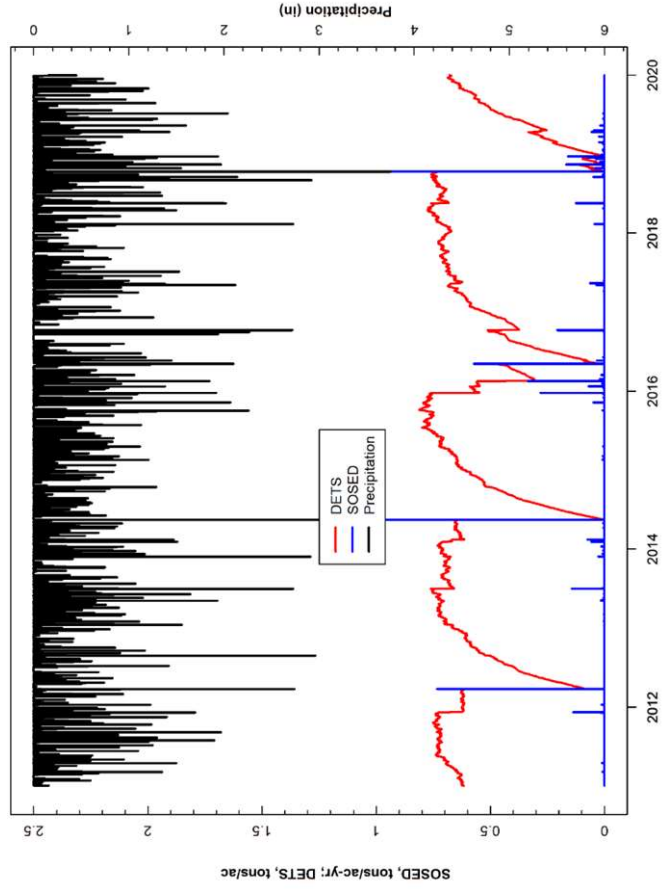


Figure E-28. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Upper James River—Fishing Creek watershed.

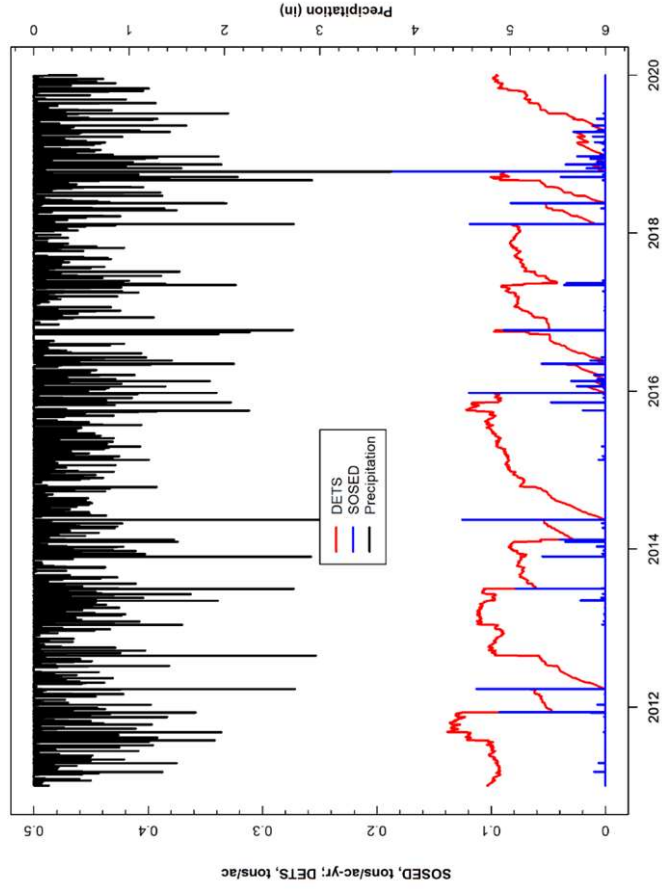


Figure E-29. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Upper James River—Fishing Creek watershed.

Impervious Land Use Calibration

Figure E-30 shows the observed precipitation (upper axis) and SOSLD and SLDS values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011 to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

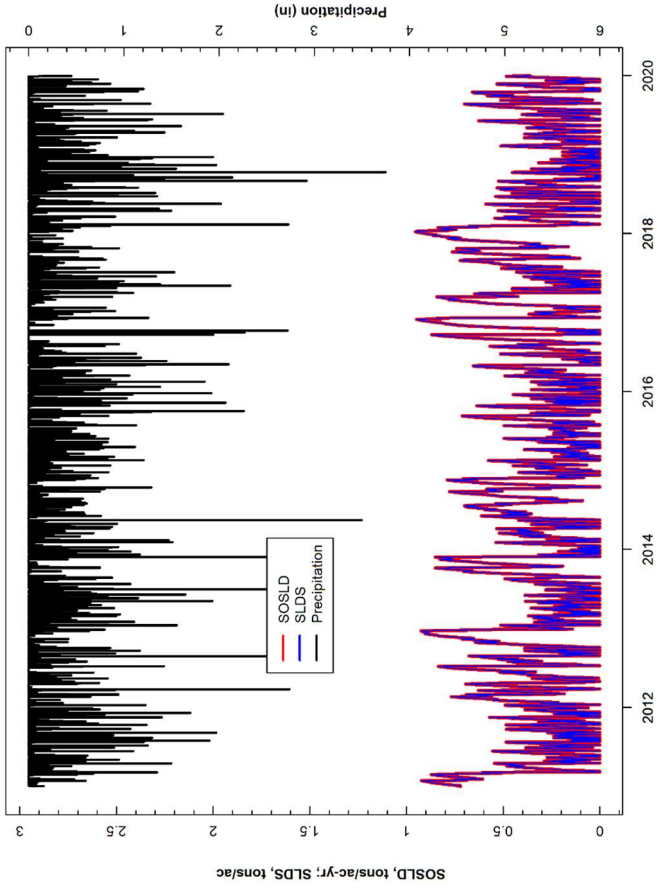


Figure E-30. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Upper James River—Fishing Creek watershed.

SOSED, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided

a reasonable approximation of the behavior of sediment detachment and removal in the James River—Fishing Creek overland sediment transport calibration. Due to the large number of subwatersheds and land uses in Upper James River – Fishing Creek, Phase I graphs for the other subwatersheds are not included in this report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-12.

Table E-12. Final calibrated parameters for the Upper James River—Fishing Creek Phase I Calibration.

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [†]	CALCULATION METHOD [‡]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	1	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.050 - 0.352 ^b	0.05 - 0.75	Based on Technical Note Recommended Values, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	2.0 – 3.0 ^b	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.01 - 0.50 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.20-0.97	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 – 10.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.10 – 9.50 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.00 – 2.50	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	2.0	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	0.28	0.1 - 10.0	Based on Tech. Note Recommended Values Calibrated in HSPF
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	2.5	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0114	0.0 - 30.0	" "
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segments

^b Varies with land use (data available upon request by referring to the contact information on page ii)

^c Impervious land segment

E.4.4 Phase II Calibration: Upper James River – Fishing Creek

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration efficiency metrics were analyzed after each run to determine if it's necessary to continue the model calibration procedure further.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-31 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2013 to December 31, 2019 for reach 01, the reach corresponding to subwatershed 01 in the Upper James River – Fishing Creek, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality

monitoring station 2-JMS229.14 and the observed flow at the corresponding USGS flow gage on James River—Fishing Creek (Red triangles). The USGS flow gage closest to VADEQ station 2-JMS229.14 with a complete flow record is USGS 02026000 (James River at Bent Creek, VA).

Figure E-31 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases except for one date. On that particular date the observed SSC was very low despite the high observed flow of the river at two of the reaches. A similar sediment concentration-flow correlation was illustrated with the simulated data.

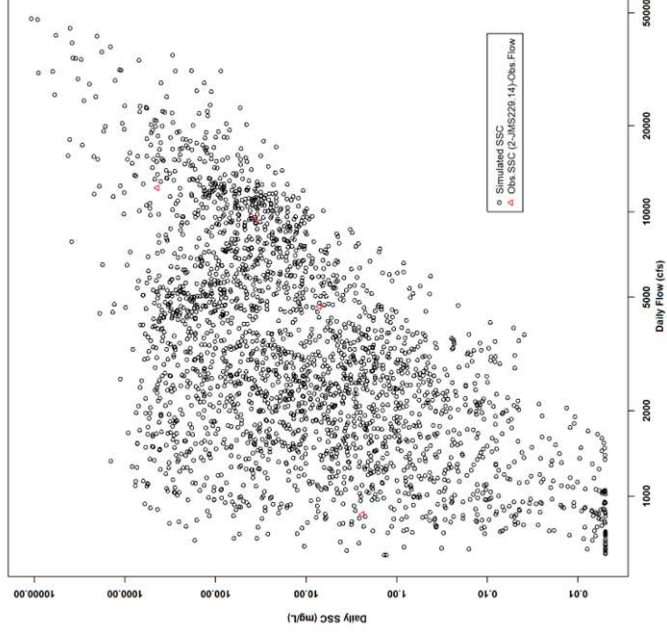


Figure E-31. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 1 in Upper James River—Fishing Creek watershed.

Figure E-32 further illustrates the model performance showing simulated and observed sediment concentrations plotted on each day at which observed SSC data were collected at DEQ station 2-JMS229.14. The average daily simulated and observed SSC for a 5-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 5-day window are shown. The figure shows three out of four observed SSC data points were captured within the

5-day sediment windows by the model for reach 1 of the James River—Fishing Creek watersheds.

Figure E-33 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for the river section within the subwatershed 1 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

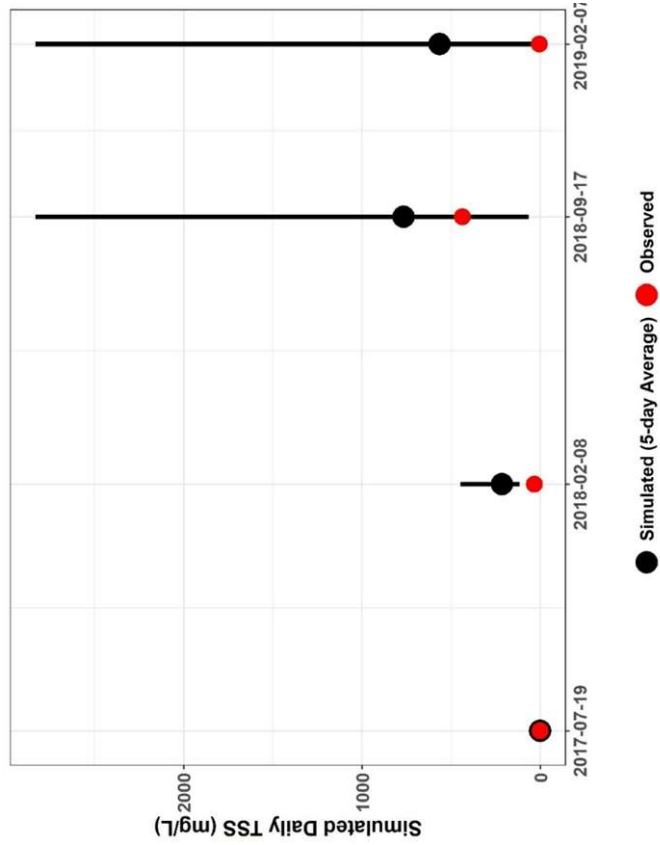


Figure E-32. Three-day window plot for sediment concentration showing the 5-day average, maximum minimum, and observed values at station 2-JMS229.14 (Upper James River—Fishing Creek watershed reach 1).

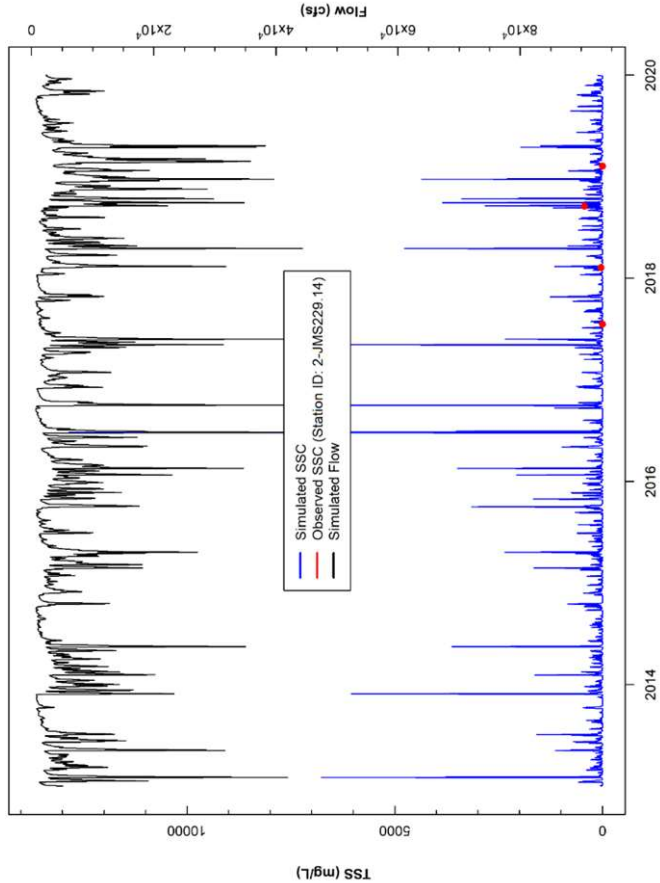


Figure E-33. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 1 in the Upper James River—Fishing Creek watershed.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-13 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Upper James River – Fishing Creek watershed. 3- and 5-day windows were only calculated around the days on which observed data were available. The 76% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim et al., 2007), and the 70% of the observed data within the 3-day window is greater than the desired 50% discussed earlier. It is worth mentioning that for the river section within subwatershed 1 three out of four observed data points were within the 5-day window. And while the model under-predicted some of the SSC data as indicated by the slightly larger percentage ‘above’ values for the 3 and 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-14.

Table E-13. Three- and five-day window calibration statistics for the Upper James River—Fishing Creek Phase II Calibration.

Statistics	Value
Number of Observed Data Points	38

Percentage within 3-day window	70%
Percentage above 3-day maximum	13%
Percentage below 3-day minimum	17%
Percentage within 5-day window	76%
Percentage above 5-day maximum	10%
Percentage below 5-day minimum	14%

Calibration Summary: Upper James River – Fishing Creek

Using a “weight-of-evidence” approach presented here, the conclusion is that the James River—Fishing Creek watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all James River—Fishing Creek watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-14. Final calibrated parameters for the Upper James River—Fishing Creek watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
RCHRES ^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	13	5 - 1000	Based on Technical Note Recommended Values
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	20	0.5 - 20	Based on Technical Note Recommended Values
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.1-1.9 ^b	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.5-3.0 ^b	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.001-0.05 ^b	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	1.5-2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Silt Parameters)						

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.002 – 0.08 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.2 – 1.00 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.001	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.001- 0.80 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.01 – 1.9 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	2 sand; 2 silt; 20 clay	n/a	Based on Tech. Note Recommended Values
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	15% sand; 65% silt; 20% clay	n/a	

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.5 Lower James River

This section presents the HSPF sediment calibration results for the Lower James River TMDL Watershed that include major tributary watersheds: Tye and Rockfish Rivers; Hardware, Slate, and Willis Rivers; Rivanna River, portions of the James River, and Reedy Creek. The calibration results are summarized by Phase I and Phase II. Chapter 2 provides maps illustrating the location of the Lower James River subwatersheds that will be discussed as well as all the observed SSC water quality stations and USGS flow gages. Figure E-34 illustrates the location of TMDL watershed, major tributary boundaries, reaches, and select monitoring stations used for comparing simulated and observed values during model calibration.

E.5.1 Phase I Calibration: Lower James River –Tye and Rockfish River

Comparison analyses of model results for the outlet located downstream of the Lower James River –Tye and Rockfish River calibration portion are discussed in the following sections. Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Lower James River –Tye and Rockfish River were calibrated to within the load target ranges (Table E-1) for each Lower James River –Tye and Rockfish River subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD calibration tables for the 34 subwatersheds, they are not included in this Appendix; including tables would have made the report unmanageably long. These tables can be made available upon request by referring to the contact information on page ii.

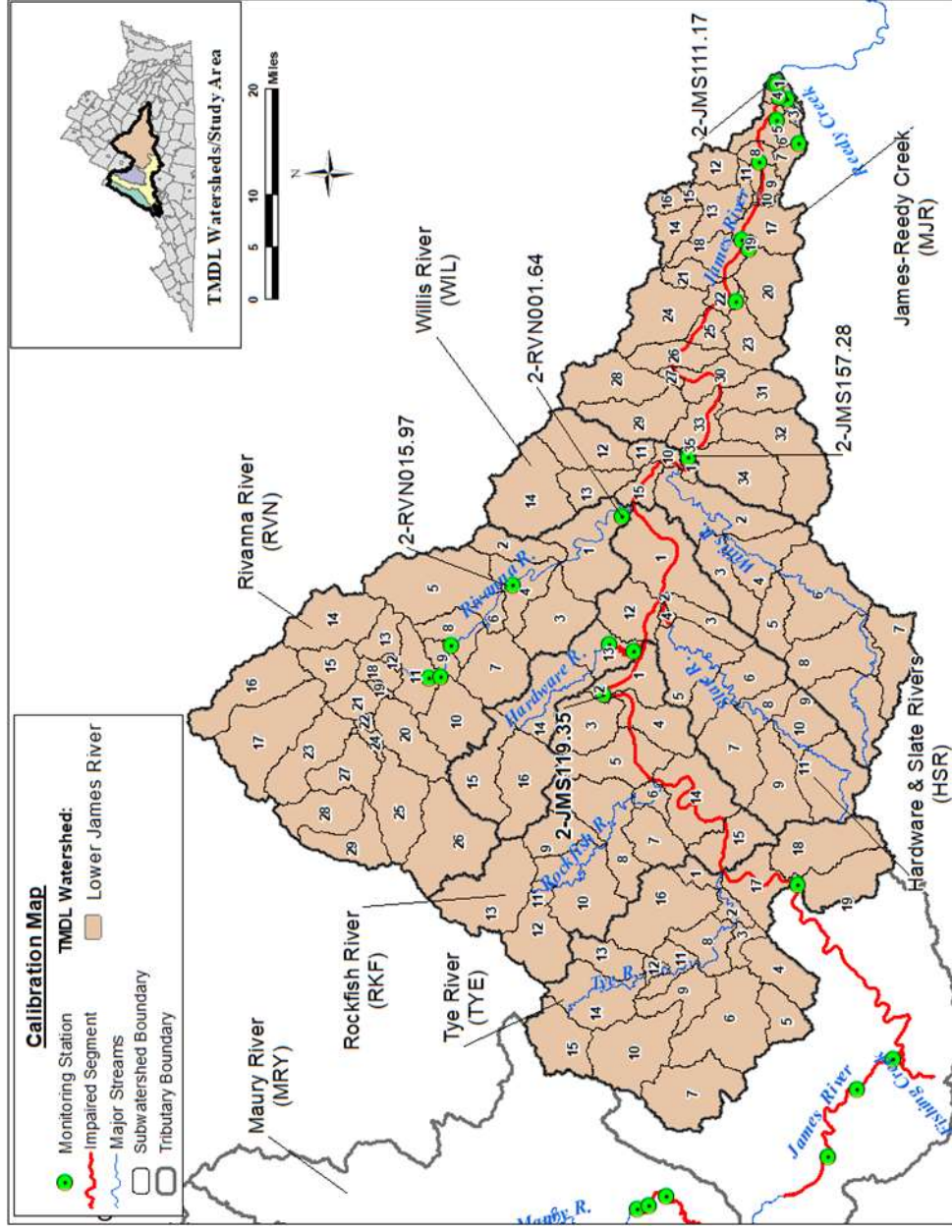


Figure E-34. Subwatersheds and monitoring stations used in calibration comparisons for the Lower James River TMDL watershed.

Pervious Land Use Calibration

Figure E-35, Figure E-36, and Figure E-37 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the

calibration period (2011-2019), respectively for subwatershed 1 in the Lower James River –Tye and Rockfish River watershed. Other pervious land uses, and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by major storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

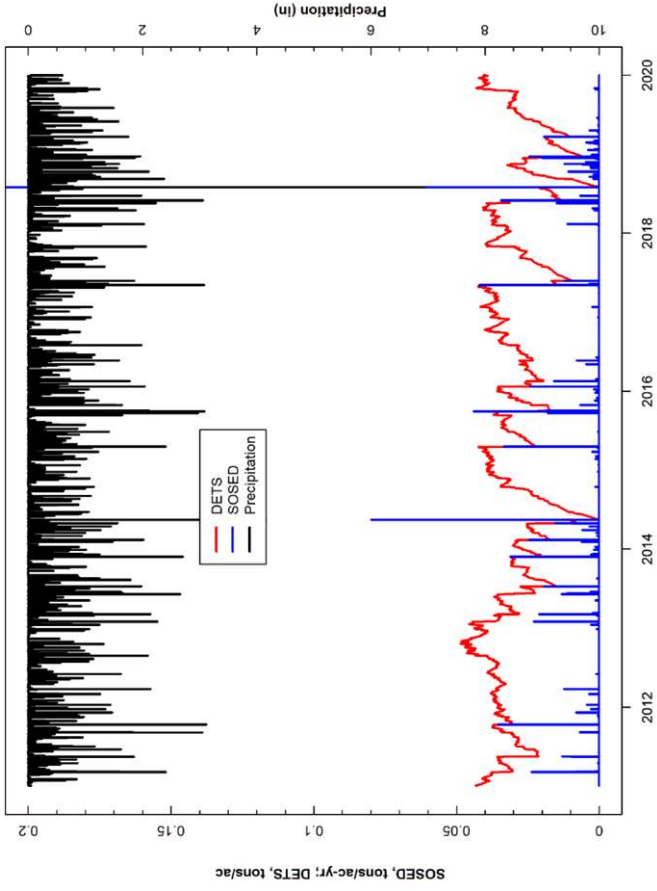


Figure E-35. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River—Tye and Rockfish River watershed

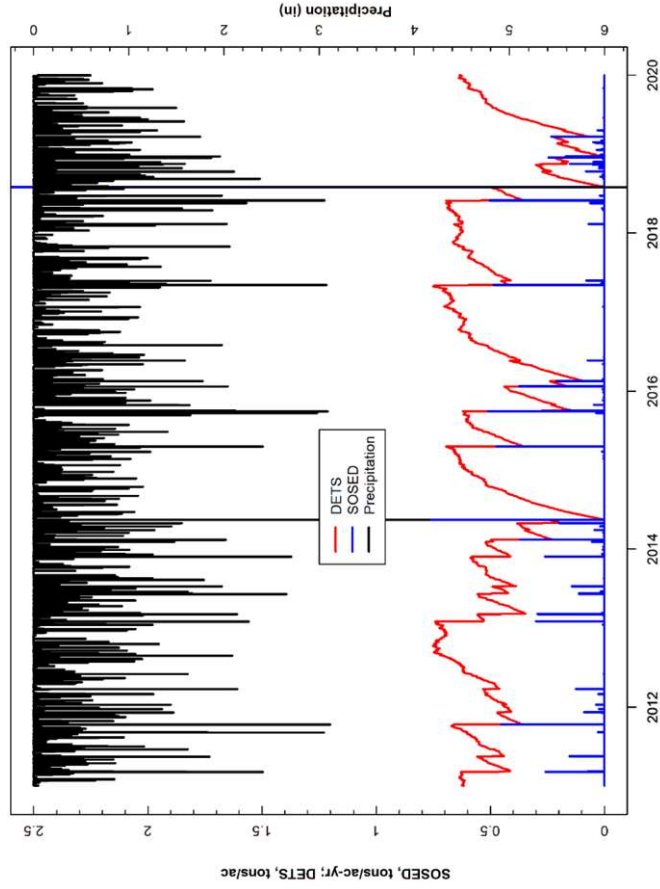


Figure E-36. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River—Tye and Rockfish River watershed.

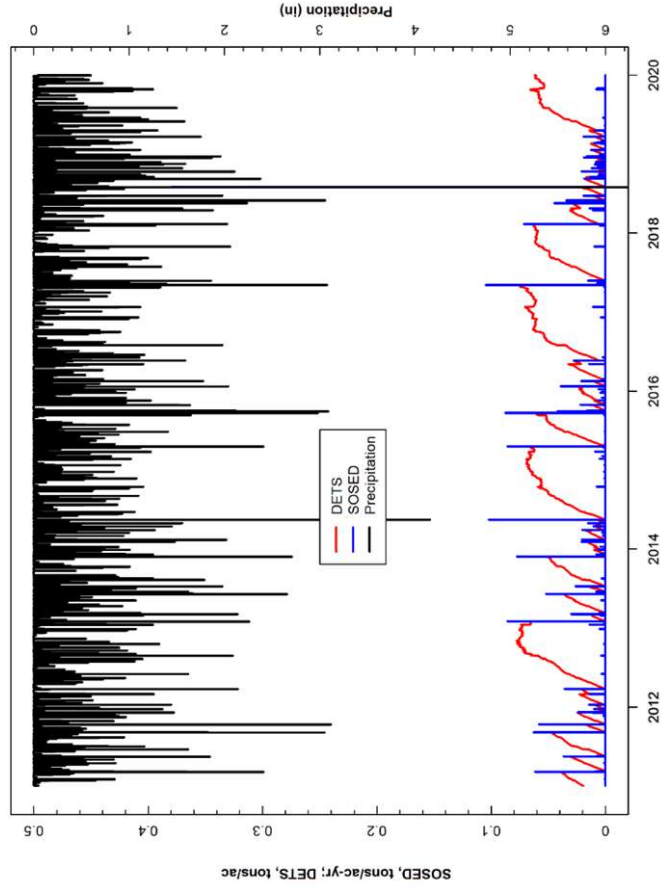


Figure E-37. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River—Tye and Rockfish River watershed.

Impervious Land Use Calibration

Figure E-38 shows the observed precipitation (upper axis) and SOSLD and SLDS values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011 to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

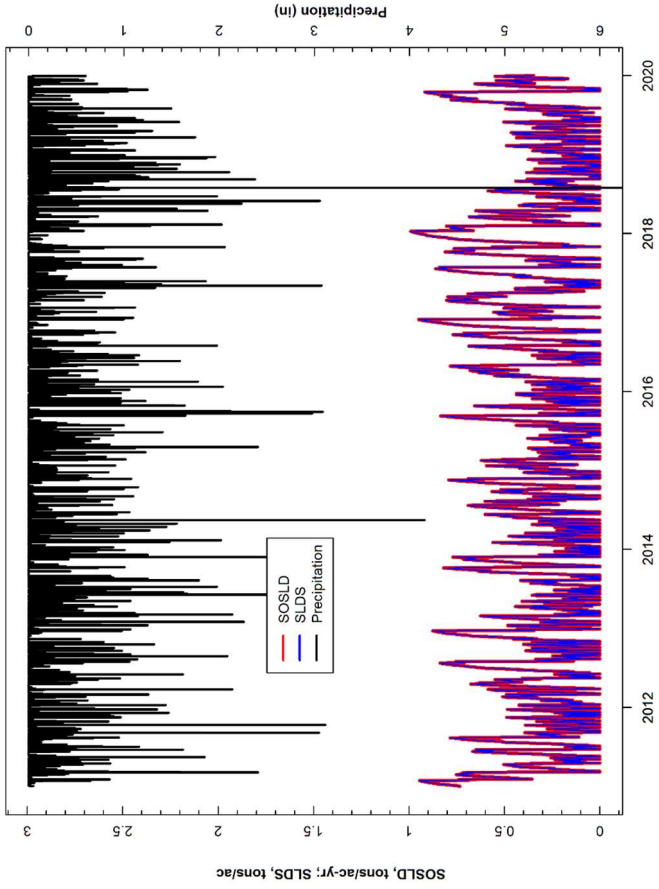


Figure E-38. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Lower James River—Tye and Rockfish River watershed.

SOSED, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided

a reasonable approximation of the behavior of sediment detachment and removal in the James River—Tye and Rockfish River overland sediment transport calibration. Due to the large number of subwatersheds and land uses in Lower James River –Tye and Rockfish River, Phase I graphs for the other subwatersheds are not included in this report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-15.

Table E-15. Final calibrated parameters for the Lower James River—Tye and Rockfish River Phase I Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	1	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.050 - 0.352 ^b	0.05 - 0.75	Based on Technical Note Recommended Values, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	2.0 - 3.0 ^b	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.01 - 0.50 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.20 - 0.97	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 - 10.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.10 - 9.50 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.10 - 2.50	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	2.0	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	0.28	0.1 - 10.0	Based on Tech. Note Recommended Values, Calibrated in HSPF
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	2.5	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0086	0.0 - 30.0	" "

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segments

^b Varies with land use (data available upon request by referring to the contact information on page ii)

^c Impervious land segment

E.5.2 Phase II Calibration: Lower James River –Tye and Rockfish River

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration efficiency metrics were analyzed after each run to determine if it's necessary to continue the model calibration procedure further.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-39 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2013 to December 31, 2019 for reach 01, the reach corresponding to subwatershed 01 in the Lower James River –Tye and Rockfish River, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station 2-JMS189.31 and the observed flow at the corresponding USGS flow gage on Lower James River –Tye and Rockfish River (Red triangles). The USGS flow gage closest to VADEQ station 2-JMS189.31 with a complete flow record is USGS 02029000 (James River at Scottsville, VA).

Figure E-39 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC

combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases except for one date. On that particular date the observed SSC was very low despite the high observed flow of the river at two of the reaches. A similar sediment concentration-flow correlation was illustrated with the simulated data.

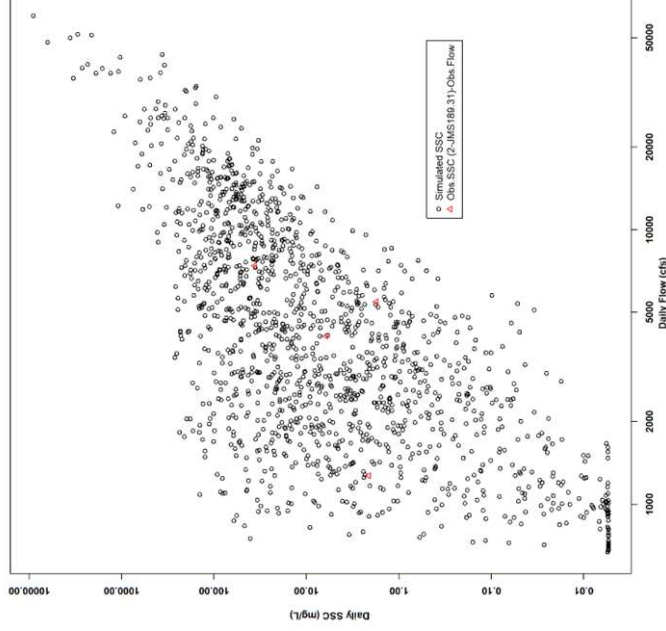


Figure E-39. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 2 in Lower James River—Tye and Rockfish River watersheds.

Figure E-40 further illustrates the model performance showing simulated and observed sediment concentrations plotted on each day at which observed SSC data were collected at VADEQ station 2-JMS189.31. The average daily simulated and observed SSC for a 5-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 5-day window are shown. The figure shows three out of four observed SSC data points were captured within the 5-day sediment windows by the model for reach 2 of the Lower James River –Tye and Rockfish River watersheds.

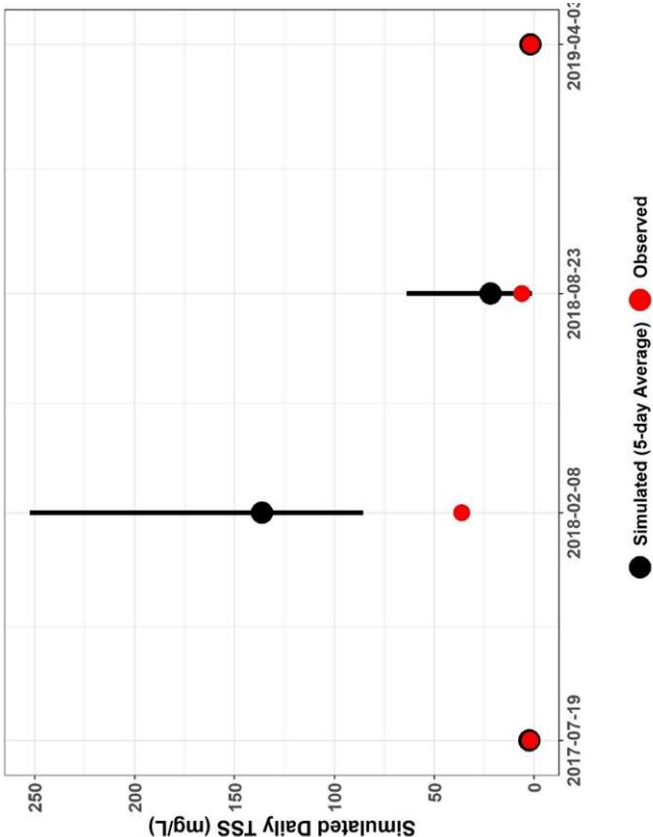


Figure E-40. Three-day window plot for sediment concentration showing the 5-day average, maximum minimum, and observed values at station 2-JMS189.31 (Lower James River—Tye and Rockfish River watershed reach 1).

Figure E-41 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for the river section within the subwatershed 1 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

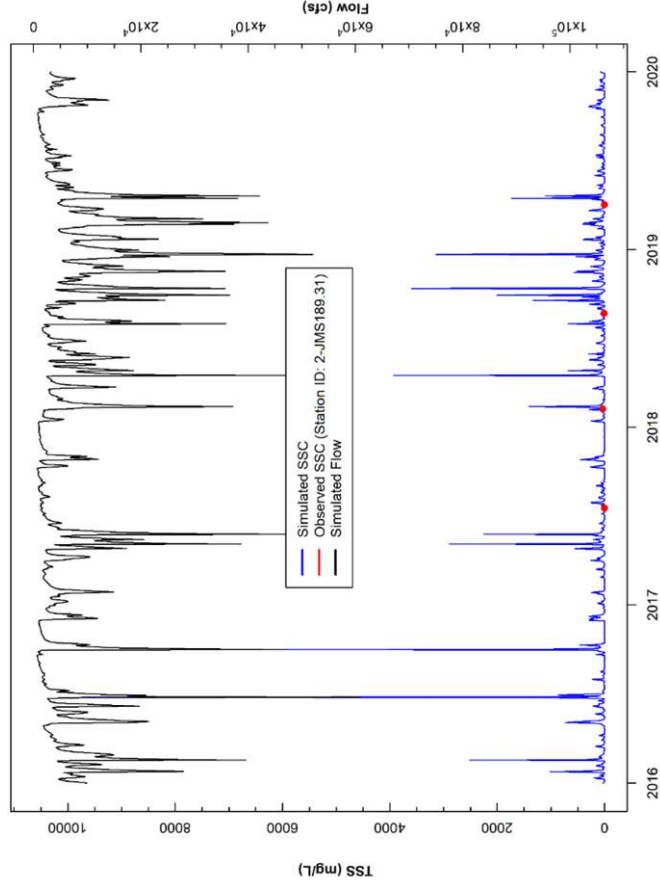


Figure E-41. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 1 in the Lower James River—Tye and Rockfish watersheds.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-16 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Lower James River – Tye and Rockfish River watersheds. 3- and 5-day windows were only calculated around the days on which observed data were available. The 72% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim et al., 2007), and the 70% of the observed data within the 3-day window is greater than the desired 50% discussed earlier. It is worth mentioning that for the river section within subwatershed 2, three out of four observed data points were within the 5-day window. And while the model over-predicted some of the SSC data as indicated by the slightly larger percentage ‘above’ values for the 3 and 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-17.

Table E-16. Three- and five-day window calibration statistics for the Lower James River—Tye and Rockfish River Phase II Calibration.

Statistics	Value
Number of Observed Data Points	7
Percentage within 3-day window	72%
Percentage above 3-day maximum	14%
Percentage below 3-day minimum	14%
Percentage within 5-day window	72%
Percentage above 5-day maximum	14%
Percentage below 5-day minimum	14%

Calibration Summary: Lower James River –Tye and Rockfish River

Using a “weight-of-evidence” approach presented here, the conclusion is that the Lower James River –Tye and Rockfish River watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all Lower James River –Tye and Rockfish River watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-17. Final calibrated parameters for the Lower James River—Tye and Rockfish River watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
RCHRES ^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	13	5 - 1000	Based on Technical Note Recommended Values
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	20	0.5 - 20	Based on Technical Note Recommended Values
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.1-1.9 ^b	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.5-3.0 ^b	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.001-0.05 ^b	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	1.5-2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Silt Parameters)						
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.002 – 0.08 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.2 – 1.00 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.001	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.001- 0.80 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.01 – 1.9 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	2 sand; 2 silt; 20 clay	n/a	Based on Tech. Note Recommended Values
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	15% sand; 65% silt; 20% clay	n/a	

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.5.3 Phase I Calibration: Lower James – Rivanna River

Comparison analyses of model results for the outlet of the Lower James – Rivanna River model watershed are discussed in the following sections. Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Lower James – Rivanna River were calibrated to within the load target ranges (Table E-1) for each subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD calibration tables, they are not included in this

Appendix; including tables would have increased report length significantly. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-42, Figure E-43, and Figure E-44 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Lower James – Rivanna River watershed. Other pervious land uses and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

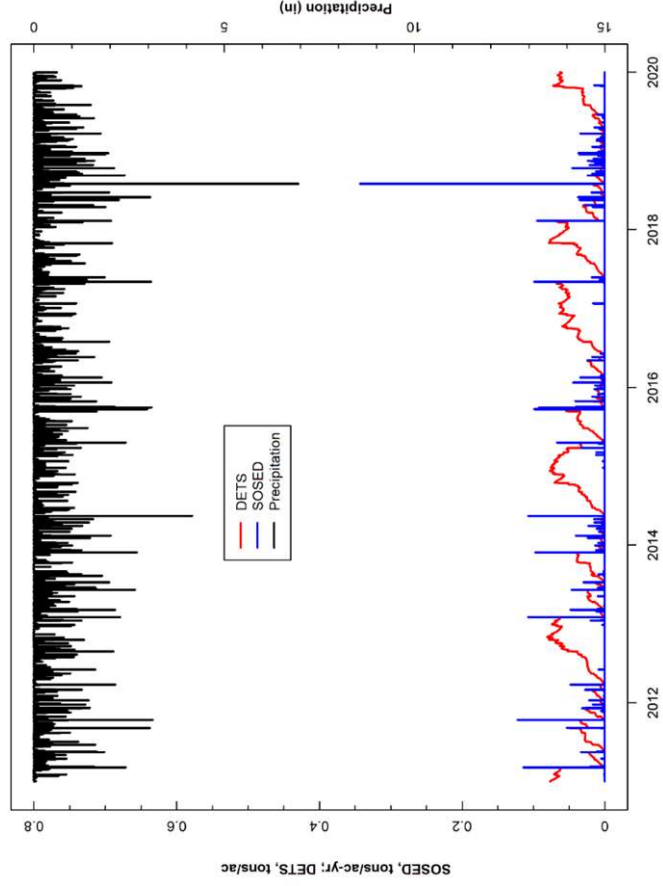


Figure E-42. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James – Rivanna River watershed.

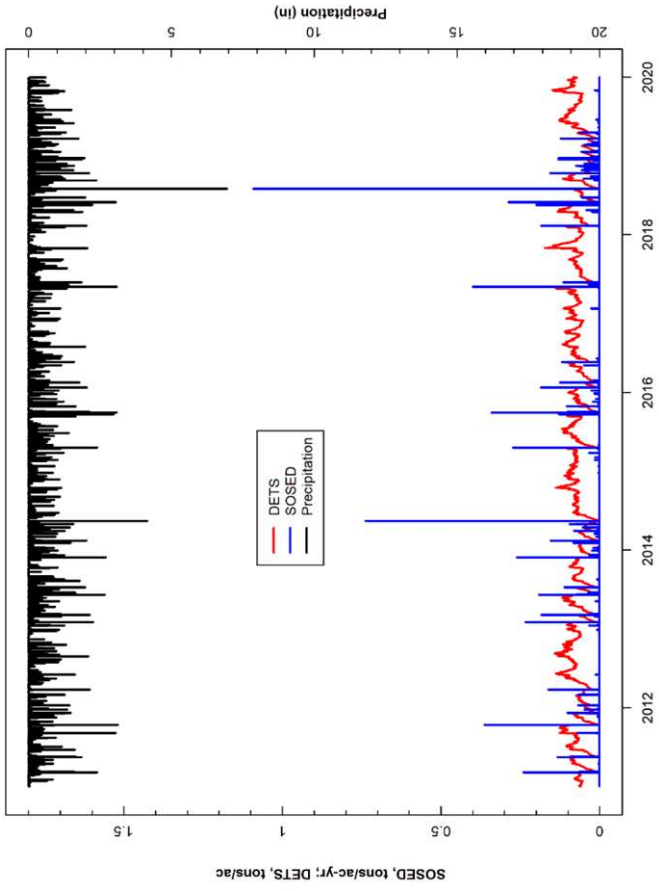


Figure E-43. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James – Rivanna River watershed.

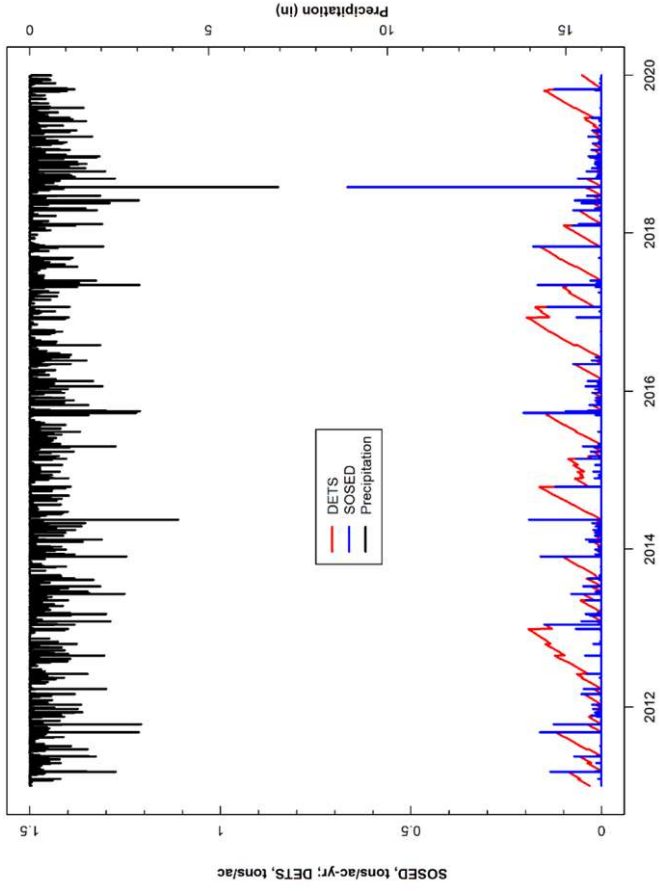


Figure E-44. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James – Rivanna River watershed.

Impervious Land Use Calibration

Figure E-45 shows the observed precipitation (upper axis) and SOSLD and SLDs values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011

to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

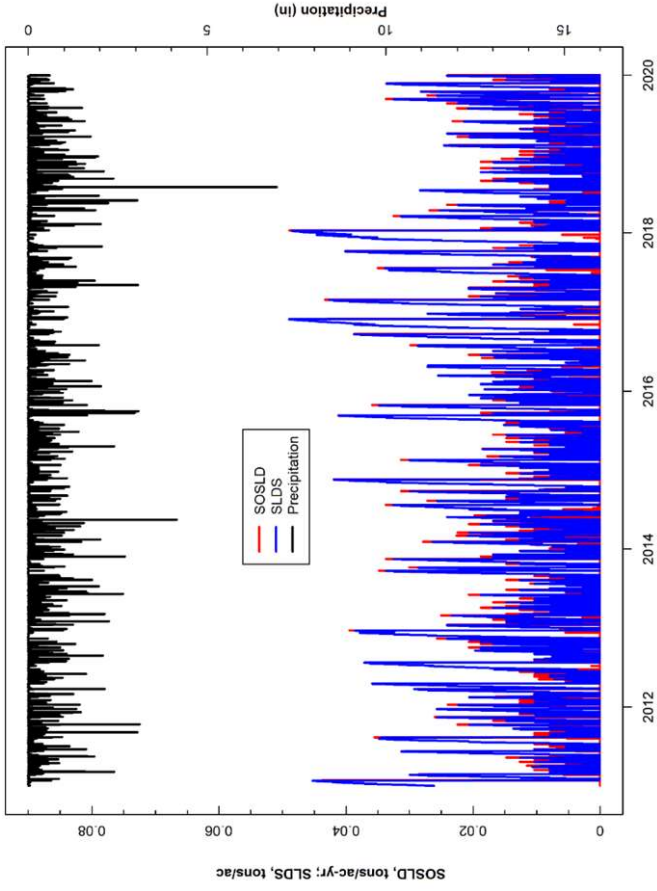


Figure E-45. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Lower James – Rivanna River watershed.

SOSED, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided a reasonable approximation of the behavior of sediment detachment and removal in the Lower James – Rivanna River calibration. Due to the large number of subwatersheds and land uses in Lower James – Rivanna River, Phase I graphs for the other subwatersheds are not included in

this report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-18.

Table E-18. Final calibrated parameters for the Lower James – Rivanna River Phase I Calibration.

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	0.0-1.0	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.050 - 0.752 ^b	0.05 - 0.75	Estimated in GIS, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	2.0 for water and forest and 2.5 for others	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.001 - 0.065 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.0-0.225	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 - 6.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.010 - 5.90 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.0 - 1.6	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0 - 0.5	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	1.0 - 2.0	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	1.0	0.1 - 10.0	Based on Tech. Note Recommended Values
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	1.8	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0028	0.0 - 30.0	" "
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

[#] Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segment

^bVaries with land use (data available upon request by referring to the contact information on page ii)

^cImpervious land segment

E.5.4 Phase II Calibration: Lower James – Rivanna River

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration sufficiency metrics were analyzed after each run to determine if model calibration would continue. Although not explicitly part of the calibration evaluation process, another check that was performed after each calibration run examined the change in sediment bed depth. Bed depth was output as an annual average for each subwatershed reach. Large swings in bed depth trends were indications that the model could be encountering calculation errors and misrepresenting the subwatershed.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-46 and Figure E-47 provide an initial visual analysis of model fit during calibration and validation periods respectively. In these graphs, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2015 to December 31, 2019 and January 1, 2011 to December 31, 2014 during calibration and validation periods respectively for reach 4, the channel corresponding to subwatershed 4 in the Lower James – Rivanna River, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). For both periods, observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station RVN015.97 and the observed flow at the corresponding USGS flow gage on Lower James – Rivanna River (red triangles). The USGS flow gage closest to VADEQ station RVN015.97 with a complete flow record is USGS02034000 Rivanna River at Palmyra, VA.

Figure E-46 and Figure E-47 show that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate during both calibration and validation periods. The simulated data “cloud” encompasses the observed data

points during both periods, although the model missed some high TSS during both periods. These graphs show for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition during both periods. Additionally, as observed flow increases, observed SSC also increases. A similar sediment concentration-flow correlation was illustrated with the simulated data.

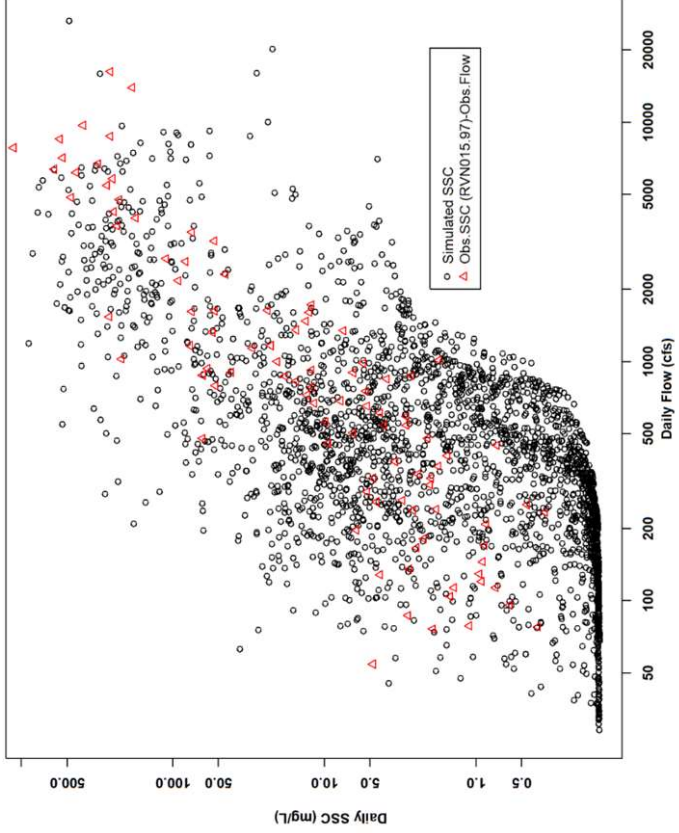


Figure E-46. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 4 in Lower James – Rivanna River watershed during calibration period (2015 to 2019).

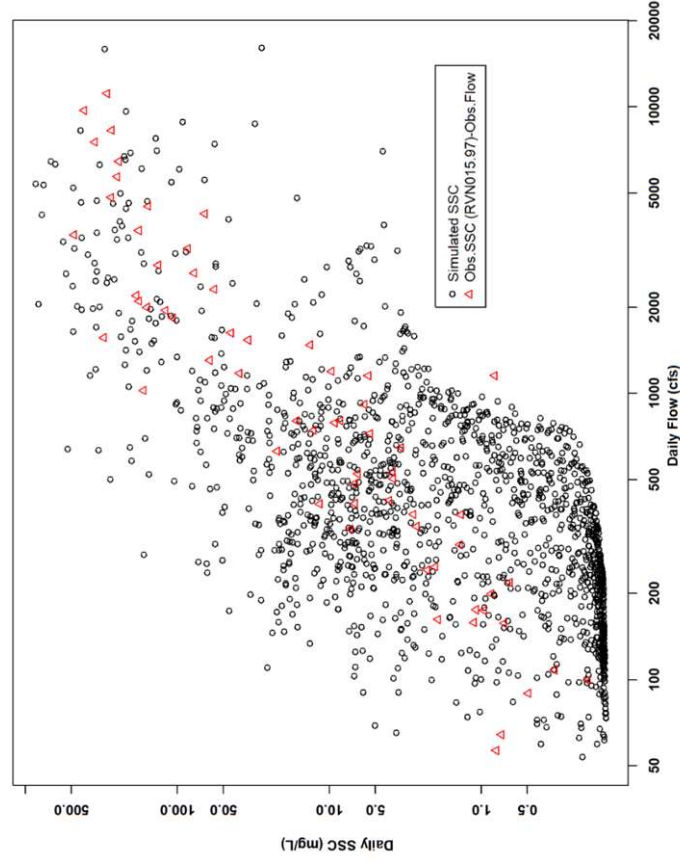


Figure E-47. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 4 in Lower James – Rivanna River watershed during validation period (2011 to 2014).

Figure E-48 further illustrates the model performance during the calibration period for reach 1, with simulated and observed sediment concentrations plotted on each day that observed SSC data were collected at DEQ station RVN001.64 at the outlet of the watershed. The performance of the 3-day window surrounding the date of the observed SSC were different for each reach in the Lower James – Rivanna River based on the number of SSC observed data points in each reach. The average daily simulated, and observed SSC for a 3-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 3-day window are shown. Figure E-48 shows among three data points two of the observed SSC data points were captured within the 3-day sediment windows by the model for reach 1 of the Lower James – Rivanna River watersheds during the calibration period.

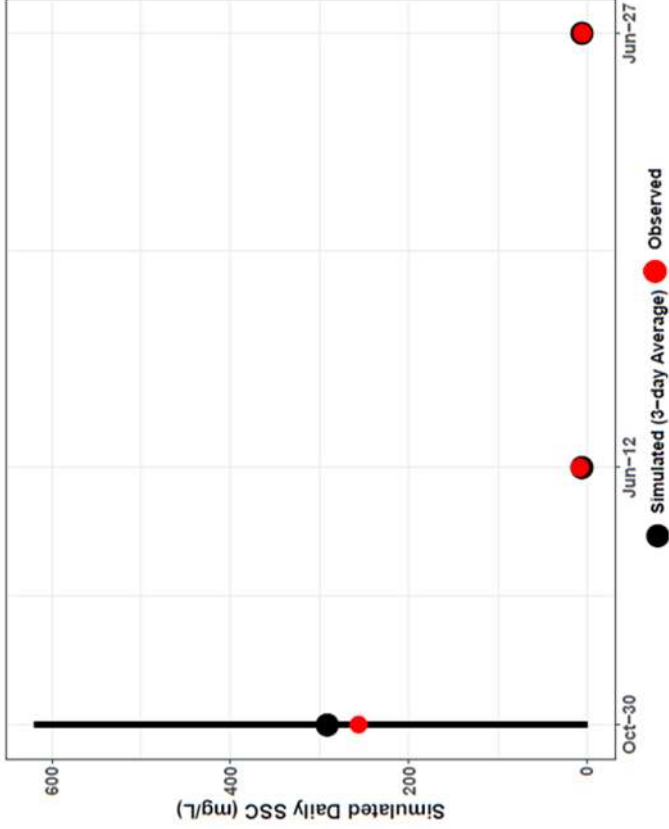


Figure E-48. Three-day window plot for sediment concentration showing the 3-day average, maximum minimum, and observed values at station RVN001.64 (Lower James – Rivanna River watershed reach 1) during the calibration period (2015 – 2019).

Figure E-49 and Figure E-50 illustrate another comparison of daily average simulated SSC and observed SSC during both calibration and validation periods. Both were plotted on the same graph with the daily average simulated flow for subwatershed reach 4 on a secondary axis during both periods. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This time series plot is representative of the results from other Lower James – Rivanna River subwatershed reaches and water quality stations. These graphs show that increases in simulated flow resulted in increases in simulated sediment concentration during both periods. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points except missed some TSS peaks during both periods. These plots clearly show high intensity rainfall condition is the main source of high sediment concentration in the watershed.

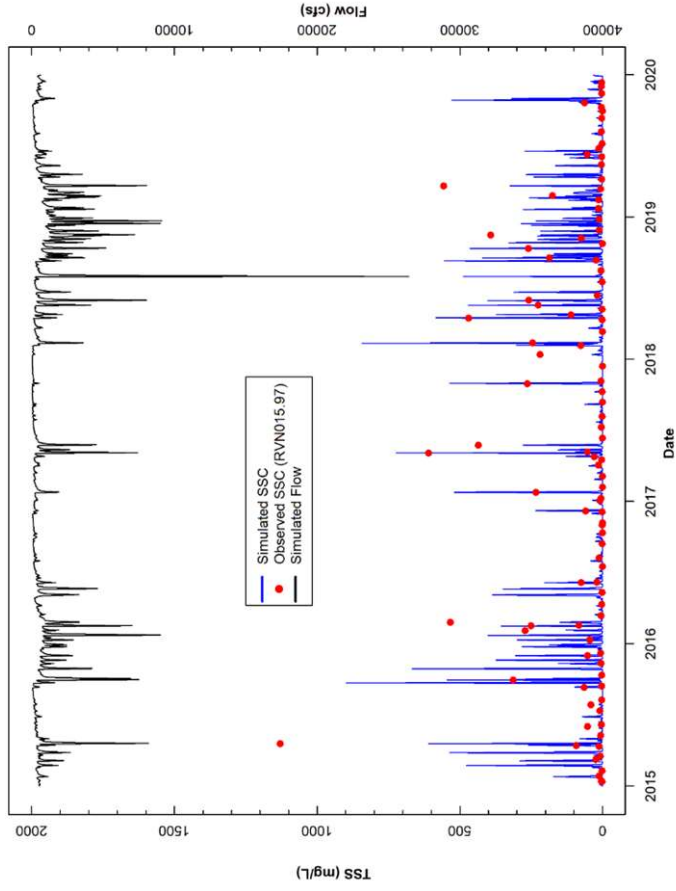


Figure E-49. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 4 in the Lower James – Rivanna River watershed during the calibration period (2015 – 2019).

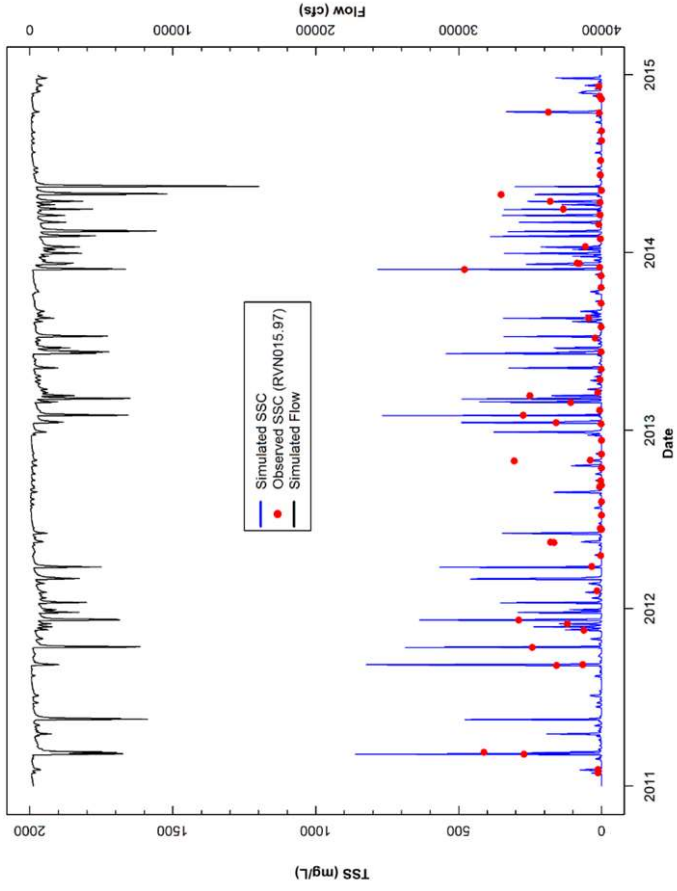


Figure E-50. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 4 in the Lower James – Rivanna River watershed during the validation period (2011 – 2014).

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-19 and Table E-20 include the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Lower James – Rivanna River watershed. Since Lower James – Rivanna River has large number of data points of TSS, 115 data points were used during calibration and 65 data points all from reach 4 were used during validation period. Three- and 5-day windows were only calculated around the days on which observed data is available for both periods. The 70.4 and 73.8% of observed data within the 5-day window during calibration and validation periods respectively is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim *et al.*, 2007), and the 50.8% of the observed data within the 3-day window during validation periods is greater than the desired 50% discussed earlier, but 49% of the observed data within the 3-day window during calibration period is a little less than the desired 50%, but still acceptable since more TSS data points were used during calibration period than validation period where slightly harder to achieve the 3- day window criteria normally used to spare data points. And while the model did exhibit under-prediction bias as indicated by the larger percentage ‘below’ values for both the 3- and 5-day windows, overall the model performed well. Despite the 3-day window result during the calibration period, other results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-21.

Table E-19. Three- and five-day window calibration statistics for the Lower James – Rivanna River Phase II Calibration.

Statistics	Value
Number of Observed Data Points	115
Percentage within 3-day window	49%
Percentage above 3-day maximum	42%
Percentage below 3-day minimum	9%
Percentage within 5-day window	70%
Percentage above 5-day maximum	29%
Percentage below 5-day minimum	1%

Table E-20. Three- and five-day window validation statistics for the Lower James – Rivanna River Phase II Calibration.

Statistics	Value
Number of Observed Data Points	65
Percentage within 3-day window	51%
Percentage above 3-day maximum	34%
Percentage below 3-day minimum	15%
Percentage within 5-day window	74%
Percentage above 5-day maximum	23%
Percentage below 5-day minimum	3%

Calibration Summary: Lower James – Rivanna River

Using a “weight-of-evidence” approach presented here, the conclusion is that the Rivanna River watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all Lower James – Rivanna River watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-21. Final calibrated parameters for the Lower James – Rivanna River watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
RCHRES ^a						
SANDFG (Sand Parameter Flags)						
SANDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	10-13	5 - 1000	Estimated from ArcGIS 3D Analyst
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	5.5-20	0.5 - 20	Estimated from ArcGIS 3D Analyst
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.4	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.6	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.005 – 0.02	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	1.0 - 2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Silt Parameters)						
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0001 – 0.001	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.003 – 0.885 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.009– 2.287 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-1.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.0001-0.005	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.00001-0.001	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.003- 0.796 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.009 – 2.160 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-1.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	2-50 sand; 2-50 silt; 2-50clay	n/a	Estimated
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	25% sand; 45% silt; 30% clay	n/a	Estimated

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.5.5 Phase I Calibration: Lower James River – Hardware, Slate, and Willis River

Comparison analyses of model results for the outlet located downstream of the collective Lower James River – Hardware, Slate, and Willis River calibration portion are discussed in the following sections. Average annual SOSED and SOSLD (sediment and solids wash-off rate) values were calibrated to within the load target ranges (Table E-1) for each subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD calibration tables for the 30

subwatersheds, they are not included in this Appendix; including tables would have made the report unmanageably long. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-51, Figure E-52, and Figure E-53 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Lower James River – Hardware, Slate, and Willis River watershed. Other pervious land uses, and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by major storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

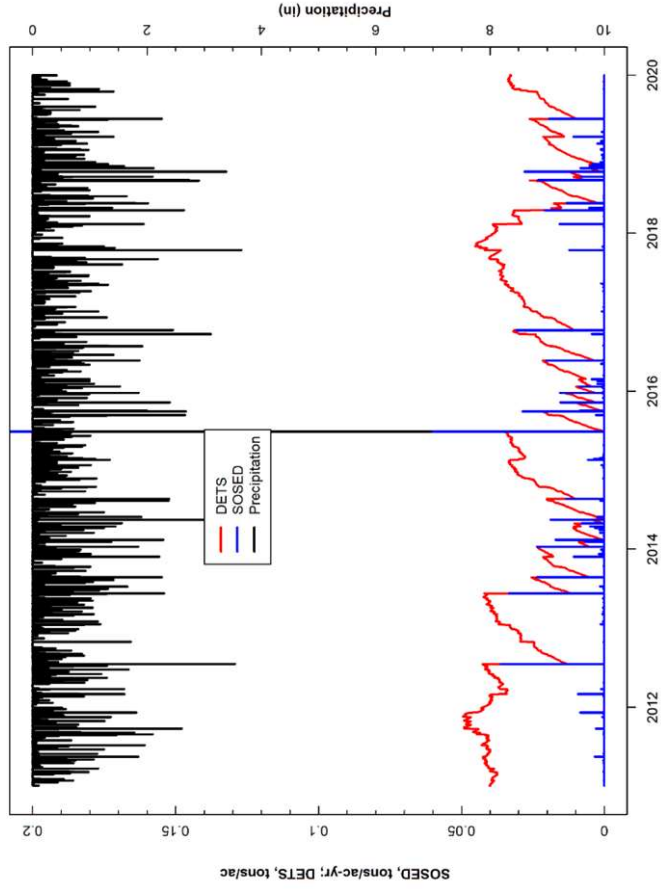


Figure E-51. Forest SOSED, DETS, and observed precipitation for subwatershed 1 downstream Lower James River – Hardware, Slate and Willis Rivers.

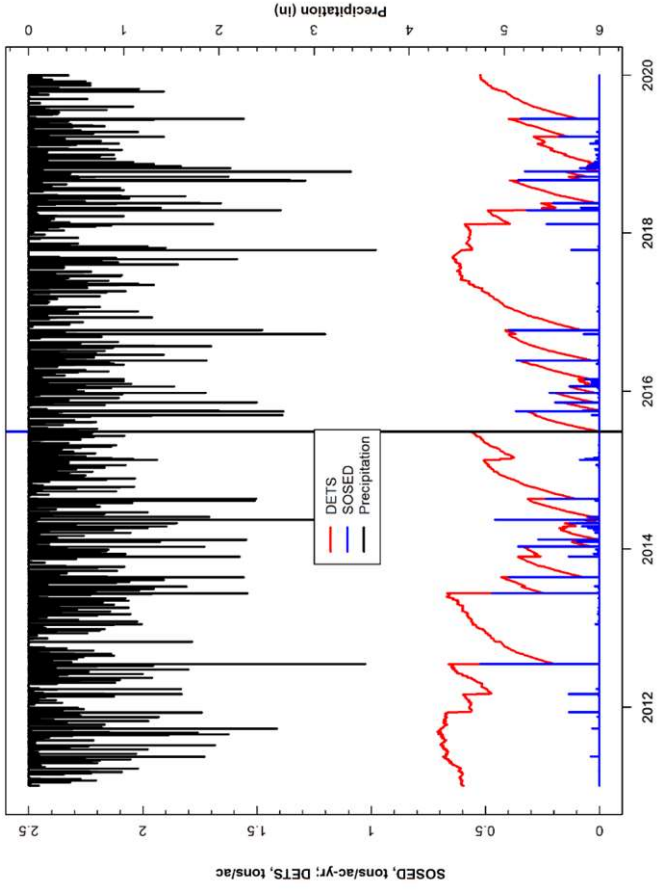


Figure E-52. Cropland SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River – Hardware, Slate, and Willis River watersheds.

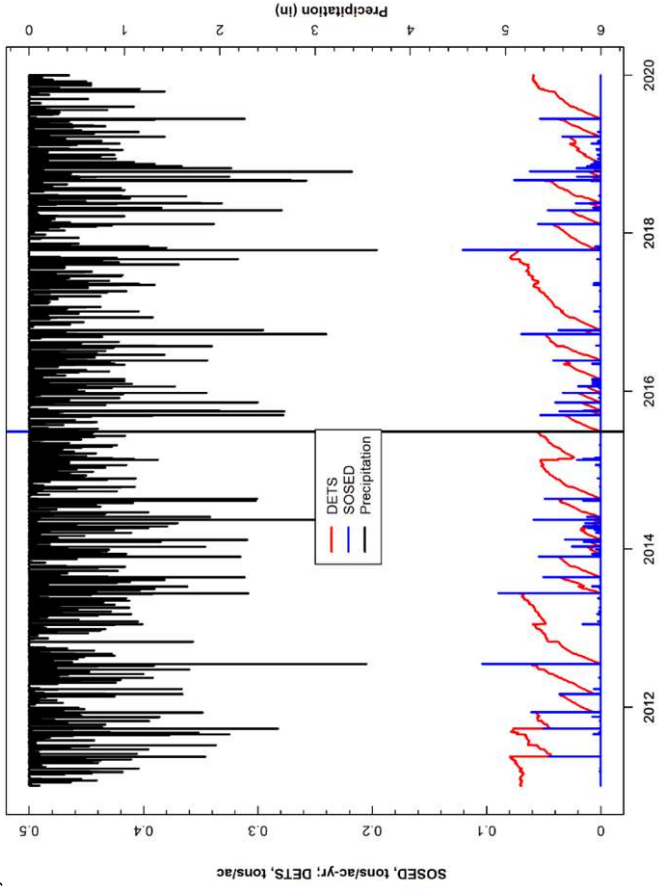


Figure E-53. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River – Hardware, Slate, and Willis Rivers watersheds.

Impervious Land Use Calibration

Figure E-54 shows the observed precipitation (upper axis) and SOSLD and SLDS values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011

to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

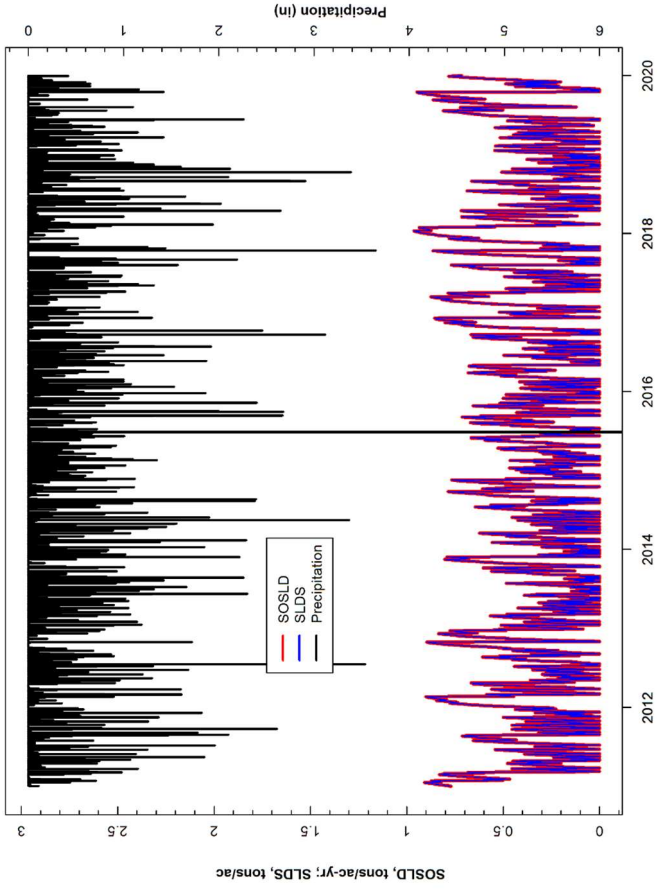


Figure E-54. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Lower James River – Hardware, Slate, and Willis Rivers watershed

SOSLD, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided a reasonable approximation of the behavior of sediment detachment and removal in the Lower James River – Hardware, Slate, and Willis Rivers overland sediment transport calibration. Due to the large number of subwatersheds and land uses in Lower James River – Hardware, Slate,

and Willis Rivers, Phase I graphs for the other subwatersheds are not included in this report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-22.

Table E-22. Final calibrated parameters for the Lower James River – Hardware, Slate, and Willis Rivers Phase I Calibration.

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
PERLND^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMIPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	1	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.050 - 0.352 ^b	0.05 - 0.75	Based on Technical Note Recommended Values, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	2.0 – 3.0 ^b	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.01 - 0.50 ^b	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.24 - 0.97	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0 – 10.0 ^b	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.1 – 9.5 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.00 – 2.50	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	2.0	1.0 - 5.0	" "
IMPLND^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions,	complex	0.28	0.1 - 10.0	Based on Tech. Note Recommended Values

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES ^a	CALCULATION METHOD ^b
		solids characteristics				Calibrated in HSPF
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	2.5	1.0 - 3.0	" "
ACCSDP	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.0086	0.0 - 30.0	" "
REMSDP	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

^a Acquired from EPA BASINS Technical Note 8 (2006)

^b Pervious land segments

^c Varies with land use (data available upon request by referring to the contact information on page ii)

^d Impervious land segment

E.5.6 Phase II Calibration: Lower James River – Hardware, Slate, and Willis Rivers

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration efficiency metrics were analyzed after each run to determine if it's necessary to continue the model calibration procedure further.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-55 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2013 to December 31, 2019 for reach 01, the reach corresponding to subwatershed 01 in the James River---Hardware, Slate and Willis River, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station 2-JMS157.28 and the observed flow at the corresponding USGS flow gage on James River---Hardware, Slate and Willis (Red triangles). The USGS flow gage closest

to VADEQ station 2-JMS157.28 with a complete flow record is USGS 02035000 (James River at Cartersville, VA).

Figure E-55 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases except for one date. On that particular date the observed SSC was very low despite the high observed flow of the river at two of the reaches. A similar sediment concentration-flow correlation was illustrated with the simulated data.

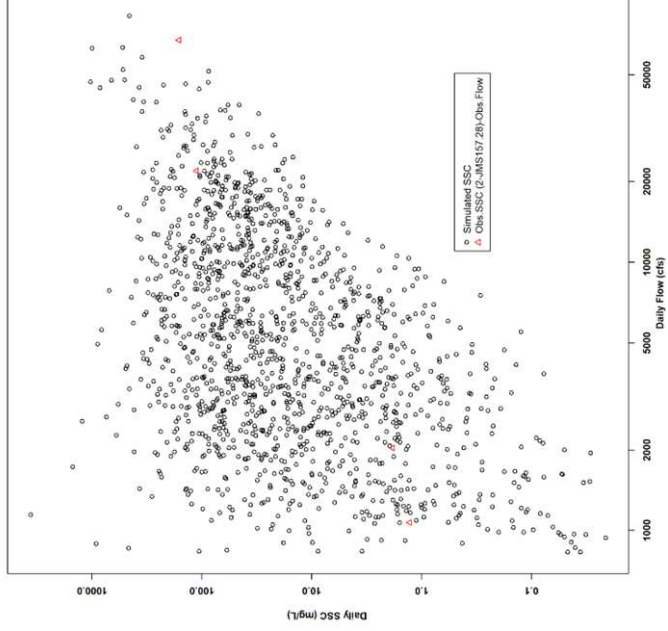


Figure E-55. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 1 in Lower James River – Hardware, Slate, and Willis Rivers watersheds.

Figure E-56 further illustrates the model performance showing simulated and observed sediment concentrations plotted on each day at which observed SSC data were collected at VADEQ station 2-JMS157.28. The average daily simulated and observed SSC for a 5-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 5-day window are shown. The figure shows three out of four observed SSC data points were captured within the 5-day sediment windows by the model for reach 1 of the Lower James River – Hardware, Slate, and Willis Rivers watersheds.

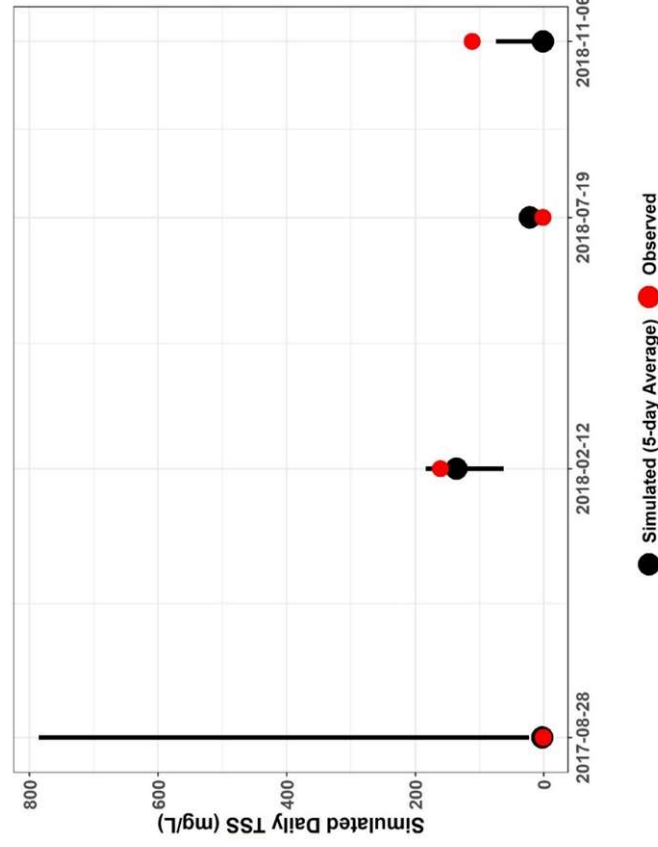


Figure E-56. Three-day window plot for sediment concentration showing the 5-day average, maximum minimum, and observed values at station 2-JMS157.28 (Lower James River – Hardware, Slate, and Willis Rivers watersheds reach 1).

Figure E-57 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for the river section within the subwatershed 1 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

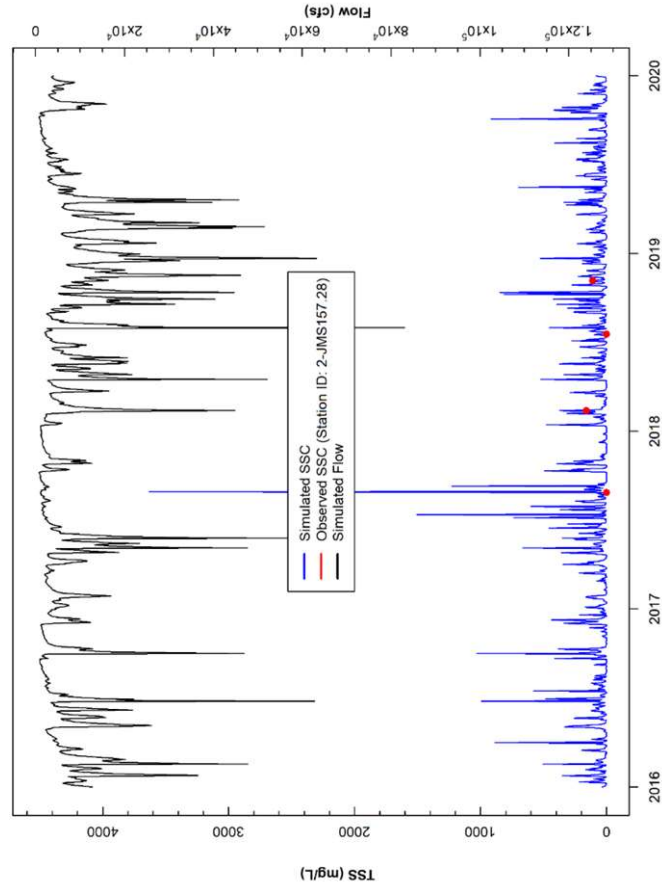


Figure E-57. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 1 downstream the Lower James River – Hardware, Slate, and Willis Rivers watersheds.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-23 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Lower James River – Hardware, Slate, and Willis Rivers watershed. 3- and 5-day windows were only calculated around the days on which observed data were available. The 72% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim et al., 2007), and the 57% of the observed data within the 3-day window is greater than the desired 50% discussed earlier. It is worth mentioning that for the river section within subwatershed 1 three out of four observed data points were within the 5-day window. And while the model over-predicted some of the SSC data as indicated by the slightly larger percentage ‘below’ values for the 3 window, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-24.

Table E-23. Three- and five-day window calibration statistics for the Lower James River – Hardware, Slate, and Willis Rivers Phase II Calibration.

Statistics	Value
Number of Observed Data Points	7
Percentage within 3-day window	57%
Percentage above 3-day maximum	15%
Percentage below 3-day minimum	28%
Percentage within 5-day window	72%
Percentage above 5-day maximum	14%
Percentage below 5-day minimum	14%

Calibration Summary: James River—Hardware, Slate, and Willis River

Using a “weight-of-evidence” approach presented here, the conclusion is that the Lower James River – Hardware, Slate, and Willis Rivers watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all Lower James River – Hardware, Slate, and Willis Rivers watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-24. Final calibrated parameters for the Lower James River – Hardware, Slate, and Willis Rivers watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
RCHRES ^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	13	5 - 1000	Based on Technical Note Recommended Values
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	20	0.5 - 20	Based on Technical Note Recommended Values
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.1-1.9 ^b	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.5-3.0 ^b	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.001-0.05 ^b	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
EXPSPND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	1.5-2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Silt Parameters)						
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.002 – 0.08 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.2 – 1.00 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.001	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.001- 0.80 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.01 – 1.9 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	2 sand; 2 silt; 20 clay	n/a	Based on Tech. Note Recommended Values
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	15% sand; 65% silt; 20% clay	n/a	

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.5.7 Phase I Calibration: Lower James River – Reedy Creek

Comparison analyses of model results for the outlet located downstream of the Lower James River – Reedy Creek calibration portion (the outlet of the James River study area) are discussed in the following sections. Average annual SOSED and SOSLD (sediment and solids wash-off rate) values for Lower James River – Reedy Creek were calibrated to within the load target ranges (Table E-1) for each Lower James River – Reedy Creek subwatershed and land use. Due to the large size of the resulting SOSED and SOSLD calibration tables for the 30

subwatersheds, they are not included in this Appendix; including tables would have made the report unmanageably long. These tables can be made available upon request by referring to the contact information on page ii.

Pervious Land Use Calibration

Figure E-58, Figure E-59, and Figure E-60 show observed precipitation (upper axis) and simulated SOSED, DETS values for Forest, Cropland and pervious Residential land uses for the calibration period (2011-2019), respectively for subwatershed 1 in the Lower James River – Reedy Creek watershed. Other pervious land uses, and subwatersheds produced similar SOSED and DETS plots. As expected, the DETS in each subwatershed for each pervious land use increased over time before decreasing during instances of sediment removal caused by major storm events. The magnitude of DETS was smallest for the Forest land use and largest in Cropland land use, which was expected since forested lands have a greater percentage of vegetative cover and cropland is periodically followed.

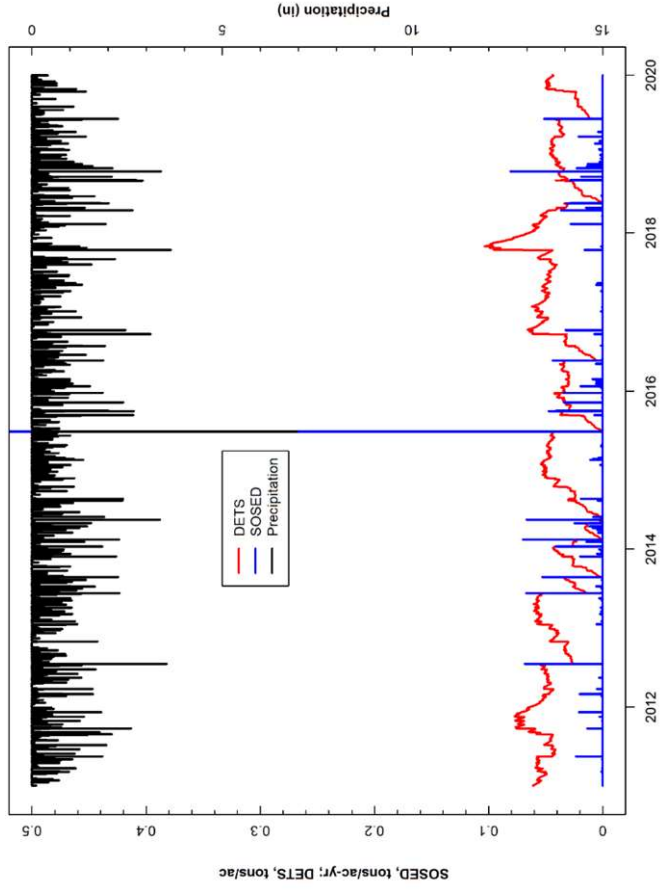


Figure E-58. Forest SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River – Reedy Creek watershed.

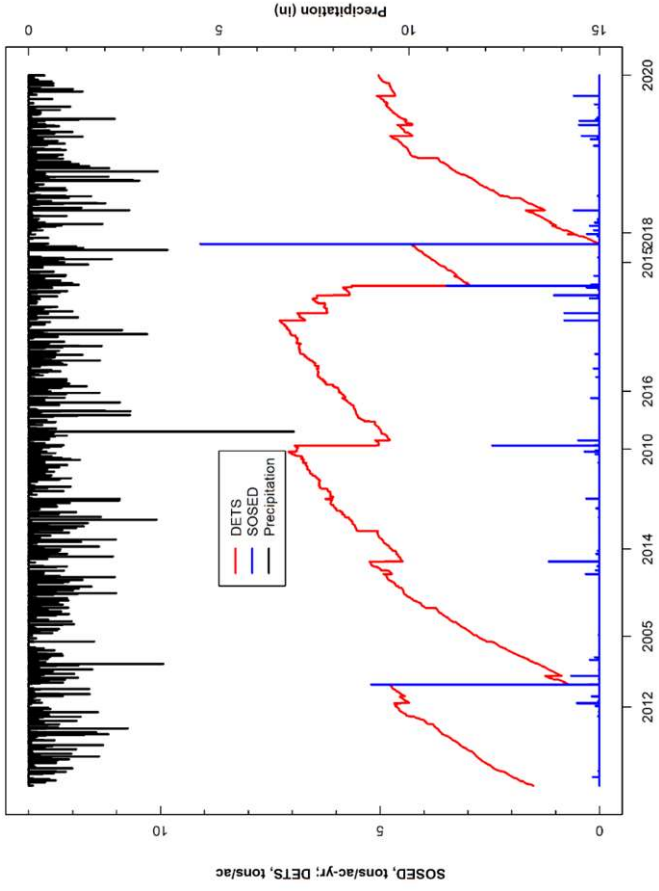


Figure E-59. Cropland SOSED, DETS, and observed precipitation for subwatershed 12 in Lower James River – Reedy Creek watershed.

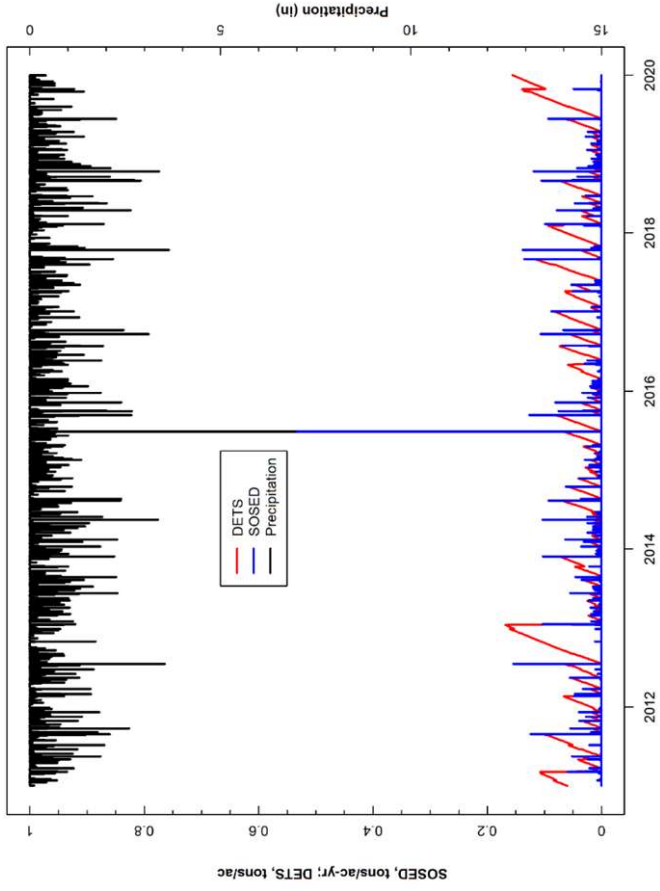


Figure E-60. Pervious Residential SOSED, DETS, and observed precipitation for subwatershed 1 in Lower James River – Reedy Creek watershed.

Impervious Land Use Calibration

Figure E-61 shows the observed precipitation (upper axis) and SOSLD and SLDS values for the impervious fraction of the Residential land use for subwatershed 1 from January 1, 2011

to December 31, 2019. Impervious land cover was subject to greater sediment loss during smaller magnitude precipitation events than pervious land cover. Compared to pervious land uses, significant storage reductions were more frequent on impervious lands.

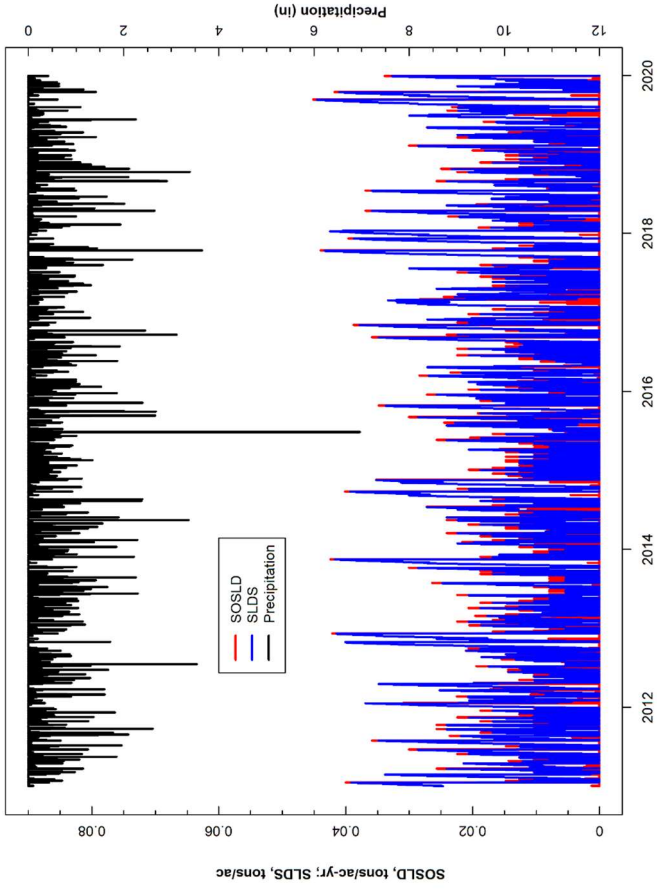


Figure E-61. Impervious Residential SOSLD, SLDS, and observed precipitation for subwatershed 1 in Lower James River – Reedy Creek watershed

SOSED, SOSLD, DETS, and SLDS Summary

The simulated SOSED, SOSLD, DETS, and SLDS values on the pervious and impervious land uses followed expected patterns and sediment removal characteristics. On pervious land uses, the DETS (sediment storage) increased steadily before decreasing sharply due to spikes in SOSED (sediment removal) which were a result of major storm events. This periodic rise and fall of sediment storage are characteristic of a well-calibrated model. On impervious land use, the SLDS (solids storage) fluctuations (increases and decreases) were more frequent when compared to the DETS for the pervious land uses. Impervious land uses were more sensitive to smaller storms and subject to more frequent wash off. Pervious and impervious Residential land use were included in the analysis to provide a comparison of the difference between pervious and impervious land cover. The calibrated Phase I model provided a reasonable approximation of the behavior of sediment detachment and removal in the Lower James River – Reedy Creek overland sediment transport calibration. Due to the large number of subwatersheds and land uses in Lower James River – Reedy Creek, Phase I graphs for the

other subwatersheds are not included in this report due to lengthiness, but they can be made available upon request by referring to the contact information on page ii. The final calibrated sediment parameters for the Phase I calibration are presented in Table E-25.

Table E-25. Final calibrated parameters for the Lower James River – Reedy Creek Phase I Calibration.

Parameter	Definition	FUNCTION OF ...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES [†]	CALCULATION METHOD [‡]
PERLND ^a						
SED-PARM2 (Sediment Parameter Group 2)						
SMPF	Management Practice (P) factor from USLE	Land use, agricultural practices	none	1	0.0 - 1.0	Constant at 1.0, Assumed no Management Practices
KRER	Coefficient in the soil detachment equation	Soils	complex	0.05 - 0.50 ^b	0.05 - 0.75	Based on Technical Note Recommended Values, Calibrated in HSPF
JRER	Exponent in the soil detachment equation	Soils, climate	none	1.81	1.0 - 3.0	Based on Technical Note Recommended Values
AFFIX	Daily reduction in detached sediment	Soils, compaction, agricultural operations	per day	0.08	0.01 - 0.50	Estimated from Recommended Values, Calibrated in HSPF
COVER	Fraction land surface protected from rainfall	Vegetal cover, land use	none	0.30-0.95	0.0 - 0.98	Estimated from Recommended Values, Calibrated in HSPF
NVSI	Atmospheric additions to sediment storage	Deposition, activities, etc.	lb/ac-day	0.0	0.0 - 20.0	Based on Tech. Note Recommended Values
SED-PARM3 (Sediment Parameter Group 3)						
KSER	Coefficient in the sediment washoff equation	Soils, surface conditions	complex	0.01 - 4.35 ^b	0.001 - 10.0	Estimated from Recommended Values, Calibrated in HSPF
JSER	Exponent in the sediment washoff equation	Soils, surface conditions	none	1.67	1.0 - 3.0	" "
KGER	Coefficient in the soil matrix scour equation	Soils, evidence of gullies	complex	0.0	0.0 - 10.0	" "
JGER	Exponent in the soil matrix scour equation	Soils, evidence of gullies	none	2.5	1.0 - 5.0	" "
IMPLND ^c						
SLD-PARM2 (Solids Parameter Group 2)						
KEIM	Coefficient in the solids washoff equation	Surface conditions, solids characteristics	complex	1.6	0.1 - 10.0	Based on Tech. Note Recommended Values, Calibrated in HSPF
JEIM	Exponent in the solids washoff equation	Surface conditions, solids characteristics	none	1.5	1.0 - 3.0	" "
ACCSDR	Solids accumulation rate on the land surface	Land use, traffic, human activities	lb/ac-day	0.004	0.0 - 30.0	" "
REMSDR	Fraction of the solids removed per day	Street sweeping, wind, traffic	per day	0.05	0.01 - 1.0	" "

[†] Acquired from EPA BASINS Technical Note 8 (2006)

^a Pervious land segments

^b Varies with land use (data available upon request by referring to the contact information on page ii)

^c Impervious land segment

E.5.8 Phase II Calibration: Lower James River – Reedy Creek

As mentioned in the introductory calibration methodology section, the first run of the Phase II calibration was used to generate initial estimates of critical shear stress values. TAU represents the critical bed shear stress. TAUCD is the parameter used to calculate critical shear stress for deposition, and TAUCS is the parameter used to calculate critical shear stress for scour. Once the initial run was complete, the calibration continued by substituting the placeholder TAUCD and TAUCS values with updated estimates. In subsequent calibration runs, all sediment calibration parameters including TAUCD and TAUCS were subject to adjustment. Phase II calibration efficiency metrics were analyzed after each run to determine if it's necessary to continue the model calibration procedure further.

Graphical Model Performance Assessment (Qualitative)

The Phase II graphical calibration focused on model fit at the stations and subwatersheds where observed SSC data were available. Figure E-62 provides an initial visual analysis of model fit. In this graph, observed and simulated sediment concentrations were plotted against flow. Simulated data from January 1, 2013 to December 31, 2019 for reach 01, the reach corresponding to subwatershed 01 in the Lower James River – Reedy Creek, were included in the graph as daily averages (open circles); the simulated daily average SSC (mg/L) on a given date was plotted against its corresponding simulated daily average flow rate (cfs). Observed data were plotted similarly using the observed SSC (mg/L) at VADEQ water quality monitoring station 2-JMS111.17 and the observed flow at the corresponding USGS flow gage on Lower James River – Reedy Creek (Red triangles). The USGS flow gage closest to VADEQ station 2-JMS111.17 with a complete flow record is USGS 02037500 (James River near Richmond, VA).

Figure E-62 shows that the model is capable of simulating the appropriate sediment concentration magnitude given a particular flow rate. The simulated data “cloud” encompasses the observed data points. This graph shows for a certain observed flow rate and SSC combination, the model is capable of generating sediment-flow condition. Additionally, as observed flow increases, observed SSC also increases except for one date. On that particular date the observed SSC was very low despite the high observed flow of the river at two of the reaches. A similar sediment concentration-flow correlation was illustrated with the simulated data.

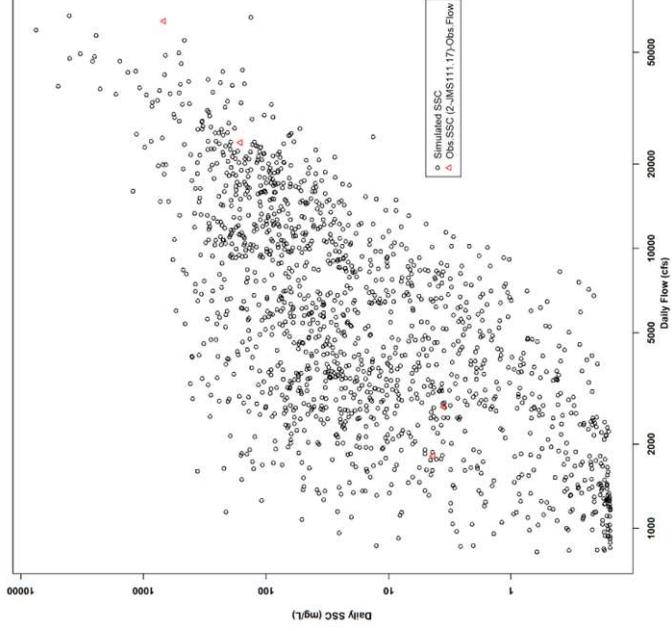


Figure E-62. Sediment concentration-flow plot including daily average simulated SSC vs. daily average simulated flow, observed flow and observed SSC for subwatershed reach 1 in Lower James River – Reedy Creek watersheds.

Figure E-63 further illustrates the model performance showing simulated and observed sediment concentrations plotted on each day at which observed SSC data were collected at DEQ station 2-JMS111.17. The average daily simulated and observed SSC for a 5-day window surrounding the date of the observed sampling was also included in the plot. In addition, the maximum and minimum simulated daily SSC concentrations during that 5-day window are shown. The figure shows three out of four observed SSC data points were captured within the 5-day sediment windows by the model for reach 1 of the Lower James River – Reedy Creek watersheds.

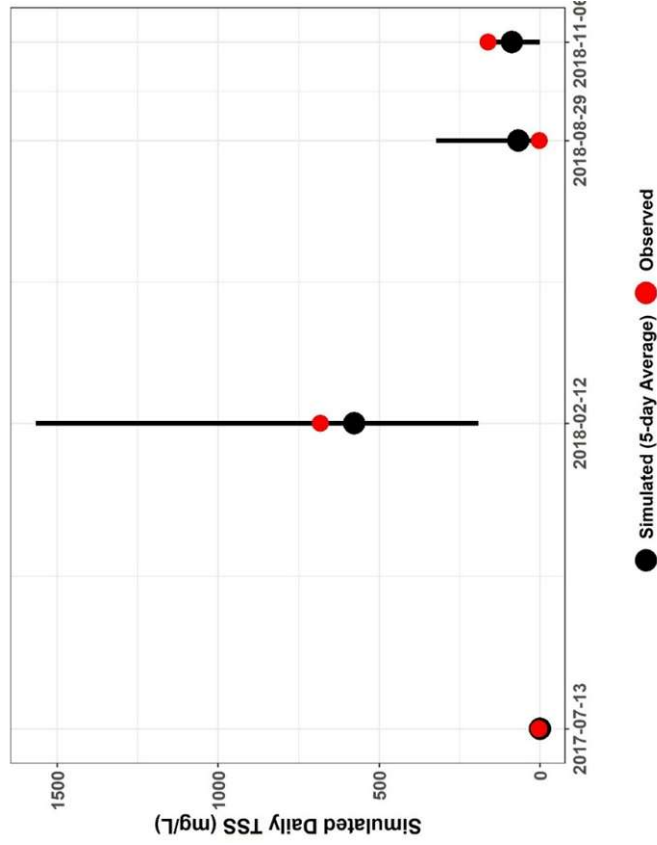


Figure E-63. Three-day window plot for sediment concentration showing the 5-day average, maximum minimum, and observed values at station 2-JMS111.17 (Lower James River – Reedy Creek watershed reach 1).

Figure E-64 illustrates another comparison of daily average simulated SSC and observed SSC. Both were plotted on the same graph with the daily average simulated flow for the river section within the subwatershed 1 on a secondary axis. The flow and SSC time series have been scaled along the y-axis to emphasize the magnitude of simulated SSC fluctuations and to better illustrate observed and simulated SSC. This graph shows that increases in simulated flow resulted in increases in simulated sediment concentration. It also shows that simulated sediment concentration increased as observed SSC increased, and the model capture all observed SSC data points. This plot clearly shows high intensity rainfall condition is the main source of high sediment concentration in the watershed.

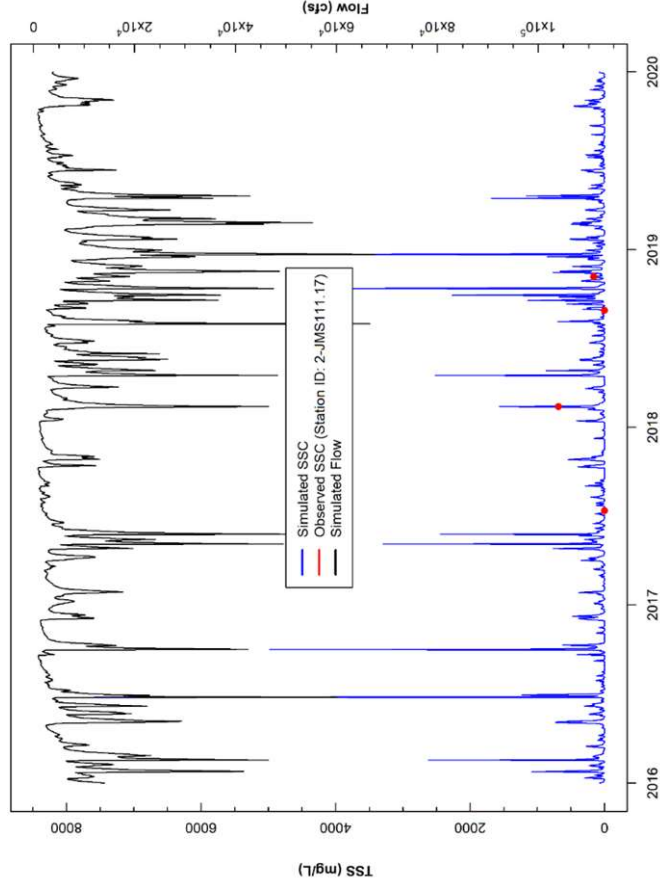


Figure E-64. Comparison of observed SSC, simulated SSC, and simulated flow for subwatershed reach 1 in the Lower James River – Reedy Creek watershed.

Three- and Five-day Window Model Performance Assessment (Quantitative)

Table E-26 includes the results of the quantitative 3- and 5-day window calibration sufficiency analysis which was calculated for all observed SSC data in the Lower James River – Reedy Creek watershed. 3- and 5-day windows were only calculated around the days on which observed data were available. The 80% of observed data within the 5-day window is greater than the published 70% criteria that has been used for sparse data bacteria model calibration applications (Kim et al., 2007), and the 62% of the observed data within the 3-day window is greater than the desired 50% discussed earlier. It is worth mentioning that for the river section within subwatershed 1, three out of four observed data points were within the 5-day window. And while the model under-predicted some of the SSC data as indicated by the slightly larger percentage ‘above’ values for the 3-day window, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated. The final calibrated sediment parameters for the Phase II calibration can be found in Table E-27.

Table E-26. Three- and five-day window calibration statistics for the Lower James River – Reedy Creek Phase II Calibration.

Statistics	Value
Number of Observed Data Points	34
Percentage within 3-day window	62%
Percentage above 3-day maximum	26%
Percentage below 3-day minimum	12%
Percentage within 5-day window	80%
Percentage above 5-day maximum	17%
Percentage below 5-day minimum	3%

Calibration Summary: Lower James River – Reedy Creek

Using a “weight-of-evidence” approach presented here, the conclusion is that the James River—Reedy Creek watershed HSPF sediment model is sufficiently well calibrated to adequately simulate sediment loads. SSC-flow time series plots for all James River—Reedy Creek watershed SSC stations can be provided upon request by referring to the contact information on page ii.

Table E-27. Final calibrated parameters for the Lower James River – Reedy Creek watershed Phase II Calibration.

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES ^a	CALCULATION METHOD ^b
RCHRES ^a						
SANDFG (Sand Parameter Flags)						
SNDFG	Indicates method used for Sandload Simulation	Type of stream; user experience	none	3	1 - 3	Constant, Power Function Method
SED-GENPARM (General Parameters)						
BEDWID	Width of cross-section over which HSPF will assume bed sediment is deposited	Reach \ Waterbody morphology	ft	13	5 - 1000	Based on Technical Note Recommended Values
BEDWRN	Bed depth which, if exceeded (i.e., through deposition) will cause a warning message to be printed	Reach \ Waterbody morphology, User needs	ft	20	0.5 - 20	Based on Technical Note Recommended Values
POR	Porosity of the bed (volume voids/total volume)	Reach \ Sediment Bed Characteristics	none	0.5	0.25 - 0.9	Based on Technical Note Recommended Values
SAND-PM (Sand Parameters)						
D	Effective diameter of the transported sand particles	Sediment properties	in	0.005	0.0005 - 0.2	Based on Tech. Note Recommended Values
W	Fall velocity of transported sand particles in still water	Particle diameter and density	in/sec	0.1-1.9 ^b	0.1 - 10	" "
RHO	Density of sand particles	Sediment properties	g/cm ³	2.5-3.0 ^b	1.5 - 3.0	" "
KSAND	Coefficient in sandload power function formula	Sand properties and hydraulics	complex	0.001-0.05 ^b	0.001 - 10	Estimated from Recommended Values, Calibrated in HSPF

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Parameter	Definition	FUNCTION OF...	Units	FINAL CALIBRATION	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
EXPSND	Exponent in sandload power function formula	Sand properties and hydraulics	complex	1.5-2.0 ^b	1.0 - 6.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Silt Parameters)						
D	Effective diameter of silt particles	Sediment properties	in	0.0006	0.0001 - 0.004	Based on Tech. Note Recommended Values
W	Fall velocity of transported silt particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of silt particles	Sediment properties	g/cm ³	2.3	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Silt properties and hydraulics	lb/ft ²	0.002 – 0.08 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Silt properties and hydraulics	lb/ft ²	0.2 – 1.00 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Silt properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SILT-CLAY-PM (Clay Parameters)						
D	Effective diameter of clay particles	Sediment properties	in	0.001	0.000005 - 0.00025	Based on Tech. Note Recommended Values
W	Fall velocity of transported clay particles in still water	Particle diameter and density	in/sec	0.0005-0.0295 ^b	0.0 - 0.1	" "
RHO	Density of clay particles	Sediment properties	g/cm ³	2.0	1.5 - 3.0	" "
TAUCD	Critical bed shear stress for deposition	Clay properties and hydraulics	lb/ft ²	0.001- 0.80 ^b	0.001 - 1.0	Estimated from Initial Run, Calibrated in HSPF
TAUCS	Critical bed shear stress for scour	Clay properties and hydraulics	lb/ft ²	0.01 – 1.9 ^b	0.01 - 3.0	Estimated from Initial Run, Calibrated in HSPF
M	Erodibility coefficient	Clay properties and hydraulics	lb/ft ² -d	0.001-4.5 ^b	0.001 - 5.0	Estimated from Recommended Values, Calibrated in HSPF
SSED-INIT	Initial concentrations of suspended sediment	Reach	mg/L	2 sand; 2 silt; 20 clay	n/a	Based on Tech. Note Recommended Values
BED-INIT	Initial content of bed sediment	Sediment Bed Characteristics	pct.	15% sand; 65% silt; 20% clay	n/a	Based on Tech. Note Recommended Values

* Acquired from EPA BASINS Technical Note 8 (2006)

^a Main stem of stream in each subwatershed

^b Varies with subwatershed reach (data available upon request by referring to the contact information on page ii)

E.6 References

- DEQ. 2009. Roanoke River PCB TMDL Development (Virginia). Prepared for United States Environmental Protection Agency, Region 3. December 2009.
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Appendix F: PCB Calibration for the James River PCB TMDL Study Area

The final phase of the James River PCB TMDL model calibration focused on modeling the fate and transport of polychlorinated biphenyls (PCBs) throughout the study area. PCBs in the James River study area were simulated as water quality constituents that existed in “dissolved”² and sediment-associated states. The PCB calibration includes the TMDL watersheds: Jackson River, Maury River, Upper and Lower James Rivers. Chapter 2 provides maps illustrating the subwatersheds, impaired segments and the PCB water quality stations within the four James River TMDL watersheds.

F.1 Calibration Methodology

The James River study area was organized into four TMDL watersheds and were further subdivided and modeled as individual subwatersheds. The PCB model calibration process was organized by major tributaries similar to the sediment model calibration (Figure E-1). The simulated, dissolved PCB concentrations were calibrated against observed water column PCB samples. PCB sources in each subwatershed included wash-off loading from known contaminated sites (i.e., spills), direct drainage sources (i.e., the net atmospheric PCB deposition on land and water surfaces, loads from small tributaries not explicitly specified in the model, regulated and unspecified stormwater runoff, loads from unidentified contaminated sites, and unspecified point source discharges), legacy instream sediment-associated PCBs (i.e., streambed sediment), railyards and railways. The PCB model calibration was an iterative process in which calibration parameters were adjusted, the model was executed, and the outputs were assessed using graphical and quantitative analyses. This series of steps was repeated until an acceptable model calibration was achieved. The calibration results are reported for each James River TMDL watershed and calibration segment separately section by section.

F.1.1 Calibration Parameters

The HSPF parameters and inputs that were used in the PCB calibration are described below. Calibration parameters included selected PCB loading rates and PCB-sediment association variables. Initial estimates for parameters were calculated from the best available

²PCBs are hydrophobic and do not quickly break down in water. It is assumed that “dissolved” PCBs are those PCBs freely available in the water column and not associated with sediment.

observed data. Calibration decisions for each parameter are specified in the following parameter descriptions.

Atmospheric Deposition

For the James River PCB TMDL, atmospheric deposition was applied or “input” into the model differently on water and land surfaces, and was included as a portion of the direct drainage load. Within HSPF, atmospheric deposition is modeled as a dissolved pollutant. Thus, atmospheric deposition of a given pollutant, as defined by the model, cannot be sediment-associated. While modeling PCB atmospheric deposition applied to water surfaces as a “dissolved” constituent has been done previously, BSE believes that it is more reasonable and defensible to treat PCB atmospheric deposition on the land surface as a sediment-associated pollutant. As a result, PCB atmospheric deposition was quantified using two different model parameters. The first parameter, MONTH-DATA, applied a PCB atmospheric deposition rate to only the water surface and is discussed further in the next subsection. The second parameter, washoff potency factor (POTFW), quantified the washoff of PCBs from the land surface per ton of simulated sediment loss.

The MONTH-DATA parameter was used to apply a constant rate of dissolved PCBs to the surface of all stream/river reaches and reservoirs. The deposition rate of pg/acre/month was subdivided by HSPF into the user-selected time step units (hours). This method is similar to that used in previous Virginia PCB TMDLs. In the New River (DEQ, 2018), Roanoke River (DEQ, 2009) and Levisa River (DEQ, 2011) PCB TMDLs, monthly atmospheric deposition was applied only to reaches and reservoirs.

During calibration of the James River PCB model an initial PCB atmospheric deposition rate of 5.4×10^8 pg/ac/month was used. However, this value resulted in simulated instream PCB concentrations at low flows that were greater than the available, observed data. The modelers of the Roanoke River (DEQ, 2009) and New River (DEQ, 2018) PCB TMDLs found similar issues when using the PCB atmospheric deposition rate reported by the USEPA Chesapeake Bay Program (CBP) in 1999 (CBP, 1999).

Based on the James River PCB study area modeling results and the results reported in the Roanoke River (DEQ, 2009) and New River (DEQ, 2018) PCB TMDLs, BSE elected to use atmospheric deposition as a calibration parameter. BSE reduced the atmospheric deposition rate until the simulated instream PCB concentrations at low flow compared reasonably well with the observed data. The final calibrated PCB atmospheric deposition rate was 3.0×10^6 pg/ac/month.

Research has shown that PCB atmospheric deposition is a function of near-field land use such as urban development, manufacturing facilities, or contaminated sites (Totten *et al.*, 2006). However, the data needed to discretely apply varying atmospheric deposition rates within the James River study area were not available. The James River PCB TMDL model applies the PCB atmospheric deposition to the water surface at a constant rate that does not fluctuate during the year.

Washoff Potency Factor, POTFW (pg/ton)

The washoff potency factor (POTFW) parameter determines the PCB loading from the land surface during precipitation events. It is used when the water quality constituent of interest, such as PCBs, is sediment-associated. The POTFW value determines the mass of PCBs (pg) that are washed from the land surface per ton of simulated sediment loss. Higher POTFW values simulate greater PCB loads entering a stream as sediment is detached from the land surface.

The magnitude of the POTFW varied depending on whether or not the land surface was part of a known, contaminated site. Known contaminated sites include active and inactive manufacturing facilities and were modeled as discrete land parcels. Known contaminated sites retained the same hydrological properties as the subwatershed where they were located, but they were assigned different water quality parameters. For known contaminated sites, data collected at the sites by VADEQ were used to calculate POTFW values. For one specific type of known contaminated site, railyards, the POTFW estimate from the New River (DEQ, 2018) and Roanoke River (DEQ, 2009) PCB TMDLs (7.02×10^{10} pg/ton) was used because of the proximity and similar history of rail activity within those watersheds and the James River study area. The same railyard POTFW value was used for the James River PCB TMDL.

For land surfaces that were not part of a known contaminated site, an initial POTFW value of 3.0×10^{11} pg/ton was used to account for direct drainage within the study area. In order to maintain consistency, the same POTFW for direct drainage loads from land surfaces was used on both pervious land and impervious land despite the possibility of different commercial or industrial activities occurring on pervious and impervious surfaces. In the absence of observed data, the rationale for this decision was to avoid incorrectly assigning a larger PCB load to one land surface type, which could cause issues during the TMDL allocation process. Because the quantity of sediment that washes off varies by land use, the PCB loading is also a function of land use. Because of the inherent uncertainty of the direct drainage POTFW

parameter, it was used as a primary calibration parameter. The POTFW values used in the James River model implicitly include atmospheric deposition of PCBs on the land surface.

PCB Adsorption Coefficient, KD (L/mg)

The adsorption coefficient (KD) is a measure of the tendency for PCBs to adsorb to sediment. HSPF splits KD values into six categories for each reach corresponding to the type of sediment-associated PCBs: 1) sand, 2) silt, and 3) clay in the water column; and 4) sand, 5) silt, and 6) clay on the streambed. KD values were calculated in two stages. In the first stage, an initial KD value was calculated based on a formula that accounts for the proportion of each PCB homolog and associated organic carbon content. In the second stage, the initial KD values were multiplied by a sediment adjustment factor. This factor adjusted the KD value for each sediment size fraction (sand, silt, and clay) according to the corresponding organic carbon content.

All observed water column samples and some observed sediment PCB samples provided PCB homolog composition data. From this information, initial KD values were calculated using Equation **E-1**.

$$KD = 1 \times 10^{-6} \times f_{oc} \times K_{ow} \quad \text{Eq. E-1}$$

Where:

KD = the (initial) adsorption coefficient between the dissolved and sediment-associated states (L/mg)

f_{oc} = weight fraction of the total carbon in the solid matter (gC/g)

K_{ow} = octanol-water partition coefficient (L/kg)

In Equation **E-1**, f_{oc} was derived from observed total organic carbon (TOC) data, and K_{ow} is a coefficient that varies by PCB homolog type as listed in Table F-1 (ICPRB, 2007). For a given observed PCB water quality sample with a distinct distribution of homolog concentrations, a weighted K_{ow} value was calculated by multiplying each homolog concentration by its respective K_{ow_H} , summing, and dividing by the total PCB concentration. The initial estimate for KD was calculated using the weighted K_{ow} and the derived f_{oc} .

Table F-1. Homolog-specific partitioning coefficients

Homolog	log K_{ow_H}	K_{ow_H} (L/kg)
K _{ow_mono+di}	4.675	47,315
K _{ow_tri}	5.425	266,073
K _{ow_tetra}	6.005	1,011,579
K _{ow_penta}	6.525	3,349,654
K _{ow_hexa}	6.73	5,370,318
K _{ow_hepta}	7.235	17,179,084
K _{ow_octa}	7.6	39,810,717
K _{ow_nona}	7.915	82,224,265
K _{ow_deca}	8.18	151,356,125

Source: ICPRB, 2007.

The second stage of the KD calculation multiplied the initial KD by a sediment adjustment factor since organic carbon content varies by sediment size fraction (Li and Ping, 2014). The results of Li and Ping (2014) showed that organic carbon content attached to clay is 70% greater than on silt, and the quantity of organic carbon content attached to sand is 94.1% less than on silt. As a result, silt was established as the baseline. A sediment adjustment factor of 1 was used for silt KD values. The silt KD values were effectively equal to the initial KD values from the first stage. Sand and clay KD values were then calculated by multiplying by their respective sediment adjustment factors, 1.7 and 0.059 (1 - 0.941).

Suspended sediment KD values were calculated with observed water column samples. Bed sediment KD values were calculated using observed sediment PCB data when available. Since every subwatershed reach in the James River study area did not have its own water quality monitoring station with observed PCB data, KD values were assigned from similar reaches that did have observed data. KD values were calculated from observed data and were not adjusted during the calibration.

Adsorption/Desorption Rate, ADRATE (1/day)

The adsorption/desorption rate (ADRATE) quantifies how quickly PCBs attach and detach from sediment and enter the water column. In HSPF, ADRATE is split into six categories corresponding to the size fraction of sediment-associated PCBs: suspended sand, silt, and clay; and bed sand, silt, and clay. In the Roanoke River PCB TMDL (DEQ, 2009) and New River PCB TMDL (DEQ, 2018), the ADRATE was calculated by first identifying the median representative homolog from the observed water column PCB data. This entailed summing the concentrations of each homolog of all observed water column samples, reordering the homologs from mono to deca, and then determining which homolog was at the median point in the list. The

adsorption/desorption rate corresponding to that median homolog was calculated from the rates provided in Schneider (2005).

A similar methodology was used for the James River PCB model in that the median representative homolog was determined for each reach. The adsorption/desorption rate corresponding to that median homolog was calculated from the rates provided in Schneider (2005). A consistent ADRATE value was used in all reaches within the James River study area. Also adhering to the modeling methodology used in the Roanoke River and New River PCB TMDLs, an ADRATE value was only applied to the suspended sediment (sand, silt, and clay). The bed sediment ADRATE value was set to the minimum allowable in HSPF. It was assumed that the adsorption/desorption on the bed sediment is negligible. Similar to KD, the ADRATE value was derived from observed data. As such, once the initial value was calculated, it was not adjusted during calibration. The ADRATE value for suspended sediment in the James River study area varies from 0.79 to 6.32 because the median representative homologs for the water column PCB samples in the calibration segments were pentachlorobiphenyl and tetrachlorobiphenyl homologs.

Initial Concentration of PCBs on Sediment, SEDCONC (pg/mg)

The initial concentration of PCBs bound to sediment (SEDCONC) is a measure of the mass of sediment-associated PCBs (pg) per unit mass of sediment (mg). Similar to KD and ADRATE, SEDCONC is also split into six categories for each reach corresponding to sediment size fraction: suspended sand, silt, and clay; and bed sand, silt, and clay. Compared to water column PCB observed data, there were few, recent sediment-associated PCB concentration observations. The available observed data were used as the initial estimates of SEDCONC. During calibration, it was found that low concentrations of SEDCONC (<10 pg/mg) had a small impact on the dissolved PCB concentrations. However, when increased into the range of >40 pg/mg, SEDCONC increased the PCB concentrations during low flow conditions.

Adhering to the modeling methodology used in the Roanoke River and New River PCB TMDLs, SEDCONC values were only applied on the bed sediment silt and clay. It was assumed that the initial concentration of sediment-associated PCBs on suspended sediment and bed sand was negligible. The bed sediment SEDCONC values were adjusted during the calibration process and range from 0.1 – 134 pg/mg depending on the stream segment.

F.1.2 Calibration Analysis

The analysis of each calibration run involved a series of assessments both graphical and quantitative. The simulated dissolved PCB concentrations output at the end of each model run were compared against the observed water column PCB samples. The number of water quality stations used for calibration, and the number of total observed water column PCB samples are shown in Table F-2. A total of 155 observed water column PCB samples were available in the James River PCB TMDL study area. All of these data were reviewed/considered when developing/calibrating the James River PCB model.

Table F-2. Number of water column PCB water quality stations and samples used in the calibration.

TMDL Watershed	No. Calibration		Total No. of
	Water Quality	Observed PCB Data	
Jackson River	4	Observed PCB Data	Observed PCB Data
Maury River	2	13	10
Upper James River	22	52	52
Lower James River	28	58	58
Total	56	133	133

Model performance was assessed using a “weight-of-evidence” approach. The calibration process focused on subwatershed reaches where observed data were available, and the model was evaluated based on knowledge of the study area. Similar to the sediment model calibration, a graphical analysis was used to compare the simulated and observed data. Additionally, a quantitative analysis was used to assess how well the model output compared with the observed data.

PCB Concentration Time Series Graphs

Two PCB concentration time series graphs were generated for each subwatershed reach with observed PCB water quality data. Both graphs include simulated average daily and observed PCB concentrations on the primary y-axis, and date on the x-axis. One graph shows observed daily rainfall on a secondary inverted y-axis, while the other plots simulated average flow rate on a secondary inverted y-axis. The time series graphs are used to show how simulated PCB concentrations respond to fluctuations in observed rainfall and simulated flow, and demonstrate the ability of the model to simulate PCB concentrations comparable to observed data.

Five-Day Calibration Window Assessments

Five-day calibration window metrics were used to quantitatively analyze model performance. Each 5-day window consists of the date of each observed PCB sample, two days before the sample was collected and two days after. The simulated daily PCB concentration outputs during those 5 days are used to identify the hourly maximum and minimum PCB concentrations within the 5-day window. If the observed PCB value falls between the minimum and maximum simulated values, then that observed PCB value was “within” the window. If the observed PCB value was less than the minimum value, then it was considered to be “below” the calibration window. If the data point was greater than the maximum, then it was considered to be “above” the calibration window. It should be emphasized that 5-day windows were only generated around the date and time when each observed PCB sample was collected.

Kim *et al.* (2007) justified the use of a 5-day window to assess model performance for developing bacterial TMDLs in watersheds with limited observed data. They stated that the goal of the calibration was to achieve at least 70% of the observed data points within the 5-day window. Additionally, in order to avoid model bias, the fraction of data above and below the window (if any) should be roughly equal. BSE believes the use of a 5-day calibration window, with a slight modification, is effective for assessing PCB model performance. Kim *et al.* (2007) recommended a “70% within” threshold for the 5-day window for bacteria modeling. PCB modeling is more complex than bacteria modeling (i.e., PCB modeling is also dependent on modeling sediment), as a result, a threshold of “50% within” the window is considered to be reasonable for assessing PCB model performance.

The 5-day calibration window “within”, “below”, and “above” statistics were calculated once per model run using the observed PCB data from all calibration water quality stations within a given calibration segment. The 5-day statistics were examined after each run as an indicator of model calibration sufficiency. Each subwatershed PCB model calibration 5-day window analysis summary includes a box-and-whisker plot and table. Together, the visual flow-PCB concentration comparison, time series graphs, and the quantitative 5-day window analysis constituted the “weight-of-evidence” approach used to evaluate PCB calibration sufficiency for the HSPF James River PCB TMDL model.

F.2 Jackson River PCB Calibration Results

This section presents the HSPF PCB calibration for the Jackson River TMDL watershed. The calibration results are summarized in tabular format for the entire watershed and graphed for a representative subwatershed reach. Figure E-3 illustrates the location of TMDL watershed,

major tributary boundaries, reaches, and select monitoring stations used for comparing simulated and observed values during model calibration.

F.2.1 PCB Calibration

PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-1 and Figure F-2 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number one (outlet) of Jackson River. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. The model also captured reported PCB spills, i.e., the peak PCB concentrations seen in the figures are the result of reported PCB spills. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Jackson River water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

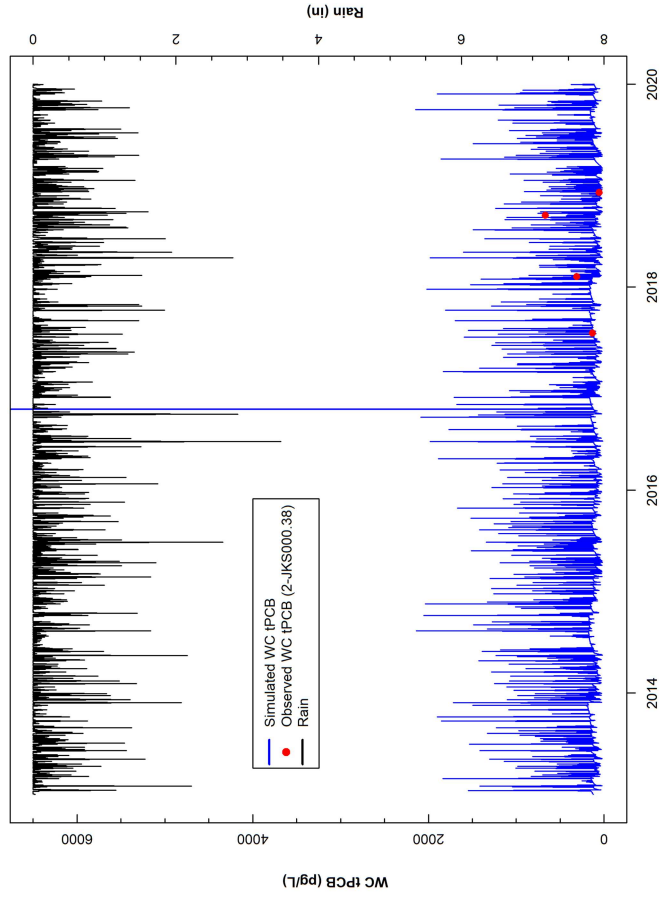


Figure F-1. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 1 in Jackson River.

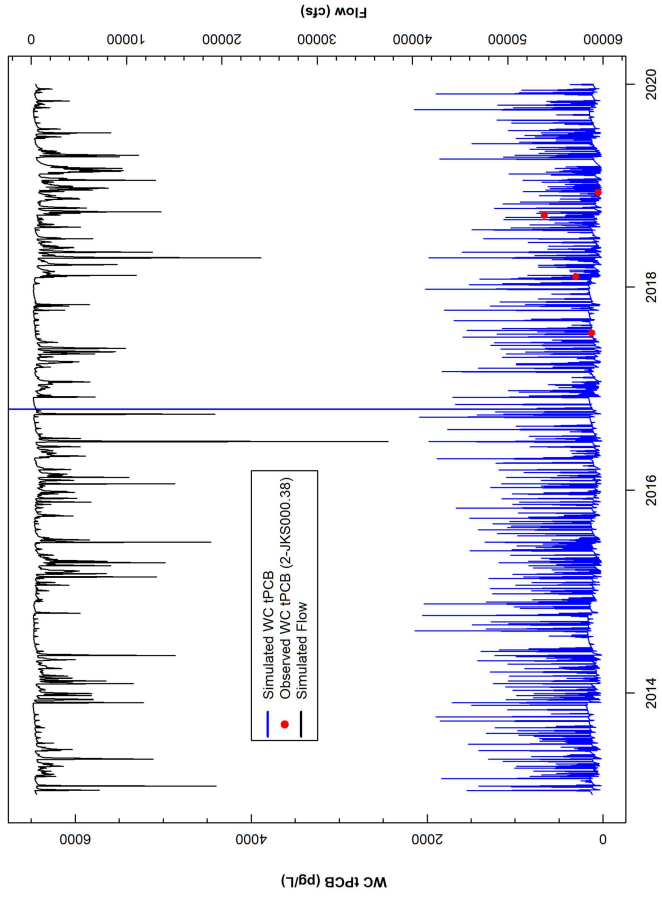


Figure F-2. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 1 in Jackson River.

Five-day Window Performance Assessment

Figure F-3 shows the 5-day windows and observed data for Jackson River reach number one (outlet). All observed data points for reach one were within the 5-day windows indicating a good fit between the simulated and observed data. The 5-day window plots for the other Jackson River water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-3 includes the results of the 5-day window calibration analysis for all Jackson River calibration reaches. Results show that across all stations, 85% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal, and also 8% of the data were above and below the 5-day windows respectively, indicating that the model is not exhibiting bias.

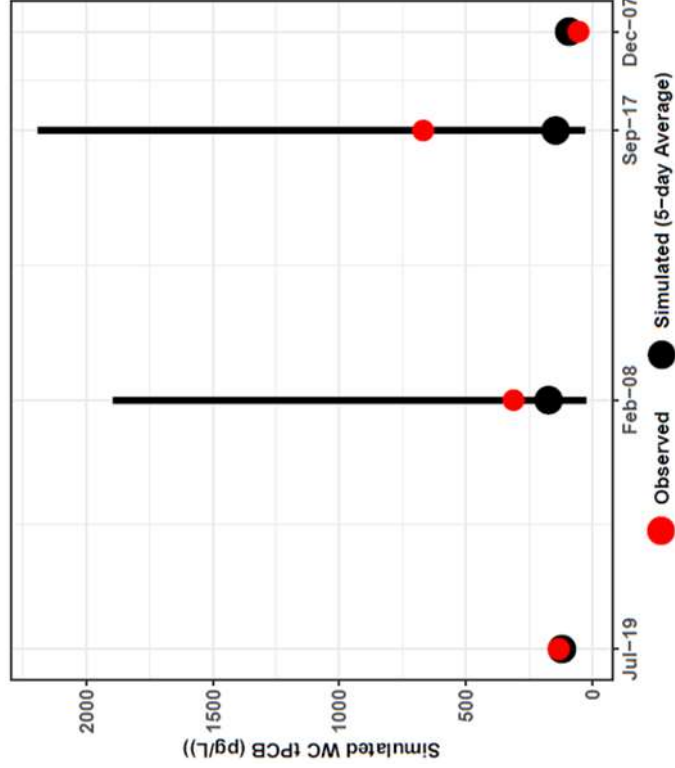


Figure F-3. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-JKS000.38 (Jackson River sub-watershed reach 1).

Table F-3. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Jackson River.

Subwatershed	Station	Date	Observed		Simulated		5-Day Min.
			Water Column	PCB	5-Day Average	5-Day Max.	
1	2-JKS000.38	7/19/2017	133.95		131.42	145.17	116.06
1	2-JKS000.38	2/8/2018	312.26		990.13	34065.29	7.28
1	2-JKS000.38	9/17/2018	668.52		242.74	7417.36	8.53
1	2-JKS000.38	12/7/2018	55.26		104.91	109.44	102.25
4	2-JKS006.67	2/8/2018	262.91		589.69	23657.81	3.40
14	2-JKS023.61	7/19/2017	275.02		273.19	306.88	229.65
14	2-JKS023.61	2/8/2018	296.36		872.53	37390.98	4.15
14	2-JKS023.61	9/17/2018	806.40		299.67	8172.61	3.63
14	2-JKS023.61	12/7/2018	195.58		195.25	199.28	191.91
17	2-JKS044.14	7/19/2017	43.35		43.19	44.16	41.56
17	2-JKS044.14	2/8/2018	76.77		58.92	499.97	9.43
17	2-JKS044.14	9/17/2018	46.58		32.97	198.85	8.35
17	2-JKS044.14	12/7/2018	67.17		36.92	37.26	36.77
			Within 5-Day Range	Above 5-Day Range	Below 5-Day Range		
			PERCENT	85%	8%	8%	

Calibration Summary

The “weight-of-evidence” approach used for the Jackson River HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Jackson River HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-4.

Table F-5 provides an estimate of the contributions from the different source categories to the annual PCB loading (mg/yr) in the stream. These contributions include loadings to unspecified land surface (atmospheric deposition, unspecified stormwater runoff, loads from unidentified contaminated sites, unspecified point source discharges), contaminated sites (including railyards and electric substations), direct loading to the stream (atmospheric deposition to water surfaces and permitted sources), instream contaminated streambed sediment, and spill sites. The “percent of total load” column shows the portion of the PCB load (mg) that originates from a particular PCB source; it does not describe the fate of the PCBs once they enter the stream/river reach.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Table F-4. Final calibrated parameters for the Jackson River PCB Calibration.

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (unspecified surface sources ¹)	pg/ton	2.39E+09 – 2.00E+13	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	Sand: 0.044 – 0.88 ^f ; Silt: 0.747 – 1.494 ^f ; Clay: 1.270 – 2.540 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	Sand: 0.001 -0.008, Silt: 0.022 – 0.133; Clay: 0.037– 0.266	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	0.79 – 1.61	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL1- SQAL4	Initial PCB concentrations on suspended sediment	pg/mg	0.0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL5- SQAL6	Initial PCB concentrations on bed sediment	pg/mg	0.01 – 133.75 ^f	0.0 - Inf.	Estimated in observed sediment sample data, Calibrated
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

[#] Acquired from HSPF Version 12.2 User's Manual

¹ Unspecified surface sources represent the sum of net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and unspecified point source discharges from land uses

² Direct drainage sources represent the sum of net atmospheric deposition to land and water surfaces, loads from small tributaries that are not specified in the model, regulated and unspecified stormwater runoff, loads from unidentified contaminated sites, and unspecified point source discharges from commercial land use

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL., 2018 New River PCB TMDL

^d Varies between contaminated sites

^e Main stem of stream in each subwatershed

^f Varies by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

Table F-5. Estimated existing annual source PCB loads for Jackson River during the allocation period (2010).

Source	Estimated Load (mg/yr)	Percent of total load (%)
Streambed Sediment	38,185	11
Atmospheric Deposition	27	<1
Spills	<1	<1
Contaminated Sites	200	<1
Permitted	23,354	7
Surface Load - Unspecified ¹	280,804	82
Total	342,570	—

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and unidentified point source discharges.

Table F-6 shows the contribution (as a %) of the various PCB sources to the in-stream PCB concentration at the outlet (pg/L). The largest source of PCBs are unspecified surface loads followed by legacy sources (i.e., PCBs associated with bed sediments).

Table F-6. Estimated existing relative contributions of different PCB sources to the overall tPCB concentration at the Jackson River TMDL outlet during the allocation period (2010).

Source	Mean Daily Water Column tPCB Concentrations by Source (pg/L)	Relative Contribution by Source (%)
All Sources	461	—
Surface Load - Unspecified ¹	356	77
Streambed Sediment	63	14
Atmospheric Deposition	<1	<1
Spills	<1	<1
Contaminated Sites	<1	<1
Permitted	41	9

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and unidentified point source discharges.

F.3 Maury River PCB Calibration Results

This section presents the HSPF PCB calibration for the Maury River TMDL watershed. The calibration results are summarized in tabular format for the entire watershed and graphed for a representative subwatershed reach. Figure E-11 illustrates the location of the subwatersheds that will be discussed as well as the observed PCB water quality stations.

F.3.1 PCB Calibration

PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the

parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

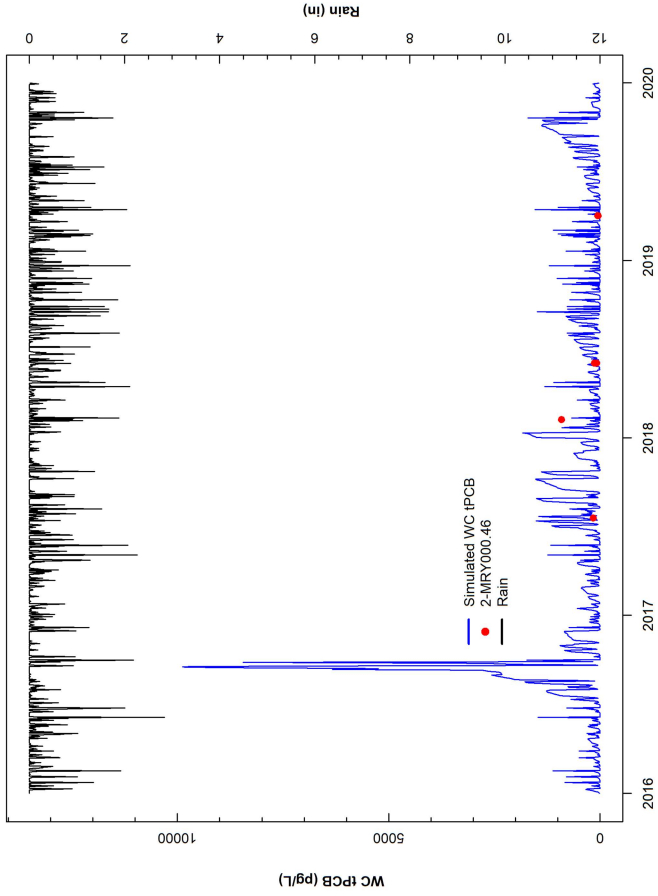


Figure F-4 and Figure F-5 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number one (outlet) of Maury River. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Maury River water quality calibration stations and their corresponding reaches can be provided by BSE upon request.

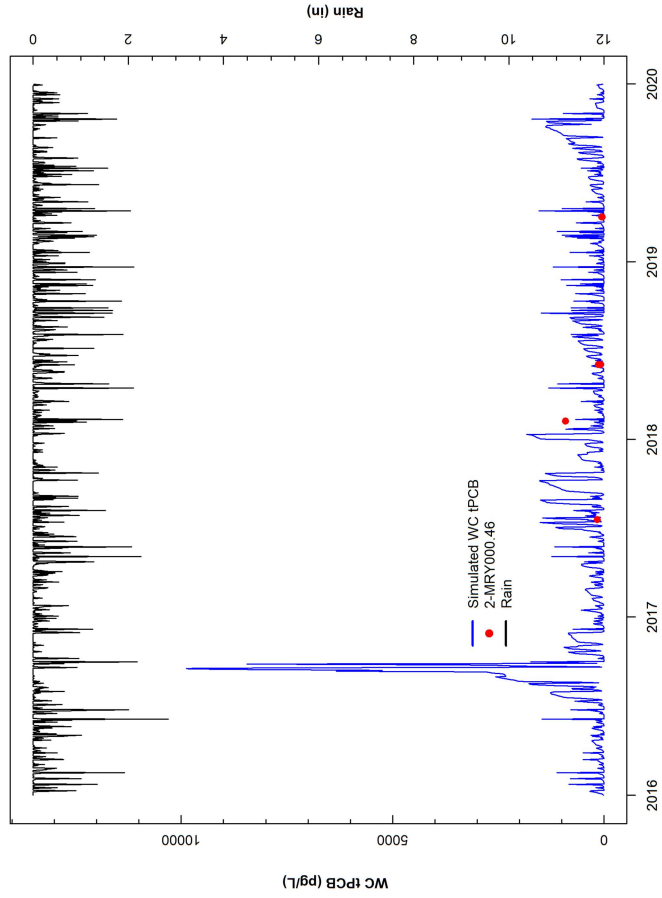


Figure F-4. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 1 in Maury River.

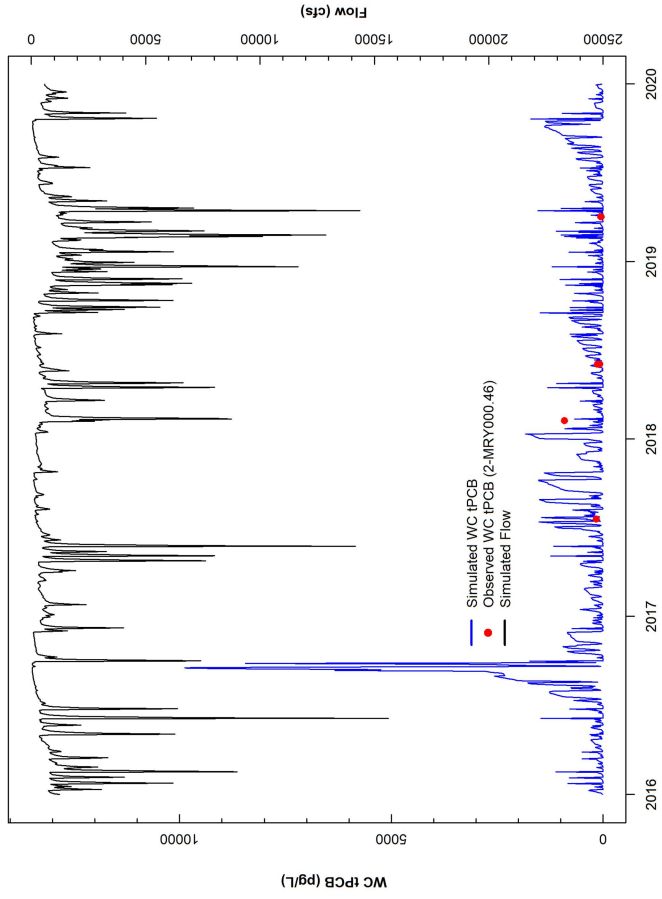


Figure F-5. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 1 in Maury River.

Five-day Window Performance Assessment

Figure F-6 shows the 5-day windows and observed data for Maury River reach number one (outlet). All observed data points for reach one were within the 5-day windows. The 5-day window plots for the other Maury River water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-7 includes the results of the 5-day window calibration analysis for all Maury River calibration reaches. Results show that across all stations, 87.5% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal, and also 12.5% of the data were above the 5-day windows respectively, indicating that the model is not exhibiting bias.

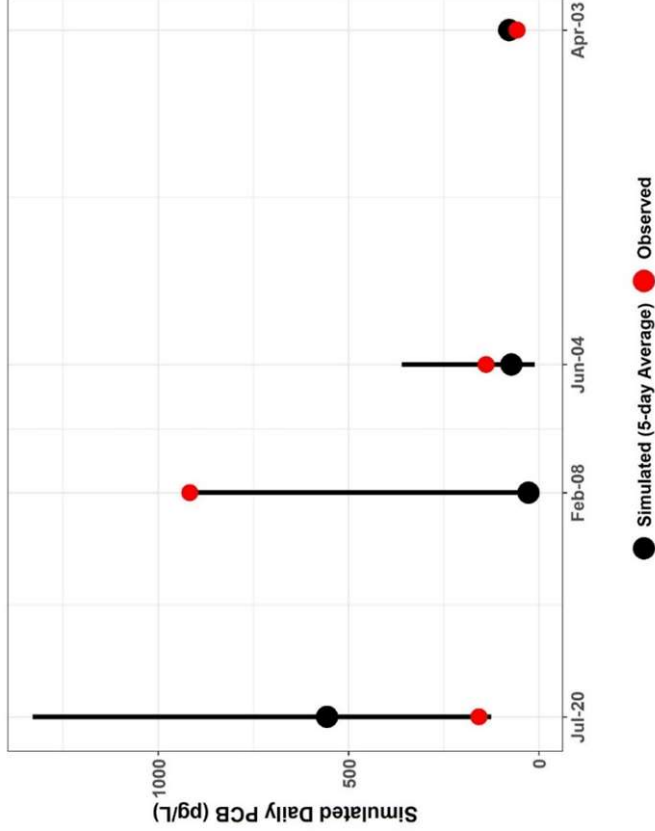


Figure F-6. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-MRY000.46 (Maury River subwatershed reach 1).

Table F-7. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Maury River

Subwatershed	Station ID	Date	Observed Water Column PCB	Simulated 5-Day Average	5-Day Max.	5-Day Min.
1	2-MRY000.46	7/20/2017	157.83	314.18	9671.73	115.39
1	2-MRY000.46	2/8/2018	917.44	355.37	6099.03	74.92
1	2-MRY000.46	6/4/2018	139.22	923.97	43493.54	53.52
1	2-MRY000.46	4/3/2019	58.25	59.28	109.14	55.54
9	2-MRY015.80	7/20/2017	119.57	56.92	1991.41	10.92
9	2-MRY015.80	2/8/2018	547.35	142.28	3446.74	11.90
9	2-MRY015.80	6/4/2018	75.93	256.26	10536.16	11.59
9	2-MRY015.80	4/3/2019	75.05	11.23	11.54	11.10
			PERCENT	Within 5- Day Range	Above 5- Day Range	Below 5- Day Range
				87.5%	12.5%	0%

Calibration Summary

The “weight-of-evidence” approach used for the Maury River HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Maury River HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-8.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Table F-8. Final calibrated parameters for the Maury River PCB Calibration

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES ^a	CALCULATION METHOD ^a
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (unspecified surface sources ¹)	pg/ton	2.39E+09 – 3.14E+14	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	Sand: 0.002 – 0.008 ^f ; Silt: 0.039 – 0.145 ^f ; Clay: 0.066 – 0.246 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	Sand: 1.0 – 5.6 ^f ; Silt: 17.8 – 95.3 ^f ; Clay: 30.2– 162.0 ^f	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	0.7896	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL1- SQAL4	Initial PCB concentrations on suspended sediment	pg/mg	0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL5- SQAL6	Initial PCB concentrations on bed sediment	pg/mg	0.01	0.0 - Inf.	Estimated in observed sediment sample data, Calibrated
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

^a Acquired from HSPF Version 12.2 User's Manual

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL., DEQ, 2018 New River PCB TMDL

^aVaries between contaminated sites

^a Main stem of stream in each subwatershed

^fVaries by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

Table F-9 provides an estimate of the contributions from the different source categories to the annual PCB loading (mg/yr) in the stream. These contributions include loadings to unspecified land surface (atmospheric deposition, unspecified stormwater runoff, loads from

unidentified contaminated sites, unspecified point source discharges), contaminated sites (including railyards and electric substations), direct loading to the stream (atmospheric deposition to water surfaces and permitted sources), instream contaminated streambed sediment, and spill sites. The “percent of total load” column shows the portion of the PCB load (mg) that originates from a particular PCB source; it does not describe the fate of the PCBs once they enter the stream/river reach.

Table F-9. Estimated existing annual source PCB loads for Maury River during the allocation period (2011).

Source	Estimated Load (mg/yr)	Percent of total load (%)
Streambed Sediment	1	<1
Spills	<1	<1
Contaminated Sites	118	<1
Permitted	34,593	7
Atmospheric Deposition	44	<1
Surface Load - Unspecified ¹	467,552	93
Total	502,308	–

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

Table F-10 shows the contribution (in percent) of the various PCB sources to the instream PCB concentration at the outlet (pg/L). The largest source of PCBs is unspecified surface sources, followed by permitted sources followed by.

Table F-10. Estimated existing relative contributions of different PCB sources to the overall tPCB concentration at the Maury River outlet during the allocation period (2011).

Source	Mean Daily Water Column tPCB Concentrations by Source (pg/L)	Relative Contribution by Source (%)
All Sources	657	–
Surface Load - Unspecified ¹	555	84
Streambed Sediment	<1	<1
Atmospheric Deposition	<1	<1
Spills	<1	<1
Contaminated Sites	<1	<1
Permitted	102	16

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

F.4 Upper James River PCB Calibration Results

This section presents the HSPF PCB calibration for the Upper James River TMDL watershed that includes: Cowpasture River, Craig Creek, Catawba Creek, portions of the James River, and Fishing Creek. The calibration results are summarized in tabular format for the entire watershed and graphed for a representative subwatershed reach. Figure E-19 illustrates the location of the subwatersheds that will be discussed as well as the observed PCB water quality stations.

F.4.1 PCB Calibration: James River – Cowpasture, Catawba, Craig Creek

This section of calibration results for James River – Cowpasture, Catawba, Craig Creeks are collectively referred to as “Upper James River”. PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-7 and Figure F-8 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number three which is close to the outlet of Upper James River. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow event. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Upper James River water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

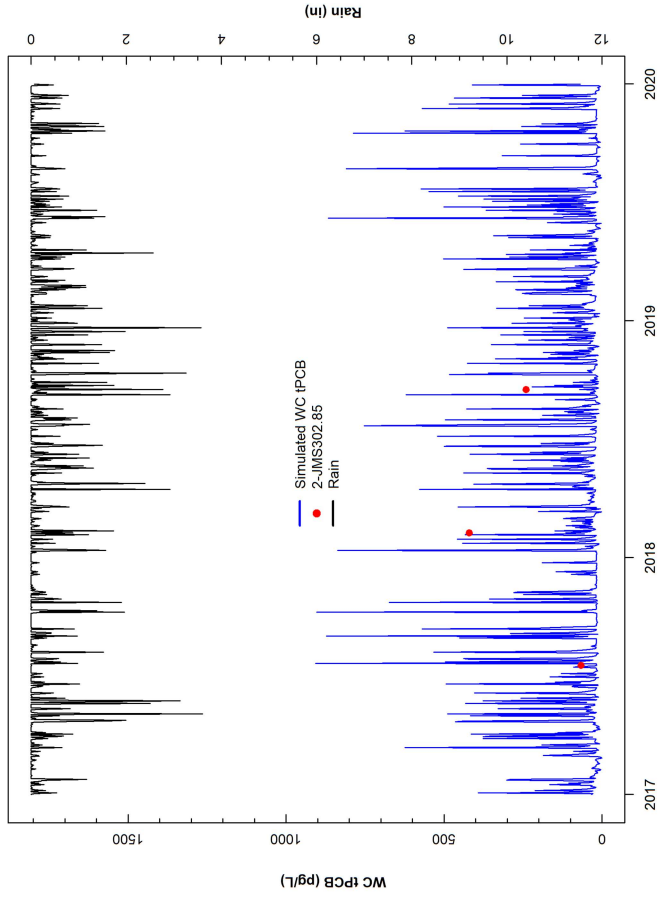


Figure F-7. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 3 in Upper James River.

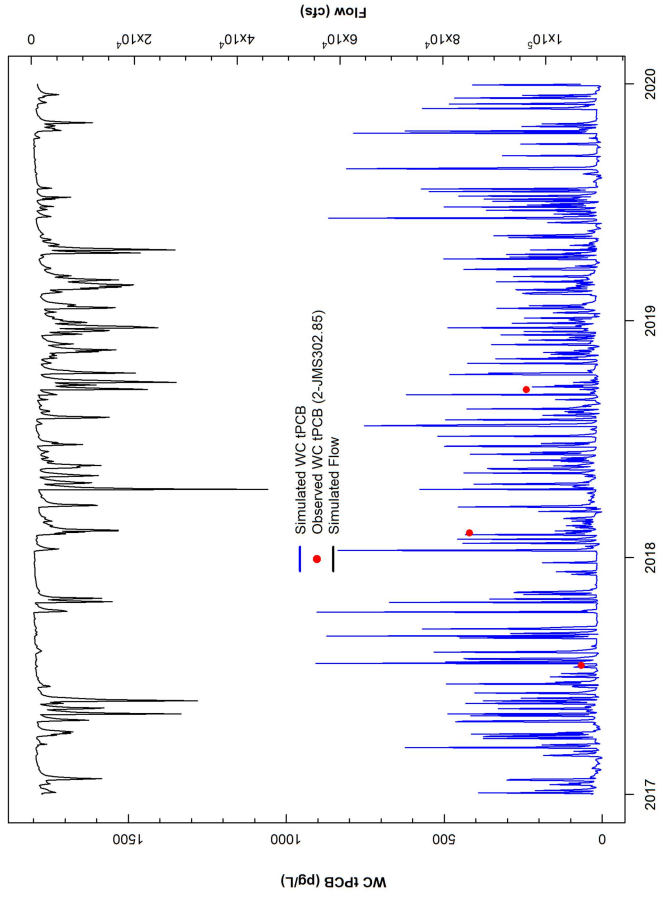


Figure F-8. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 3 in Upper James River.

Five-day Window Performance Assessment

Figure F-9 shows the 5-day windows and observed data for Upper James River reach number one (outlet). Two of the three observed data points for reach three were within the 5-

day windows. The 5-day window plots for the other Upper James River water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-11 includes the results of the 5-day window calibration analysis for all Upper James River calibration reaches. Results show that across all stations, 93.3% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal, and also only 6.7% of the data were above the 5-day windows respectively, indicating that the model is not exhibiting bias.

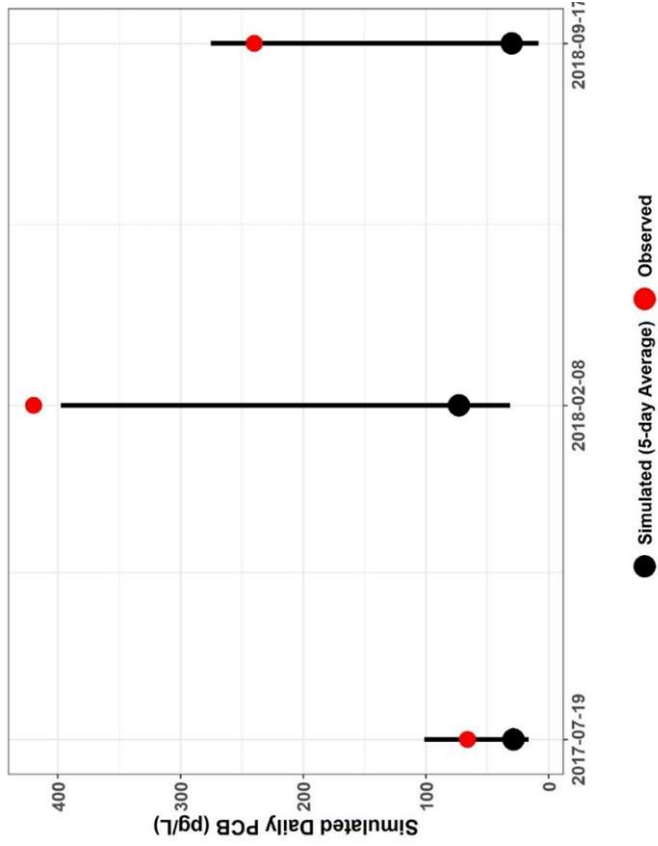


Figure F-9. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-JMS302.85 (Upper James River subwatershed reach 3).

Table F-11. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Upper James River.

Subwatershed	Station ID	Date	Observed Water Column PCB	Simulated 5-Day Average	5-Day Max.	5-Day Min.
3	2-JMS302.85	7/19/2017	66.50	457.77	4249.22	20.35
3	2-JMS302.85	2/8/2018	419.85	637.25	2519.88	102.85
3	2-JMS302.85	9/17/2018	240.20	518.66	1971.77	36.68
5	2-JMS309.13	2/8/2018	510.73	521.30	2694.65	63.00
5	2-JMS309.13	9/17/2018	238.60	614.80	7348.93	58.20
5	2-JMS309.13	12/7/2018	56.93	56.27	127.44	45.06
8	2-JMS317.62	9/17/2018	396.63	367.72	1343.68	48.87
10	2-CAT000.34	2/8/2018	189.90	74.88	680.33	5.11
21	2-CRG001.20	2/8/2018	246.89	189.43	477.10	29.03
21	2-CRG001.20	9/17/2018	125.47	363.01	2157.09	3.02
33	2AJMS334.47	9/17/2018	446.91	133.07	1326.95	6.07
37	2-JMS345.73	7/19/2017	121.13	72.83	73.69	71.94
37	2-JMS345.73	2/8/2018	167.18	169.73	3029.89	12.98
37	2-JMS345.73	9/17/2018	310.93	63.02	382.22	8.96
37	2-JMS345.73	12/7/2018	63.38	63.33	64.31	62.52
			Within 5- Day Range Above 5- Day Range Below 5-Day Range			
			PERCENT	93.9%	6.7%	0%

Calibration Summary: James River – Cowpasture River, Catawba, Craig Creeks

The “weight-of-evidence” approach used for the Upper James River HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Upper James River HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-12.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Table F-12. Final calibrated parameters for the Upper James River PCB Calibration.

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (unspecified surface sources ¹)	pg/ton	2.39E+09 – 1.00E+13	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	Sand: 0.01 – 0.06 ^f ; Silt: 0.01 – 1.0 ^f ; Clay: 0.4 – 1.7 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	Sand: 0.003 – 0.095, Silt: 0.025 – 1.611, Clay: 0.043 – 2.74	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	0.0987 – 3.158 ^f	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL1- SQAL4	Initial PCB concentrations on suspended sediment	pg/mg	0.0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL5- SQAL6	Initial PCB concentrations on bed sediment	pg/mg	0.01 – 10.00	0.0 - Inf.	Estimated in observed sediment sample data, Calibrated
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

* Acquired from HSPF Version 12.2 User's Manual

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009, Roanoke River PCB TMDL., 2018 New River PCB TMDL

^d Varies between contaminated sites

^e Main stem of stream in each subwatershed

^f Varies by calibration segment reach

^g CBP, 1999, Chesapeake Bay Basin Toxics Loading and Release Inventory.

F.4.2 PCB Calibration: Upper James River – Fishing Creek

This section presents the HSPF PCB calibration for the Upper James River – Fishing Creek watershed. This is the furthest downstream modeled watershed within the Upper James River TMDL watershed. The calibration results are summarized in tabular format for the entire watershed and graphed for a representative subwatershed reach. Figure E-19 illustrates the location of the subwatersheds that will be discussed as well as the observed PCB water quality stations.

PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-10 and Figure F-11 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number three which is close to the outlet of the Upper James River – Fishing Creek watershed. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Upper James River – Fishing Creek water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

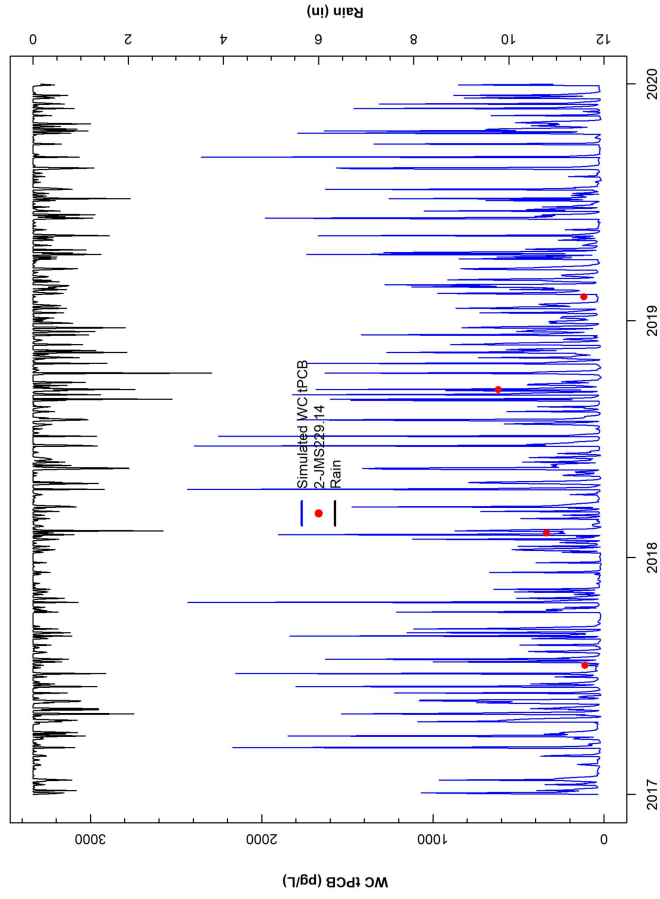


Figure F-10. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 1 in Upper James River – Fishing Creek.

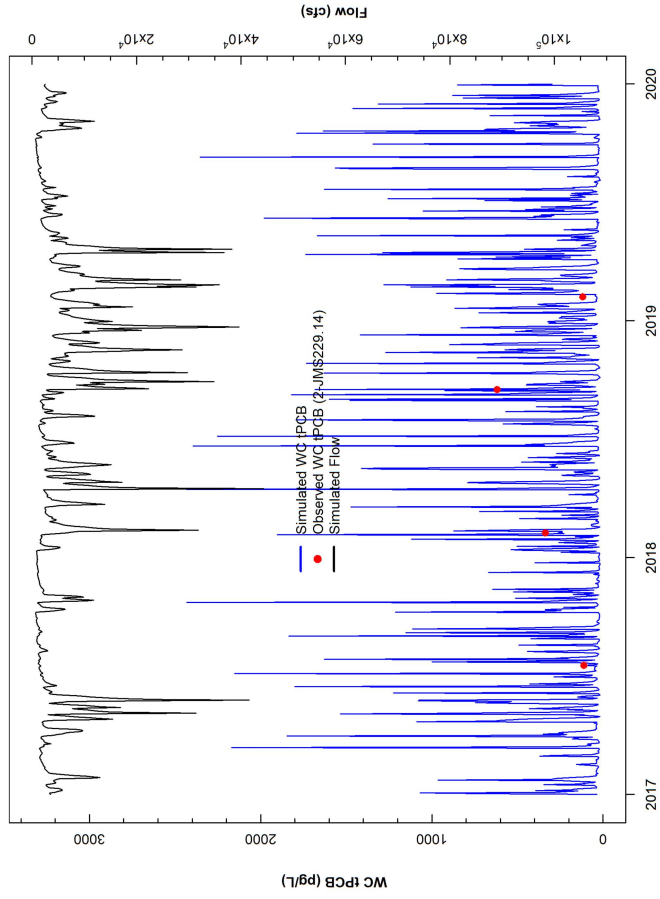


Figure F-11. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 1 in Upper James River – Fishing Creek.

Five-day Window Performance Assessment

Figure F-12 shows the 5-day windows and observed data for Upper James River – Fishing Creek watershed reach number one (outlet). Two of the three observed data points for reach three were within the 5-day windows. The 5-day window plots for the other Upper James River – Fishing Creek water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-13 includes the results of the 5-day window calibration analysis for all Upper James River – Fishing Creek calibration reaches. Results show that across all stations, 81% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal and while the model under-predicted some of the PCB data as indicated by the high percentage of ‘above’ values for the 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated.

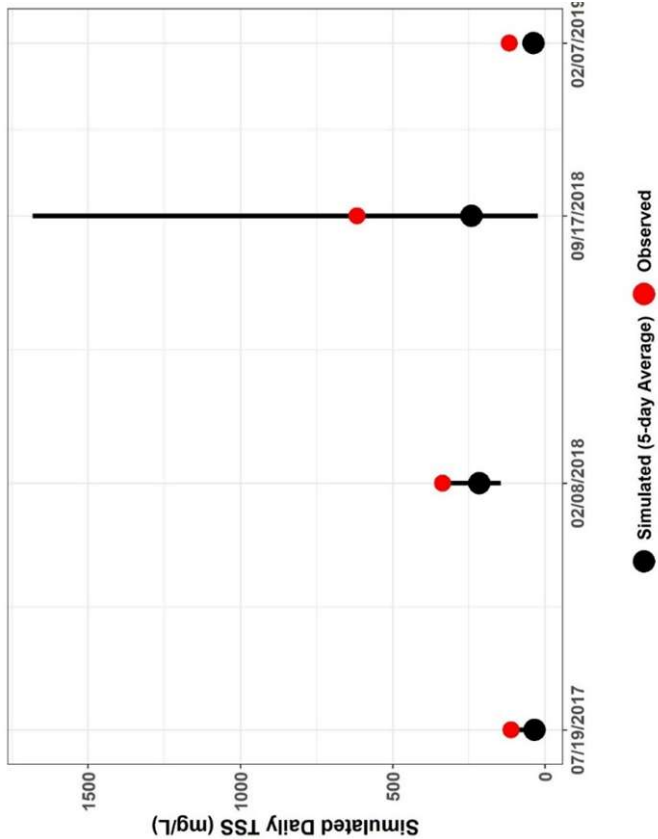


Figure F-12. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-JMS229.14 (Upper James River – Fishing Creek subwatershed reach 3).

Subwatershed	Station ID	Date	Observed				Simulated			
			Water Column PCB		5-Day Average		5-Day Max.		5-Day Min.	
1	2-JMS229.14	7/19/2017	112.07		48.47		98.75		37.40	

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1	2-JMS229.14	2/8/2018	337.03	227.57	374.10	154.77
1	2-JMS229.14	9/17/2018	618.39	226.71	821.74	28.08
1	2-JMS229.14	2/7/2019	118.06	51.93	75.27	40.68
6	2BJMS248.90	9/17/2018	228.28	54.87	289.39	9.03
6	2BJMS248.90	2/7/2019	67.62	171.41	269.56	30.77
7	2-BCR000.20	9/17/2018	1398.01	125.49	3164.00	2.86
9	2BWL000.34	9/17/2018	3965.67	6019.39	201201.00	1.03
10	2BJMS255.91	9/17/2018	608.90	38.93	1354.93	1.23
10	2BJMS255.91	2/7/2019	213.40	177.45	306.90	8.40
11	2-FSG000.85	2/8/2018	2845.14	10766.06	197591.40	1744.72
11	2-FSG000.85	9/17/2018	8907.23	5648.65	207493.10	0.56
11	2-FSG000.85	2/7/2019	305.23	54.83	73.37	47.16
12	2-FSG003.36	9/17/2018	4511.99	5015.80	240761.00	3.87
12	2-FSG003.36	2/7/2019	630.03	61.56	106.55	48.10
13	2-JMS258.54	7/19/2017	222.03	45.11	389.89	20.45
13	2-JMS258.54	2/8/2018	614.76	95.85	970.34	29.99
13	2-JMS258.54	9/17/2018	3215.95	938.00	43850.30	9.75
13	2-JMS258.54	2/7/2019	128.36	172.94	283.09	25.61
14	2-BKW000.40	2/8/2018	595.31	27.14	665.67	10.98
14	2-BKW000.40	9/17/2018	4414.24	35.25	1543.43	2.38
14	2-BKW000.40	2/7/2019	147.17	3.02	3.17	2.87
15	2-IVA000.22	9/17/2018	592.01	72.72	1784.92	10.23
16	2-BKW005.95	9/17/2018	5616.64	138.34	6164.00	3.25
20	2BJMS263.24	7/19/2017	151.61	62.99	333.90	23.02
20	2BJMS263.24	2/8/2018	183.7	55.83	190.39	24.49
20	2BJMS263.24	9/17/2018	660.12	69.38	1031.64	7.01
20	2BJMS263.24	2/7/2019	115.79	232.84	404.33	28.77
21	2-JMS270.84	7/19/2017	106.34	12.31	366.88	4.89
21	2-JMS270.84	2/8/2018	457.17	37.11	676.68	6.58
21	2-JMS270.84	9/17/2018	600.84	23.28	665.86	2.97
21	2-JMS270.84	2/7/2019	111.16	4.66	4.70	4.61
25	2BJMS273.86	2/7/2019	122.72	226.68	448.63	3.42
28	2-JMS279.41	7/19/2017	86.26	216.93	958.17	10.14
28	2-JMS279.41	2/8/2018	520.03	21.59	557.82	2.21
28	2-JMS279.41	9/17/2018	829.88	141.73	2301.66	0.56
28	2-JMS279.41	2/7/2019	100.06	472.46	1459.64	55.61
			Within 5- Day Range Above 5- Day Range Below 5- Day Range			
			PERCENT	81%	19%	0%

Calibration Summary: Upper James River – Fishing Creek

The “weight-of-evidence” approach used for the Upper James River – Fishing Creek HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Upper James River – Fishing Creek HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-14.

Table F-15 provides an estimate of the contributions from the different source categories to the annual PCB loading (mg/yr) in the stream. These contributions include loadings to regulated land surface (MS4 service areas), unspecified land surface (atmospheric deposition, unspecified stormwater runoff, loads from unidentified contaminated sites, unspecified point source discharges), contaminated sites (including railyards and electric substations), direct loading to the stream (atmospheric deposition to water surfaces and permitted sources), instream contaminated streambed sediment, and spill sites. The “percent of total load” column shows the portion of the PCB load (mg) that originates from a particular PCB source; it does not describe the fate of the PCBs once they enter the stream/river reach.

Table F-16 shows the contribution (in percent) of the various PCB sources to the instream PCB concentration at the outlet (pg/L). The largest source of PCBs is unspecified and regulated surface sources, followed by permitted sources.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Table F-14. Final calibrated parameters for the James River—Fishing Creek PCB Calibration.

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (surface sources – regulated and unspecified ¹)	pg/ton	2.39E+09 – 5.28E+13	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	<u>Sand</u> : 0.001 – 0.301 ^f ; <u>Silt</u> : 0.014 – 5.103 ^f ; <u>Clay</u> : 0.024 – 8.676	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	<u>Sand</u> : 0.006 – 0.783, <u>Silt</u> : 0.101 – 13.280, <u>Clay</u> : 0.176 – 22.576	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	3.0564	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL1- SQAL4	Initial PCB concentrations on suspended sediment	pg/mg	0.0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL5- SQAL6	Initial PCB concentrations on bed sediment	pg/mg	0.01	0.0 - Inf.	Derived from observed sediment samples
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

[#] Acquired from HSPF Version 12.2 User's Manual

¹ Unspecified surface sources represent the sum of net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, regulated and unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL., 2018 New River PCB TMDL

^d Varies between contaminated sites

^e Main stem of stream in each subwatershed

^f Varies by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

Table F-15. Estimated existing annual source PCB loads for Upper James River – Fishing Creek during the allocation period (2010).

Source	Estimated Load (mg/yr)	Percent of total load (%)
Upstream Sources	81,796	13
Streambed Sediment	203	<1
Surface Load – Unspecified ¹	310,099	50
Surface Load – Regulated ¹	200,306	33
Atmospheric Deposition	930	<1
CSOs	3,468	<1
Spills	<1	<1
Contaminated Sites	1,403	<1
Permitted	15,754	3
Total	310,099	–

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

Table F-16. Estimated existing relative contributions of different PCB sources to the overall tPCB concentration at the Upper James River – Fishing Creek outlet during the allocation period (2010).

Source	Mean Daily Water Column tPCB Concentrations by Source (pg/L)	Relative Contribution by Source (%)
All Sources	290	–
Upstream Sources	27	9
Surface Load – Unspecified ¹	158	54
Surface Load – Regulated ¹	92	32
Atmospheric Deposition	<1	<1
Streambed Sediment	<1	<1
Spills	<1	<1
Contaminated Sites	1	<1
Permitted	9	3
CSOs	2	1

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

F.5 Lower James River PCB Calibration Results

This section presents the HSPF sediment calibration results for the Lower James River TMDL Watershed that include major tributary watersheds: Tye and Rockfish Rivers; Hardware, Slate, and Willis Rivers; Rivanna River, portions of the James River, and Reedy Creek. The calibration results are summarized in tabular format for the entire watershed and graphed for a representative subwatershed reach. Figure E-34 illustrates the location of the subwatersheds that will be discussed as well as the observed PCB water quality stations.

F.5.1 PCB Calibration: Lower James River – Tye and Rockfish River

This section presents the HSPF PCB calibration for the outlet located downstream of the Lower James River – Tye and Rockfish River watersheds. PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-13 and Figure F-14 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number two which is close to the outlet of Lower James River – Tye and Rockfish River. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Lower James River – Tye and Rockfish River water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

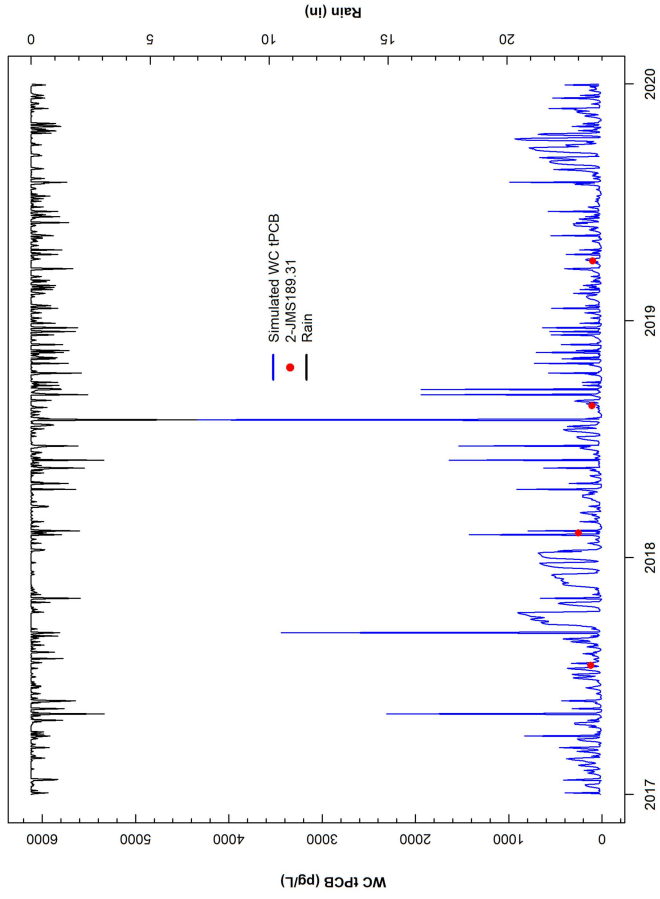


Figure F-13. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 2 in Lower James River – Tye and Rockfish River.

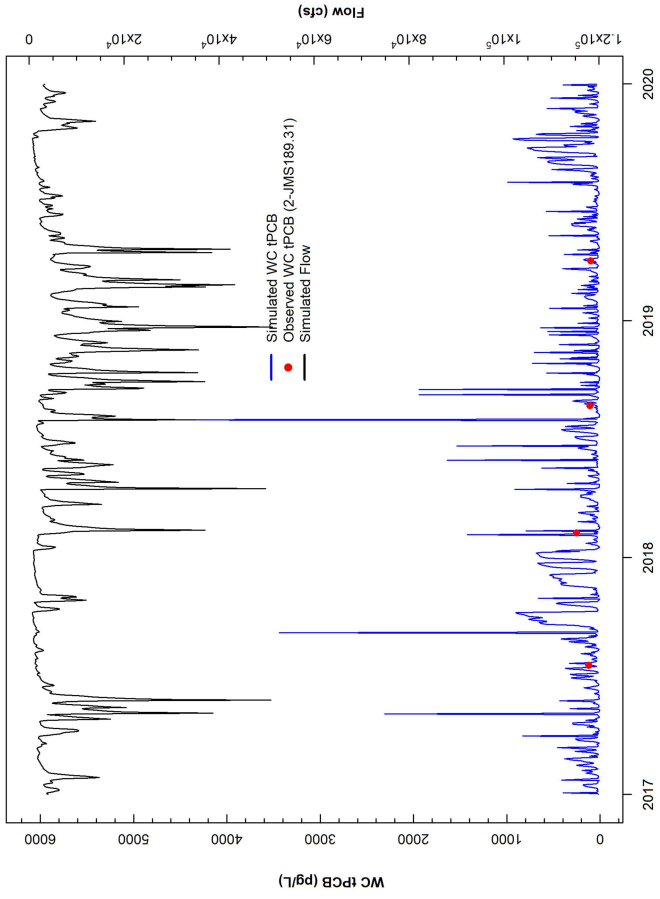


Figure F-14. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 2 in Lower James River – Tye and Rockfish River.

Five-day Window Performance Assessment

Figure F-15 shows the 5-day windows and observed data for Lower James River – Tye and Rockfish River reach number one (outlet). All of the observed data points for reach four were within the 5-day windows. The 5-day window plots for the other Lower James River – Tye and Rockfish River water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-17 includes the results of the 5-day window calibration analysis for all Lower James River – Tye and Rockfish River calibration reaches. Results show that across all stations, 85% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal and while the model over-predicted some of the PCB data as indicated by the high percentage of ‘below’ values for the 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated.

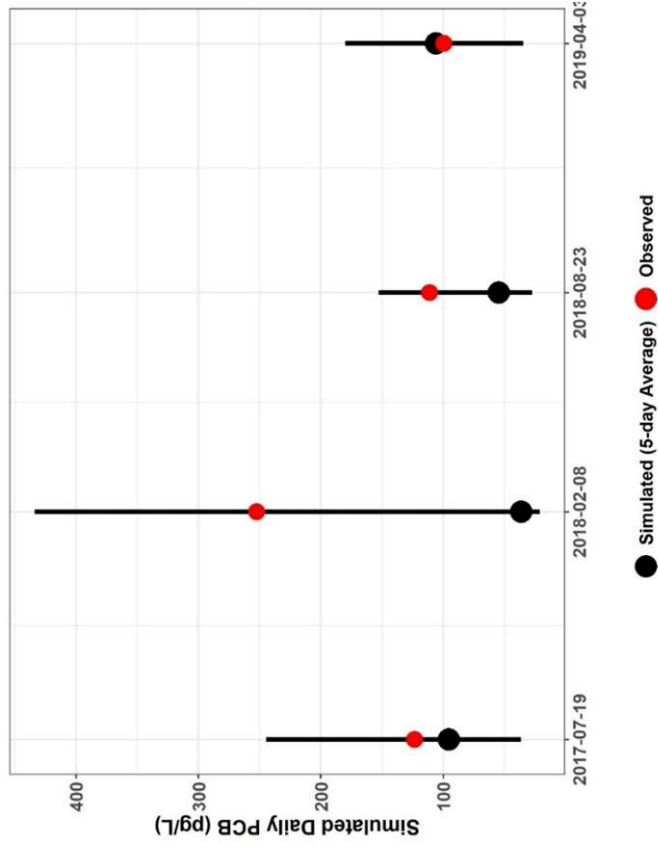


Figure F-15. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-JMS189.31 (Lower James River – Tye and Rockfish River subwatershed reach 3).

Table F-17. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Lower James River – Tye and Rockfish River

Subwatershed	Station ID	Date	Observed Water Column PCB	Simulated		
				5-Day Average	5-Day Max.	5-Day Min.
2	2-JMS189.31	7/19/2017	123.57	95.68	244.58	36.47
2	2-JMS189.31	2/8/2018	252.40	36.51	433.66	21.10
2	2-JMS189.31	8/23/2018	111.39	54.68	152.55	27.26
2	2-JMS189.31	4/3/2019	99.63	105.92	180.02	34.52
15	2BJMS214.35	2/8/2018	361.68	346.38	615.46	147.64
15	2BJMS214.35	8/23/2018	112.66	418.05	1626.36	217.58
24	2-BUF002.10	9/17/2018	2104.4	403.31	2146.93	8.42
			PERCENT			
			Within 5- Day Range		Above 5- Day Range	Below 5-Day Range
			85%		0%	15%

Calibration Summary: Lower James River – Tye and Rockfish River

The “weight-of-evidence” approach used for the James River—Tye and Rockfish River HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the James River—Tye and Rockfish River HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-18.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Table F-18. Final calibrated parameters for the Lower James River – Tye and Rockfish River PCB Calibration

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (unspecified surface sources ¹)	pg/ton	2.39E+09 – 8.15E+12	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	Sand: 0.004 – 0.072 ^f ; Silt: 0.073 – 1.227 ^f ; Clay: 0.124 – 2.086 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	Sand: 0.07, Silt: 1.25, Clay: 2.12	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	0.0595	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL1- SQAL4	Initial PCB concentrations on suspended sediment	pg/mg	0.0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL5- SQAL6	Initial PCB concentrations on bed sediment	pg/mg	21.66	0.0 - Inf.	Derived from observed sediment samples
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

[#] Acquired from HSPF Version 12.2 User's Manual

¹Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL-, 2018 New River PCB TMDL

^dVaries between contaminated sites

^e Main stem of stream in each subwatershed

^fVaries by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

F.5.2 PCB Calibration: Lower James River – Hardware, Slate, and Willis Rivers

This section presents the HSPF PCB calibration for the outlet located downstream of the collective Lower James River –Hardware, Slate, and Willis Rivers watersheds. PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-16 and Figure F-17 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number one which is close to the outlet of Lower James River – Hardware, Slate, and Willis Rivers. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Lower James River – Hardware, Slate, and Willis Rivers water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

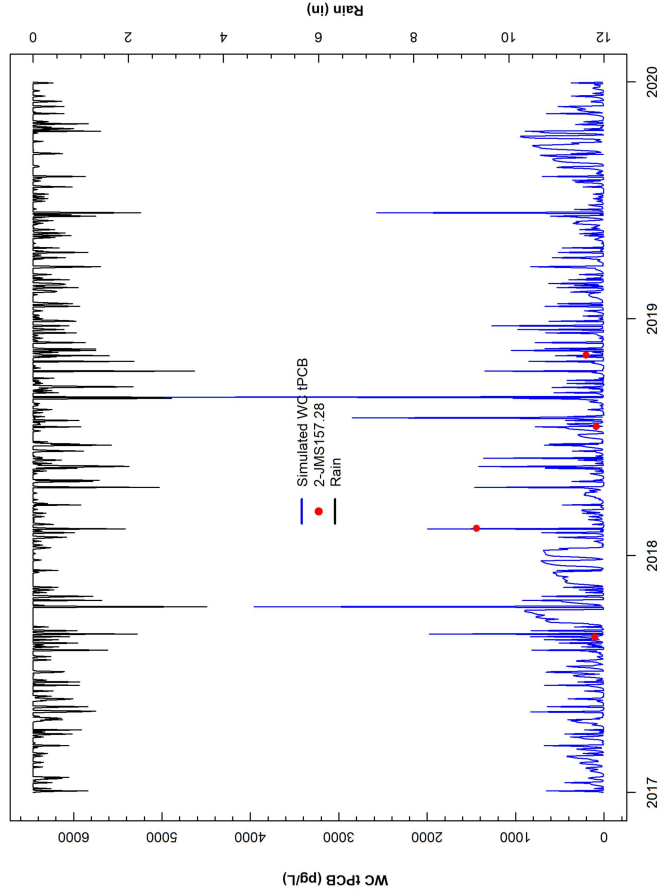


Figure F-16. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 1 in Lower James River – Hardware, Slate, and Willis Rivers.

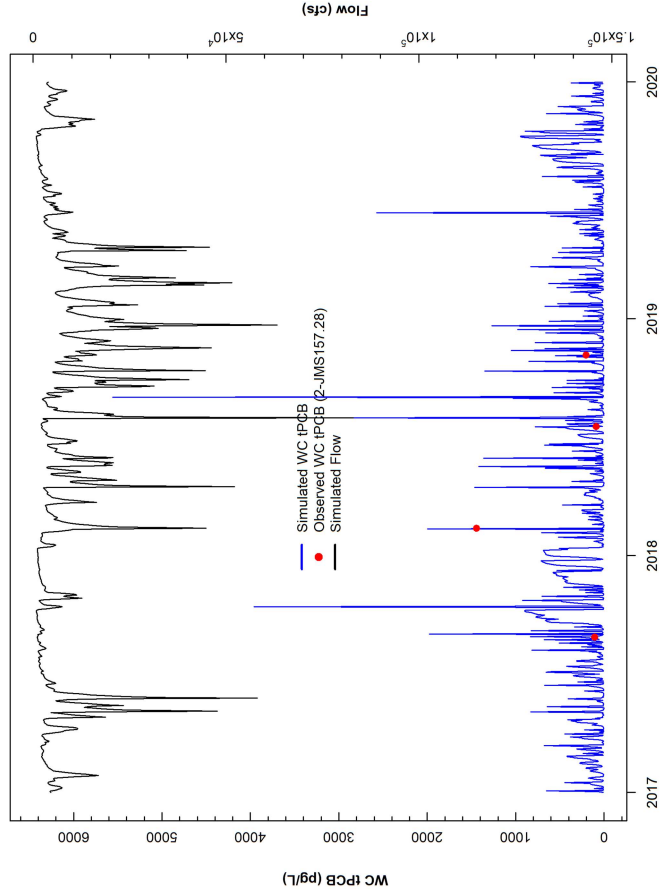


Figure F-17. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 1 in Lower James River – Hardware, Slate, and Willis Rivers.

Five-day Window Performance Assessment

Figure F-18 shows the 5-day windows and observed data for James River---Hardware, Slate and Willis reach number one (outlet). All of the observed data points for reach four were within the 5-day windows. The 5-day window plots for the other James River---Hardware, Slate and Willis water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-19 includes the results of the 5-day window calibration analysis for all James River---Hardware, Slate and Willis calibration reaches. Results show that across all stations, 85% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal and while the model over-predicted some of the PCB data as indicated by the high percentage of ‘below’ values for the 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated.

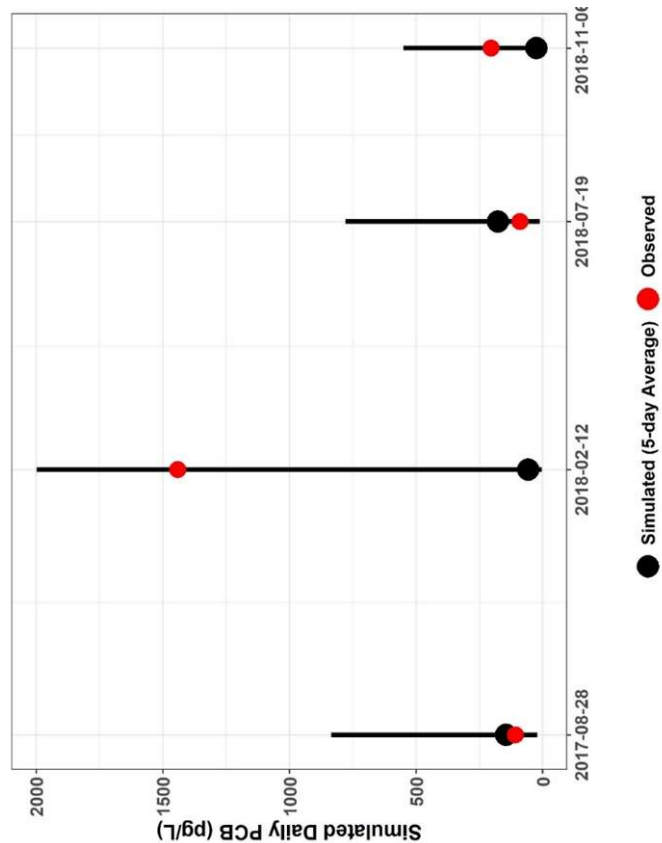


Figure F-18. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-JMS157.28(Lower James River – Hardware, Slate, and Willis Rivers subwatershed reach 1).

Table F-19. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Lower James River – Hardware, Slate, and Willis Rivers

Subwatershed	Station ID	Date	Observed Water Column PCB	Simulated		
				5-Day Average	5-Day Max.	5-Day Min.
1	2-JMS157.28	8/28/2017	109.03	146.19	835.85	21.21
1	2-JMS157.28	2/12/2018	1441.74	58.44	1997.98	4.09
1	2-JMS157.28	7/19/2018	90.21	178.33	778.88	11.70
1	2-JMS157.28	11/6/2018	205.47	25.79	549.84	7.53
22	2BSLT000.73	7/19/2017	53.55	276.72	367.33	196.44
22	2BSLT000.73	2/8/2018	121.95	109.77	952.00	35.49
33	2-HRD000.36	10/30/2017	111.34	33.09	189.42	4.72
			Within 5-Day Range		Above 5-Day Range	Below 5-Day Range
			PERCENT		85%	0% 15%

Calibration Summary: Lower James River – Hardware, Slate, and Willis Rivers

The “weight-of-evidence” approach used for the Lower James River – Hardware, Slate, and Willis Rivers HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Lower James River – Hardware, Slate, and Willis Rivers HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-20.

Table F-20. Final calibrated parameters for the Lower James River – Hardware, Slate, and Willis Rivers PCB Calibration

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES*	CALCULATION METHOD*
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (unspecified surface sources ¹)	pg/ton	2.39E+09 – 3.90E+11	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1-ADPM3	Adsorption coefficients for suspended sediment	L/mg	<u>Sand</u> : 0.002 – 0.003 ^f ; <u>Silt</u> : 0.026 – 0.048 ^f ; <u>Clay</u> : 0.044 – 0.082 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4-ADPM6	Adsorption coefficients for bed sediment	L/mg	<u>Sand</u> : 0.01 – 0.16 ^f ; <u>Silt</u> : 0.16 – 2.62 ^f ; <u>Clay</u> : 0.28 – 4.46 ^f	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1-ADPM3	Adsorption/desorption rates for suspended sediment	1/day	0.9614	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4-ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL1-SQAL4	Initial PCB concentrations on suspended sediment	pg/mg	0.0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL5-SQAL6	Initial PCB concentrations on bed sediment	pg/mg	0.01	0.0 - Inf.	Derived from observed sediment samples
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/month	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

* Acquired from HSPF Version 12.2 User's Manual

¹ Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL-, 2018 New River PCB TMDL

^d Varies between contaminated sites

^e Main stem of stream in each subwatershed

^f Varies by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

F.5.3 PCB Calibration: Lower James River – Rivanna River

This section presents the HSPF PCB calibration for the downstream outlet of the Lower James River – Rivanna River watershed. The calibration results are summarized in tabular format for the entire watershed and graphed for a representative subwatershed reach. PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-19 and Figure F-20 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number one (outlet) of Lower James River – Rivanna River. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Lower James River – Rivanna River water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

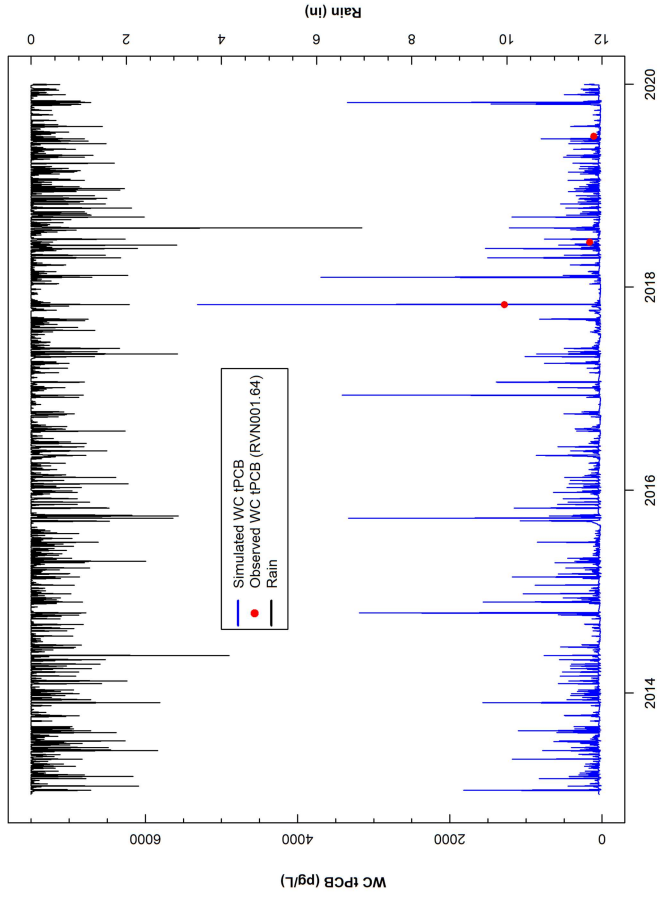


Figure F-19. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 1 in Lower James River – Rivanna River.

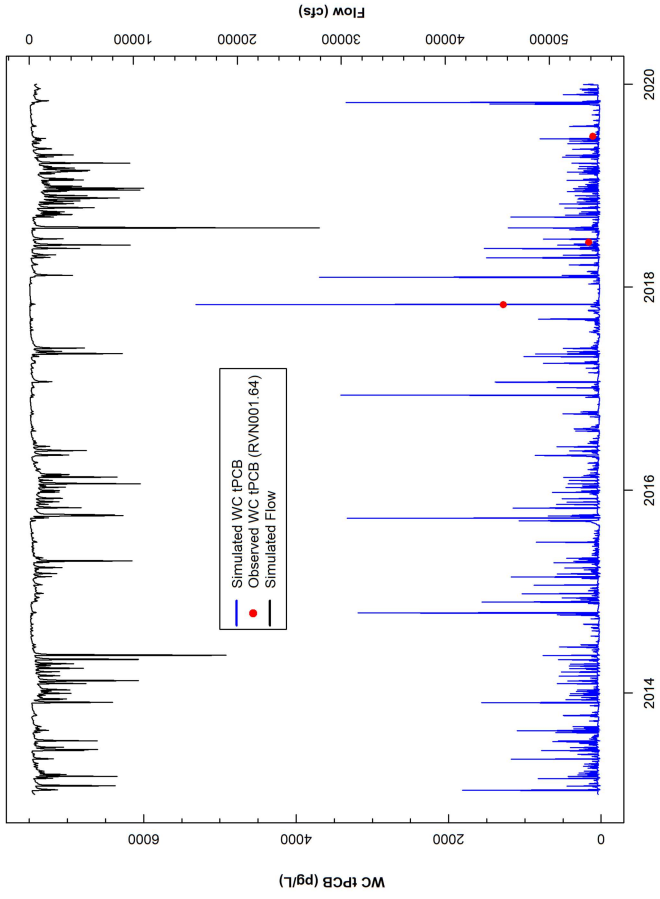


Figure F-20. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 1 in Lower James River – Rivanna River.

Five-day Window Performance Assessment

Figure F-21 shows the 5-day windows and observed data for Lower James River – Rivanna River reach number one (outlet). All observed data points for reach one were within the 5-day windows except one data point indicating a good fit between the simulated and observed data. The 5-day window plots for the other Lower James River – Rivanna River water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-21 includes the results of the 5-day window calibration analysis for all Lower James River – Rivanna River calibration reaches. Results show that across all stations, 91% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal, and also 9% of the data were above the 5-day windows respectively, indicating that the model is not exhibiting bias.

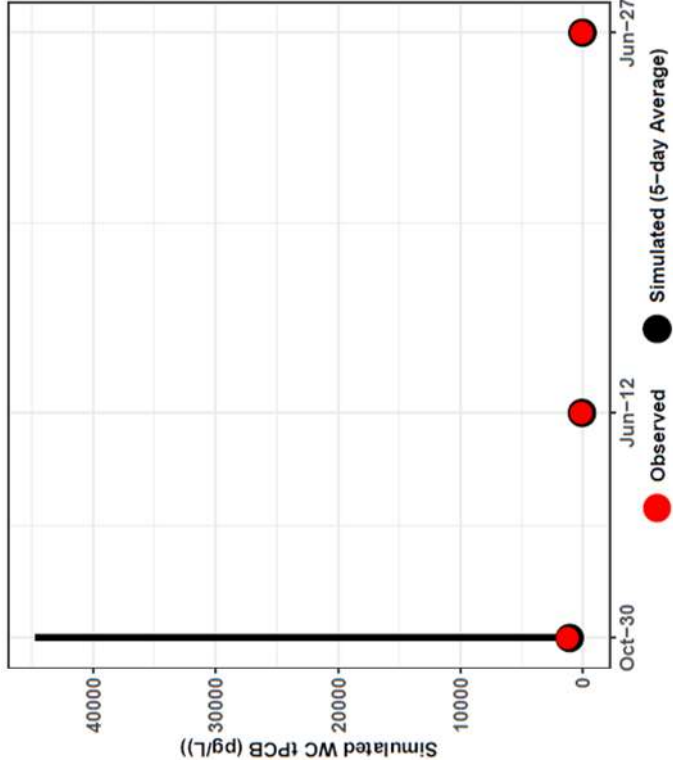


Figure F-21. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-RVN001.64 (Lower James River – Rivanna River sub-watershed reach 1).

Table F-21. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Lower James River – Rivanna River

Subwatershed	Station	Date	Observed Water Column PCB	Simulated 5-Day Average	5-Day Max.	5-Day Min.
1	2-RVN001.64	10/30/2017	1286.08	199.22	7090.90	14.52
1	2-RVN001.64	6/12/2018	163.39	34.91	122.92	21.25
1	2-RVN001.64	6/27/2019	111.36	29.87	164.50	19.52
9	2-RVN033.65	6/12/2018	144.76	124.08	229.67	53.37
9	2-RVN033.65	6/27/2019	107.33	156.67	284.15	58.86
11	2-RVN039.58	6/12/2018	100.61	49.75	249.03	8.44
11	2-RVN039.58	6/27/2019	61.47	51.66	198.34	10.72
13	2-RRN002.19	6/12/2018	120.78	67.46	559.47	8.13
13	2-RRN002.19	6/27/2019	40.33	49.94	486.25	17.30
19	2-RRS003.12	6/12/2018	151.82	60.27	184.86	15.64
19	2-RRS003.12	6/27/2019	59.41	74.97	200.93	17.39
			Within 5- Day Range		Above 5- Day Range	Below 5- Day Range
			PERCENT	91%	9%	0%

Calibration Summary: Lower James River – Rivanna River

The “weight-of-evidence” approach used for the Lower James River – Rivanna River HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Lower James River – Rivanna River HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-22.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Table F-22. Final calibrated parameters for the Lower James River – Rivanna River PCB Calibration.

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (surface sources – regulated and unspecified ¹)	pg/ton	2.39E+09 – 3.82E+10	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	<u>Sand</u> : 0.01 – 0.06 ^f ; <u>Silt</u> : 0.17 – 0.94 ^f ; <u>Clay</u> : 0.30 – 1.59 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	<u>Sand</u> : 0.001 -0.036 ^f ; <u>Silt</u> : 0.025 – 0.614 ^f ; <u>Clay</u> : 0.174– 1.043 ^f	1.0E-10 - Inf.	Derived from observed sediment samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	0.0987	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL 1- SQAL 4	Initial PCB concentrations on suspended sediment	pg/mg	0.00	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL 5- SQAL 6	Initial PCB concentrations on bed sediment	pg/mg	0.46 – 9.41 ^f	0.0 - Inf.	Estimated in observed sediment sample data
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

[#] Acquired from HSPF Version 12.2 User's Manual

¹Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL., 2018 New River PCB TMDL

^dVaries between contaminated sites

^e Main stem of stream in each subwatershed

^fVaries by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

F.5.4 PCB Calibration: Lower James River – Reedy Creek

This section presents the HSPF PCB calibration for the Lower James River – Reedy Creek watershed (the outlet of the James River study area). PCB model calibration was an iterative process in which adjustments were made to the calibration parameters. After executing the model, the results were analyzed, and the parameters were adjusted again. The results of the model were analyzed using the “weight-of-evidence” metrics discussed previously.

PCB Concentration Time Series Graphs

Figure F-22 and Figure F-23 illustrate the comparison of daily average simulated PCB concentrations and observed water column PCB concentrations for reach number one, the outlet of Lower James River – Reedy Creek. These graphs show that the simulated PCB concentration responded to fluctuations in rainfall and simulated flow. The model adequately simulated instream PCB concentrations in response to extreme rainfall and peak flow events. These plots illustrate that the simulated PCB concentrations followed a pattern of increasing and decreasing similar to the observed data. Further, the model adequately reflects the baseflow PCB concentrations and peak observed concentrations. Time series graphs for the other Lower James River – Reedy Creek water quality calibration stations and their corresponding reaches can be provided by BSE upon request by referring to the contact information on page ii.

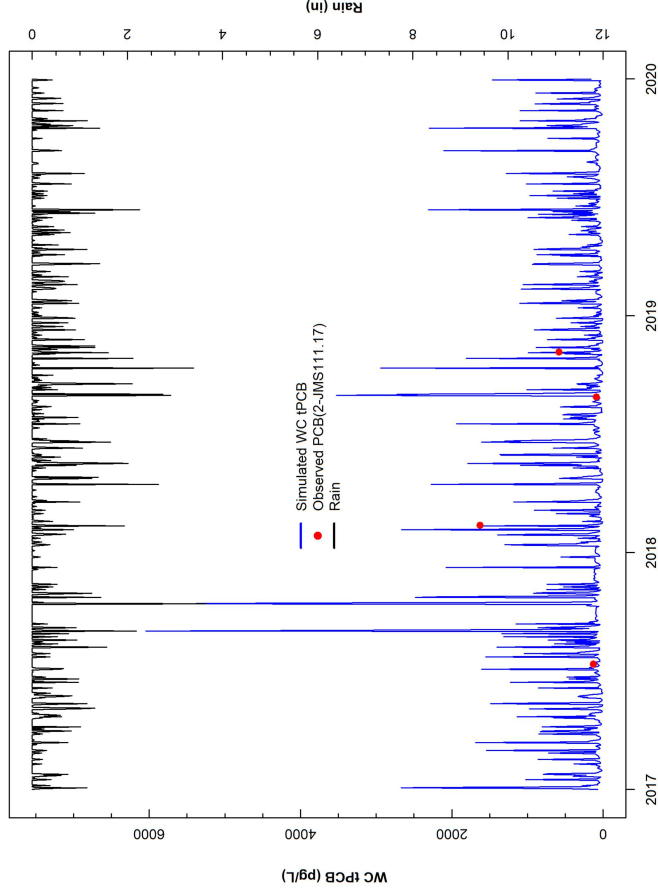


Figure F-22. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and observed rainfall for subwatershed reach 1 in Lower James River – Reedy Creek.

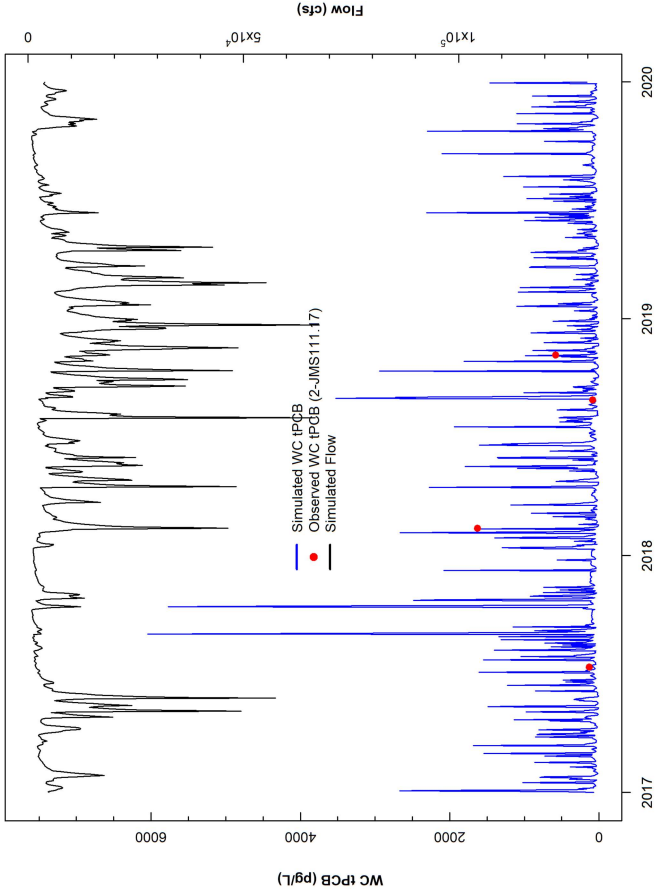


Figure F-23. Comparison of observed water column PCB concentrations, simulated water column PCB concentrations, and simulated flow for subwatershed reach 1 in Lower James River – Reedy Creek.

Five-day Window Performance Assessment

Figure F-24 shows the 5-day windows and observed data for Lower James River – Reedy Creek reach number one (outlet). All of the observed data points for reach four were within the 5-day windows. The 5-day window plots for the other Lower James River – Reedy Creek water quality calibration stations can be provided upon request by referring to the contact information on page ii. Table F-23 includes the results of the 5-day window calibration analysis for all Lower James River – Reedy Creek calibration reaches. Results show that across all stations, 88.7% of the observed data were within a 5-day window, exceeding the 50% calibration threshold goal and while the model under-predicted some of the PCB data as indicated by the high percentage of ‘Above’ values for the 5-day windows, overall the model performed well. Despite the sparsity of the observed data, the results of the calibration window analysis indicate that the model is sufficiently well-calibrated.

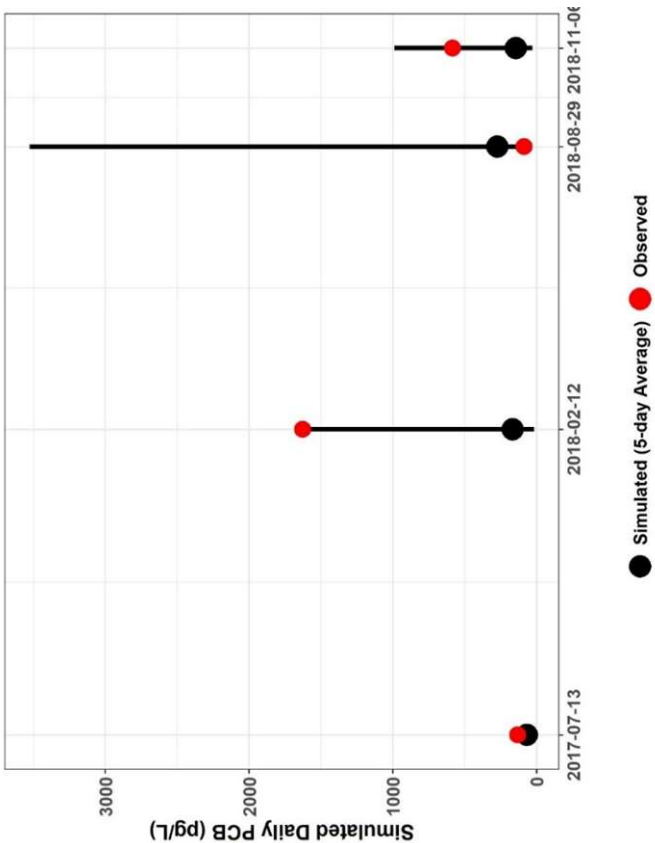


Figure F-24. Five-day window plots for water column PCB concentrations showing the 5-day average, max, and min, and observed values at station 2-JMS111.17(Lower James River – Reedy Creek subwatershed reach 1).

Table F-23. Simulated water column PCB concentrations (pg/L), 5-day calibration windows, and observed PCB concentrations (pg/L) for Lower James River – Reedy Creek

Subwatershed	Station ID	Date	Observed Water Column PCB	Simulated 5-Day Average	5-Day Max.	5-Day Min.
1	2-JMS111.17	7/13/2017	131.72	68.26	99.16	48.39
1	2-JMS111.17	2/12/2018	1628.83	167.86	1658.19	17.42
1	2-JMS111.17	8/29/2018	89.13	274.67	3525.97	28.49
1	2-JMS111.17	11/6/2018	584.89	146.23	988.81	28.35
2	2-RDD000.19	6/26/2018	769.56	58.70	883.63	41.46
2	2-RDD000.19	11/15/2018	8529.66	483.18	8553.01	41.29
3	2-RDD001.57	6/26/2018	443.73	40.70	1195.68	20.78
3	2-RDD001.57	11/15/2018	2171.32	145.29	2890.13	20.43
4	2-JMS112.33	8/29/2018	145.83	108.96	803.97	18.82
4	2-JMS112.33	11/6/2018	336.12	59.41	391.41	17.33
6	2-PWT000.57	6/26/2018	218.52	16.22	417.11	7.50
6	2-PWT000.57	11/15/2018	1963.97	157.39	2401.19	7.67
7	2-PWT003.98	6/26/2018	117	12.82	188.13	9.19
7	2-PWT003.98	11/15/2018	2378.95	294.27	4739.21	9.85
8	2-JMS117.35	8/28/2017	112.26	44.71	167.60	33.56
8	2-JMS117.35	2/12/2018	880.93	88.08	1849.55	11.29
8	2-JMS117.35	8/30/2018	138.49	210.23	1432.54	27.02

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

8	2-JMS117.35	11/6/2018	62.19	69.38	828.54	21.35
8	2-JMS117.35	11/6/2018	154.58	69.38	828.54	21.35
9	2BIMS119.35	7/12/2017	109.14	84.59	222.23	20.08
10	2-JMS123.23	2/12/2018	372.83	25.47	621.36	4.51
12	2-TKO003.42	2/12/2018	360.15	42.70	727.38	4.73
12	2-TKO003.42	11/15/2018	561.53	50.12	582.80	3.69
12	2-TKO003.42	11/15/2018	250.7	50.12	582.80	3.69
16	2-LIY001.73	2/12/2018	669.37	54.64	1852.95	6.13
18	2-JMS127.50	7/12/2017	105.83	162.04	430.60	26.17
18	2-JMS127.50	11/6/2018	189.57	11.34	121.29	3.355
20	2-NWD002.27	6/26/2018	118.97	27.05	233.82	15.02
20	2-NWD002.27	11/15/2018	74.49	16.57	261.98	1.92
21	2-GEN000.51	11/15/2018	164.21	25.14	541.22	1.52
23	2-FIN000.81	10/11/2017	96.82	61.47	96.11	40.93
24	2-BDC000.79	11/15/2018	147.27	10.05	200.07	1.08
26	2-JMS140.00	2/12/2018	712.67	63.94	856.48	14.476
26	2-JMS140.00	7/19/2018	68.51	448.89	2008.89	244.00

PERCENT	Within 5- Day Range	Above 5- Day Range	Below 5-Day Range
	88.7%	8.5%	2.8%

Calibration Summary

The “weight-of-evidence” approach used for the Lower James River – Reedy Creek HSPF PCB model calibration sufficiency assessment included a qualitative, visual examination of the PCB concentration time series graphs and the 5-day calibration window assessment. Based on these analyses of instream PCB concentration response to precipitation and flow conditions, BSE concludes that the Lower James River – Reedy Creek HSPF PCB TMDL model was sufficiently well calibrated to adequately simulate in-stream PCB concentrations. The PCB calibration parameters are shown in Table F-24.

Table F-24. Final calibrated parameters for the Lower James River – Reedy Creek PCB Calibration

Parameter	Definition	Units	FINAL CALIBRATION VALUE	POSSIBLE RANGE OF VALUES [#]	CALCULATION METHOD [#]
PERLND/IMPLND ^a					
QUAL-INPUT (Nonseasonal Sediment-Associated Quality Constituent Parameters)					
POTFW ^b	Washoff potency factor (surface sources – regulated and unspecified ¹)	pg/ton	2.39E+09 – 9.18E+13	0.0 - Inf.	Calibrated
POTFW ^b	Washoff potency factor (contaminated sites)	pg/ton	7.02E+10 – 1.29E+12	0.0 - Inf.	Approximated from previous PCB TMDLs ^c Estimated from observed sampling data
RCHRES ^e					
GQ-KD (Adsorption Coefficients of PCB Quality Constituent)					
ADPM1- ADPM3	Adsorption coefficients for suspended sediment	L/mg	Sand: 0.0004 – 0.01926 ^f ; Silt: 0.0077 – 3.2653 ^f ; Clay: 0.0131 – 5.5511 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
ADPM4- ADPM6	Adsorption coefficients for bed sediment	L/mg	Sand: 0.02 – 1.82 ^f ; Silt: 0.25 – 30.94 ^f ; Clay: 0.42 – 52.59 ^f	1.0E-10 - Inf.	Derived from observed water column samples with PCB homolog and TOC data, Calibrated
GQ-ADRATE (Adsorption/Desorption Rate Parameters)					
ADPM1- ADPM3	Adsorption/desorption rates for suspended sediment	1/day	3.1121	1.0E-05 - Inf.	Derived from observed water column samples with PCB homolog data, Applied to entire calibration segment
ADPM4- ADPM6	Adsorption/desorption rates for bed sediment	1/day	1.0E-05	1.0E-05 - Inf.	Assumed approx. zero as in previous PCB TMDLs ^c
GQ-SEDCONC (Initial PCB Concentrations on Sediment)					
SQAL 1- SQAL 4	Initial PCB concentrations on suspended sediment	pg/mg	0.0	0.0 - Inf.	Assumed zero as in previous PCB TMDLs ^c
SQAL 5- SQAL 6	Initial PCB concentrations on bed sediment	pg/mg	0.4 – 47.0 ^f	0.0 - Inf.	Derived from observed sediment samples
MONTH-DATA	PCB atmospheric deposition rate on water surface	pg/ac/mo- nth	3.0E+06	N/A	Initial value based on Chesapeake Bay Toxics Report ^g , Calibrated

[#] Acquired from HSPF Version 12.2 User's Manual

¹Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

^a Pervious and Impervious land segment

^b Includes the atmospheric deposition on the land surface

^c DEQ, 2009. Roanoke River PCB TMDL., 2018 New River PCB TMDL

^dVaries between contaminated sites

^e Main stem of stream in each subwatershed

^fVaries by calibration segment reach

^g CBP, 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory.

Table F-25 provides an estimate of the contributions from the different source categories to the annual PCB loading (mg/yr) in the stream. These contributions include loadings to

regulated land surfaces (MS4 service areas), unspecified land surface (atmospheric deposition, unspecified stormwater runoff, loads from unidentified contaminated sites, unspecified point source discharges), contaminated sites (including railyards and electric substations), direct loading to the stream (atmospheric deposition to water surfaces and permitted sources), instream contaminated streambed sediment, and spill sites. The “percent of total load” column shows the portion of the PCB load (mg) that originates from a particular PCB source; it does not describe the fate of the PCBs once they enter the stream/river reach.

Table F-25. Estimated existing annual source PCB loads for Lower James River – Reedy Creek during the allocation period (2002).

Source	Estimated Load (mg/yr)	Percent of total load (%)
Upstream Sources	286,864	59
Streambed Sediment	1,476	<1
Surface Load – Unspecified ¹	19,741	4
Surface Load – Regulated ¹	169,327	35
Atmospheric Deposition	1,685	<1
CSOs	<1	<1
Spills	<1	<1
Contaminated Sites	777	<1
Permitted	9,717	2
Total	489,587	–

¹Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and my include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

Table F-26 shows the contribution (in percent) of the various PCB sources to the instream PCB concentration at the outlet (pg/L). The largest source of PCBs are upstream sources followed by regulated surface loads (MS4s).

Table F-26. Estimated existing relative contributions of different PCB sources to the overall tPCB concentration at the Lower James River – Reedy Creek outlet during the allocation period (2002).

Source	Mean Daily Water Column tPCB Concentrations by Source (pg/L)	Relative Contribution by Source (%)
All Sources	157	–
Upstream Sources	87	55
Surface Load – Unspecified ¹	8	5
Surface Load – Regulated ¹	53	34
Atmospheric Deposition	1	<1
Streambed Sediment	<1	<1
Spills	<1	<1
Contaminated Sites	<1	<1
Permitted	8	5
CSOs	<1	<1

¹Unspecified surface sources is a term used to represent model calibration to the instream PCB concentration for surface loads other than regulated surface loads and may include inputs from net atmospheric deposition to land surfaces, loads from small tributaries that are not specified in the model, unspecified stormwater runoff, loads from unidentified contaminated sites, and currently unidentified point source discharges.

F.6 References

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Appendix G: Public Comments and Responses

Response to Comments from the First Public Comment Period for the PCB Total Maximum Daily Load Development for the James River, Maury River, and Jackson River Watersheds

The first PCB Public Meeting was held virtually through a webinar platform on Tuesday, January 12, 2021. There were 76 attendees. The meeting, hosted by DEQ staff, included background information on PCBs and related human health concerns, long term PCB monitoring data from the study area, and an overview of the TMDL process was used in this project. Representatives from Virginia Tech's Biological Systems Engineering Department discussed the modeling process and tools that were used to predict PCB fate and transport. A 30-day comment period was held after the meeting from January 12, 2021 - February 11, 2021. During the public comment period, comments were received from Joe Dinardo (Rockbridge Area Conservation Council and 50 Ways Rockbridge Member - Lexington VA), Chris French, William T. Wilson, President, Jackson River Preservation Association), Ryan L. Hendrix (Virginia Association of Municipal Wastewater Agencies, Inc.), and Andrea W. Wortzel (Troutman Pepper Hamilton Sanders representing VMA). The full text of the original comments and VDEQ's response to those comments are provided below.

*Comments from Joe Dinardo and DEQ responses:
January 29, 2021*

1. The wording that PCBs have been banned since 1979 in the US is somewhat misleading and a misnomer, especially in light of the increasing levels in the environment. Obviously, the loopholes noted via the “unintentional production of PCBs” (heat + Cl + C) = non-PCB transformers (<50 ppm PCBs) and inadvertent manufacture of PCBs (<25 ppm PCBs) appears to allow for the excessive levels observed. The latter requiring lengths of rivers to be considered unsafe and restrictions placed on fish consumption from those locations. It is unclear if the unintentional PCB levels allowed were based on 1979 population needs and did not estimate the growth rate which now includes an additional ~100 million people in our country? Increase in needs causes an increase in demand which causes an increase in supply which causes and increase in unintentional PCB production and pollution. Similarly, I have been working on sunscreen regulations developed in 1978 that were never updated for safety/efficacy and are also under scrutiny because many of the drug actives (which have endocrine disrupting activity) according to FDA may not be safe for human use ... “Because the public record does not currently contain sufficient data to support positive Generally Recognized As Safe and Effective determinations”. Unfortunately, our regulatory agencies have become political pawns inhibiting them from updating many critical scientific rulings that negatively impact environmental and human health.

DEQ Response: Thank you for your comment and the additional information that you provide. It is the goal of this PCB TMDL to identify the different sources of PCBs and allocate reductions in their loads in order to restore water quality and make the fish safer to eat. As such, the TMDL's scope is limited to sources within the James, Maury, and Jackson River watersheds. In this way the TMDL has the ability to make local and meaningful improvements. Additionally, it may be helpful to provide more clarity on these exemptions in Federal Law (Toxic Substances Control Act). Based on the state of the science in the 1970s, the manufacture of PCBs were banned, and other actions were taken to phase out their use where they already existed. For example, transformers with PCB concentrations >2 ppm and <50 ppm were allowed to stay in operation for the duration of their lifespan. An additional exception to PCB regulations is the allowance for inadvertent production of PCBs so long as no product has >50 ppm PCBs and the average concentration in products leaving a manufacturer over a year is <25 ppm PCBs.

2. Another concern that needs to be addressed is that PCBs are considered endocrine disrupting chemicals (EDCs) according to the World Health Organization - WHO (downloaded available if interested: <https://www.who.int/ceh/publications/endocrine/en/>). Wildlife populations have been affected by endocrine disruption, with negative impacts on growth and reproduction. These effects are widespread and have been due primarily to persistent organic pollutants (POPs). Bans of these chemicals have reduced exposure and led to recovery of some populations. There are several places in the WHO-EDC document that make comments about PCBs ... below are just a few examples:

Page 116 "PCB bans and restrictions have led to a decline in PCB concentrations in humans and wildlife over the past few decades, although geographic hotspots still exist where certain PCB congeners persist (Chapter 3.2.1 & 3.2.2). A few biomonitoring studies report PCBs in the brain tissues of mammalian wildlife and humans between 2-50 ng/g (ppb) wet weight. In marine mammals, however, brain PCB levels are higher (up to 450 ng/g or ppb wet weight). Dominant congeners in the brain of mammalian wildlife are coplanar and are similar to those found in humans."

Page 234 "Over time, several POPs (e.g., PCBs, PBDEs and PFOS) have increased and then more recently decreased in most areas where concentrations in wildlife were measured. These decreases are due to restrictions or bans on their use in many countries."

This information would imply that "tangible" bans/restrictions on the levels of PCBs should result in the reduction which is not what is being reported using the current 1979 guidelines.

What's more concerning about PCBs or EDCs in general, is that they have the ability to react additively/synergistically with other EDCs at levels below *their known toxicity* to produce numerous adverse effects to both the environment and human health (several papers can be found via a simple pubmed.gov or Google search). These EDC interactions are not limited to reactions with just industrial compounds, but can also react with agricultural, personal care, pharmaceutical ...etc., EDC chemicals, creating a whole new dimension and challenge for understanding the toxicological impact to life making it more imperative that the loopholes in "banned" chemicals be reevaluated.

It is unclear based on the data if chemicals like PCBs and other POPs can be controlled by using a Total Maximum Daily Load (TMDL) because the impact to both the environment and human health is unknown and, therefore, until these issues can be understood a zero-tolerance policy on unintentional production should be considered. Without doing so, will only allow for “status-quo” with no real push for newer/safer technologies to be developed that could more appropriately meet the needs of the people without PCB usage.

DEQ Response: Thank you for the detailed information. As a state environmental agency, DEQ is limited to the laws and rules that currently exist. As a result, this project is limited to the scope of PCB TMDL development which is intended to address the fish consumption use for the protection human health.

Comments from Chris French and DEQ responses:

January 25, 2021

The issue of MODEF being a source of PCBs is one that Mark Richards should remember well. He can tell you I was the person who discovered the issue while employed in the TMDL program at PRO in the 2006-07 time frame. The facilities you want to look at are those ran by Ingenico. At that time, there were 1 page reports where a facility estimated the about of destruction of PCBs in the MODEF oils they were burning in the on site generators. I discovered the connection as I was also the point of contact are PRO for EIRs. It was in the review of the either new or existing Ingenico facilities I discovered the connection. Once I discovered, this information was forwarded DEQ Central Office. There was some chatter about it for a time period, but the issue disappeared over time - one presumes due to the lack of resources.

I believe many of the records you may be looking regarding this matter would be archived. I recommend DEQ spend a little time going through the archived records for Ingenico and pulling these reports. In fact, I would be shocked if the air permitting program did not have some similar records as part of the current reporting process.

By this email, I am providing a first hand witness of these reports during my tenure at DEQ. The records are real and do exist. We all know that there is a significant disconnect between the waste/air programs in their handling of PCBs reporting limits and those the water programs through the use of different detection methods (Method 608 v 1668). We also know a common way to dispose of fuels oils with PCBs is to dilute them until they are considered "PCB free" by concentration, where they can then be disposed of (in this case via incineration at a power generation facility). Unfortunately, the incineration temperatures at these facilities are too low to destroy the PCBs, and they pass through the stacks only to be deposited what is believed to be locally, given the weight of the PCB compounds (some being lighter than others).

I do not think this is an issue DEQ can ignore, especially when a number of point source dischargers (e.g. industrial stormwater) & MS4 permittees may unfairly end up with higher WLAs due to an improper accounting of PCBs.

I would strongly encourage DEQ to investigate this issue by directly sampling some of the facilities in question so the proposed TMDLs in the James River basin can use the best and most accurate data available. Please also note, this is an environmental justice matter that affects subsistence fishermen/women and indigenous tribes (due to historic reliance on fishing).

DEQ Response: Thank you for pointing out this potential source of PCBs. Following your comment DEQ staff conducted a search of all Ingenco air permits and other air permits that have PCB limits. This included 14 Ingenco facilities and seven other facilities. Concerning Ingenco facilities, the burning of mineral oil dielectric fluid (MODEF) no longer occurs. Records show that Ingenco was not receiving MODEF as of 2011. With the exception of one facility that reported 0.0 tons/yr of PCB emissions, no other emissions data were available for the modeling period 2008-2019. With regards to the seven other facilities, records show that no used oil (potentially containing PCBs) was burned during the modeling period.

As a question - why is DEQ still relying on the 1999 Chesapeake Bay Toxics Loading and Release Inventory. That data is old. The atmospheric deposition research coming out of Rutgers in the Delaware Estuary is far more accurate. Back when I was at VCU, we attempted to get a similar study in the James watershed working with DEQ, but the funding did not come through. DEQ was supportive of the proposal and willing to contribute. Again, you will want to discuss this with Mark Richards.

DEQ Response: The Chesapeake Bay Toxics Loading and Release Inventory atmospheric deposition values are the best available, local data available to DEQ. Resources and funding would be necessary for local atmospheric depositional studies for PCBs and the whole of information and data available provides sufficient basis for move forward with the PCB TMDL development.

By this email, I request to be included as a TAC member for the upper and lower James PCB TMDLs.

DEQ Response: Thank you for your interest. You have been added to the TAC.

Comments from William T. Wilson and DEQ responses:
January 25, 2021

1. The Jackson River Preservation Association (JRPA) has been in existence since about 2013. We have worked with DEQ, the DWR, and the USACE since that time to preserve and protect the Jackson River. It has been quite a trip. Most of our efforts have involved the Jackson River above Covington but we have also had issues in, and below, Covington. For instance, we dealt with an Alleghany County sewerage spill on Potts Creek; a CSX oil spill in Clifton Forge; and permits for sewerage discharge by governing bodies. The “pulses” from Gathright Dam have also been one of the things we monitored.
2. The “impaired rivers” project now in progress is new to us, so please pardon our lack of knowledge. I think all of our members, and the entire community, would like to see a cleaner Jackson River from WestRock down to Iron Gate where the James River begins.
DEQ Response: We appreciate your commitment to the health of the Jackson River.
3. The following are my thoughts, for such weight as they may have:

- a. I think we all know that WestRock in Covington is the big industrial presence that must be considered, but we also have three, maybe four governing bodies to also be taken into account, in the “point source” department.
DEQ Response: There are four municipal wastewater treatment plants, two individual industrial permits, and four industrial stormwater general permits. These permittees were selected based on their potential to discharge PCBs into receiving waters.
- b. I would think that in your analytical process DEQ would test the Jackson River above WestRock before testing just below WestRock and just below the mouth of Dunlap Creek. Below Dunlap Creek I am not sure where the pipes are that discharge stormwater or treated sewerage, but those locations might also be tested. Potts Creek comes into the Jackson River in south Covington and testing might be done above and below that location. I think Alleghany County pumps some of its sewerage into the Covington Treatment Plant but I am not sure where that effluent pipe is located.
- c. Below Covington, I think Karnes Creek comes into the Jackson River near Low Moor and there is a creek coming in just above the Dabney S. Lancaster Community College which may be carrying the runoff from the Kim Stan Landfill, which, as you know, is a Super Fund project.
- d. Below DSLCC, I believe Smith Creek comes into the Jackson River in Clifton Forge where there is pollution and treated sewerage from CSX and the Town of Clifton Forge
- e. Simpson Creek comes in south of Clifton Forge and then we have the Town of Iron Gate.
- DEQ Response: DEQ collected water column samples for PCB analysis at four Jackson River sites for a total of 16 samples. Sampling sites are selected for a myriad of reasons including their relation to sources, major tributaries, flow gages, and other 2 considerations like cost effectiveness and watershed coverage. The upstream most sampling location was just downstream of the Gathright Dam at river mile 44.14. The next site down river is about two thirds of a mile below Dunlap Creek at river mile 23.61 at City Park. This receives waters with discharges from the Hot Springs Sewage Treatment Plant, WestRock, and industrial stormwater discharges from Chemtrade Solutions LLC – Covington and Material Handling Solutions LLC. The next site downstream is at river mile 6.67 near Dabney S. Lancaster Community College, or about 2.75 miles downstream from Low Moor. This site receives waters with discharges from an additional four permits. These include two municipal Wastewater Treatment Plants (Covington and Low Moor) and stormwater discharges from the Peters Mountain landfill and stormwater discharges from the WestRock Low Moor Converting Plant. Finally, there is a site at river mile 0.38 near Iron Gate at the Rt. 727 bridge. This receives waters with discharges from one more point source, the Alleghany County Wastewater Treatment Plant.*
- With regards to the Kim Stan Landfill, it is no longer considered a potential source of PCBs as a result of clean-up work and recent monitoring data. In 1980, it was confirmed that waste oil containing PCBs had been improperly disposed of at the Kim Stan Landfill resulting in contamination. After the landfill was shutdown in 1990, work to address the contamination occurred, including covering the landfill with soil, installing stormwater management and erosion*

control features, and pumping out 400,000 gallons of landfill leachate. When the site was revisited in 1997, EPA identified more issues with landfill leachate, contaminated groundwater and surface water. As a result, the landfill was added to the Superfund Program's National Priorities list in 1999. Work from this point on includes installation of a multi-layer cap over the landfill, installation of a leachate collection system, installation of piping and associated equipment to convey leachate to the Low Moor Waste Water Treatment Plant for treatment, performance upgrades to the treatment plant, other work to ensure the longevity of the controls, and routine groundwater monitoring. As of 2010, groundwater monitoring data in multiple locations showed no detectable concentrations of PCBs. As such, PCBs are not considered a contaminant of concern at the Kim Stan Landfill.

- f. So, I would think all of these "point sources" should be tested by DEQ above and below the points of entry.
- g. Historical data of these "point sources" should also be important to analyze during times of high and low water. I know DEQ and the DWR already have a lot of data from these sources.
DEQ Response: Regarding point source loads, DEQ has PCB concentration data from the Covington WWTP and Alleghany County Wastewater Treatment Plant in addition to the main WestRock facility. For the other point sources, DEQ is able to estimate their loads based on the type of industrial class that they fall into. DEQ maintains a database of point source data from which we are able to calculate median concentrations for different Standard Industrial Classes. Additional information is provided in this technical resource document. Additionally, for all non-stormwater discharges, DEQ has monthly flow data, which will be used to calculate the PCB loads in the model. It is worth noting that loads from these point sources and other 3 nonpoint sources will be modeled and compared to observed monitoring data to ensure that the model is calibrated and capable of replicating these observed values. As such, the model provides for the linkages between sources, transport, and fate.
- h. A number of people fish the Jackson River from Covington down but few, if any, eat the fish. The fish caught are mostly smallmouth bass, largemouth bass, fallfish, and a few trout. A few years ago, lesions were found on some of the bass but that has not been seen in recent years, as far as I know.
- i. The Jackson River used to be terribly polluted years ago because of Westvaco but over the years the river has improved remarkably.
DEQ Response: DEQ appreciates this additional information.
- 4. The JRPA is interested in being a part of DEQ's efforts to remove the Jackson River from the "impaired rivers" category. We would like to be involved at every stage and, to the extent that we can help, want to do so. Our resources are limited so we will just do what we can. Ours will be a spirit of co-operation.
- 5. We have a committee that does water monitoring so perhaps we could help DEQ in that regard.
DEQ Response: Thank you for your dedication to the health of the Jackson River. DEQ will work to include you in all watershed restoration planning activities for the Jackson River

watershed. Additionally, we welcome collaboration with the water monitoring data that you collect. In addition to the value that the data brings to your organization, citizen monitoring data can be used to put waters on the impaired waters list or remove them, provide information for TMDL development, track the restoration of waters where an approved TMDL exists, and target waters for future DEQ monitoring. If you are interested in sharing your water quality data with DEQ, we would be happy to discuss that process.

6. As a follow-up to what was said at the “Webinar” on January 12, 2021, we would like to know more about DEQ’s methodology for determining the amount and kind of pollution and step by step DEQ’s plan for getting the Jackson River out of the “impaired rivers” category. Response: DEQ uses the water quality process to identify and restore impaired waters. The water quality process involves routine monitoring and assessments of that monitoring data to determine whether or not the monitored waterbodies are meeting water quality standards. When waters are not meeting water quality standards, they are put on the impaired waters list. Once on the impaired waters list, DEQ is required by state and federal law to develop TMDLs, which determine the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. This maximum amount is determined through the TMDL development process using a computer model of the watershed. The computer model pulls together the pollutant sources and other watershed characteristics (e.g., flow, precipitation, soils, slope, etc.) to model the existing loads of the pollutant. With an endpoint concentration selected that meets water quality standards, the model is run to identify the maximum allowable load of the pollutant (i.e. the 4 TMDL). The difference between modeled existing loads and the modeled TMDL identifies the amount of reductions that are necessary to meet water quality standards. These reductions are allocated to the different sources of the pollutant. Once the TMDL is approved by the State Water Control Board and EPA, TMDLs are then implemented in point source permits and through other voluntary, incentive-based actions for unregulated nonpoint sources. The goal of TMDL implementation, of course, is to restore the waters so that they meet water quality standards. The TMDL being developed for the Jackson River PCB impairment is intended to do just that. Since the water quality impairment in this case are PCBs in fish tissue, the TMDL is being developed for this contaminant.

With regards to other water quality impairments in the Jackson River watershed, a TMDL has previously been developed for the lower sections of the Jackson River to address the impairment related to degraded benthic macroinvertebrate communities. In that case, because the water quality impairment was a degraded ecological community, the pollutant(s) causing that degradation had to be identified through a stressor analysis process. As a result, nitrogen and phosphorus were identified as the most probable stressors of that community and therefore TMDLs were developed for both pollutants. Fortunately, through the implementation of those TMDLs, some of those waters have been restored and meet water quality standards for biological health. Additionally, there exist some bacteria and temperature impairments above the Gathright Dam and some bacteria and dissolved oxygen impairments below the dam. These coincide with the PCB impairments being addressed by this TMDL. As time and resources permit, DEQ will continue to address these impairments through TMDL development or other

means of water quality restoration. Currently, DEQ is developing our priorities list for TMDL and TMDL alternative development over the next six year window, spanning 2022-2028. Before this priorities list is finalized, there will be an opportunity for public comment.

Comments from Ryan L. Hendrix and DEQ responses:
February 11, 2021

I. TMDL Efforts Should be Matched to the Underlying Standards
As you know, the human health water quality standard for PCBs and the Department of Health's fish consumption criterion are both predicated on long term (lifetime) human consumption. That is, both are calculated in ways that assume a lifetime of exposure to levels of the contaminant that may increase the risk of health impact beyond a defined de minimis level. Given this, we see the task of TMDL development as determining conditions (including wasteload allocations and load allocations) that will over a comparable long term reduce the typical or average water column and consumable fish flesh concentrations to levels below the applicable criteria. This point is reflected not only in the calculations that lead to these criteria, but also in the manner in which the water quality standard is expressed. In the case of those human health criteria, the regulation specifies design stream flows for calculating steady state wasteload allocations. Those are the harmonic mean flow for carcinogen contaminants, and the 30Q10 flow for non-carcinogens. 9 VAC 25-260 140.B, fn. 6. In both cases (carcinogens and non-carcinogens) these are essentially long term flow statistics that effectively approximate and implement the intended long term exposure assumptions.

Some of the Department personnel will recall the debate in which the New River TMDL TAC engaged over this issue. The TMDL contractor initially modeled the respective systems and calculated WLA and other reductions to levels at which the modeling projected a scenario in which there were essentially zero instantaneous instream exceedances of either the water column standard or the calculated waterway-specific target concentrations. VAMWA and some of its members argued that this was wrong because of the reasoning addressed above. It was also inconsistent with the methodology used by EPA's contractors in developing the Lower Potomac TMDLs and other TMDLs that VAMWA cited. That error was eventually corrected. Accordingly, we urge the Department to make sure that the TMDL contractors for these projects carefully coordinate their methodologies with the underlying standards.

DEQ Response: To the extent that is practicable, DEQ will utilize long term exposure factors to account for the human consumption of fish tissue that contains unsafe levels of Polychlorinated Biphenyls (PCBs), a potentially carcinogenic contaminant.

With regard to the PCB study project identified as the James, Maury, Jackson PCB TMDL study, and other on-going studies that includes Lewis Creek in Staunton and Mountain Run near Culpeper, a harmonic mean flow year will be utilized in setting allocations and reductions. For these studies the harmonic mean flow year will be selected within the TMDL segment by comparing each flow year during the 10 year TMDL modeling period to the long term annual harmonic mean flow record. The flow year that most closely resembles the long-term harmonic mean flow will then be selected. This process is consistent with that used in the New River PCB TMDL study.

For the tidal James River watershed, while the harmonic mean flow can be utilized similarly to the free flowing rivers and streams, there are a couple of options that DEQ and VIMS would like to discuss during the Technical Committee Advisory Subcommittee meetings scheduled for March 25th (Piedmont region) and March 30th (Tidewater region). The rationale for not using the long term harmonic mean flow is based on the concept that the fate and transport dynamics for PCBs 2 in an estuary depend on resuspension and depositional processes of sediment. Setting allocations to the long-term harmonic mean flow will increase the amount of time it takes to meet the instream TMDL condition as erosion of the bottom sediment will not occur or will be greatly reduced. Conversely, if high (wet) flows are used, a significant portion of the existing PCBs in the sediment will be transported outside the estuary in a nonrealistic manner. VIMS is proposing that the more realistic approach is to use a 3-year flow period that represents high, medium and low flow conditions, where after repeatedly running the model will lead to meeting the TMDL condition more quickly when compared to using the harmonic mean flow. This approach was used for the Baltimore Harbor PCB TMDL in Maryland (MDE, 2011). Lastly, until DEQ's contractors have run various modeled scenarios used to address the frequency rate of TMDL endpoint exceedance within each segment, it is difficult to know which will be the most applicable approach to use. The scenarios to be considered for the modeled instream PCB concentration at the TMDL boundary area will include the arithmetic mean, the median, the 95% Upper confidence limit, and the 90th percentile (i.e., 10% exceedance rate which is consistent with the fish tissue assessment approach). Recall 9 VAC 25-260-140 does not include a footnote that stipulates a frequency for exceeding the numeric WQC of carcinogenic pollutants. In these instances, the default assumption can be "Not to Exceed." MDE, 2011. Total Maximum Daily Loads of Polychlorinated Biphenyls in Baltimore Harbor, Curtis Creek/Bay, and Bear Creek Portions of Patapsco River Meshohaline Tidal Chesapeake Bay Segment, Maryland. Maryland Department of the Environment, p 168.

II. The Development of any Target Numbers Should be Limited and Based on the Adopted, Controlling Criteria

What has driven the impaired waters listings and this TMDL process is the VDH fish consumption advisories, based on the VDH 100 parts per billion (ppb) threshold. The Department's adopted 640 pg/1 water quality standard is also relevant. We note from the Department's presentations an apparent focus also on the 18 ppb fish concentration number, which we understand to be considered to correlate with the 640 standard. We note the consistent use of the 18 ppb number on the Department's fish concentration graphs along with VDH 100 ppb number.

We believe that the development of the TMDLs should focus on and use as their ultimate targets the VDH fish concentration number, and not the 18 ppb number; as well as the adopted 640 pg/1 standard. The process should not also focus on the parallel 18 ppb number because VDH is the agency with the responsibility for establishing this threshold and using it in its public health programs, and there should not be conflicting criteria between the sister Commonwealth agencies. The 640 pg/1 number is a proper target because it is a relevant binding regulatory requirement.

Although we recognize the use of the 18 ppb fish concentration number, and in some of these efforts a site-specific water column number (water target concentration) that correlates with the localized fish data, we see these as tools for the TMDL development process, rather than appropriate targets. For these reasons we advocate the use of the 100 ppb and 640 pg/1 values as the ultimate targets, and we believe the TMDL should avoid references to the 18 ppb number or calculated water targets as if they were binding requirements, or reference to these values as ultimate compliance points. If the processes are designed to eventually achieve the VDH number 3 and allow the removal of the fish consumption advisories, and to achieve consistency with the 640 pg/1 water quality standard, that should be defined as the ultimate end point and conclusion to the process.

DEQ Response: Since the establishment of the 640 pg/L Water Quality Criterion (WQC) in Virginia's Water Quality Standards on January 29, 2010, DEQ has applied the same risk-based assumptions to the assessment of fish tissue. As the commenter notes, the 640 pg/L WQC is directly linked to the 18 ppb fish tissue value. Both the WQC and the 18 ppb fish tissue value are derived from the same risk-based equation using Federal Environmental Protection Agency (EPA) guidelines. The WQC is derived from the fish tissue value through the application of a bioconcentration factor in the denominator. As such, the WQC was designed to prevent water column concentrations of PCBs that could ultimately result in the bioconcentration of PCBs in fish tissue at such levels that potential risk to consumers of fish is increased. Moreover, the fish tissue value of 18 ppb is utilized to provide a benchmark of acceptable risk in the fish tissue itself that is consistent with EPA guidelines. Both the 640 pg/L WQC and the 18 ppb fish tissue screening value are protective of the "fishable" component of the general standard 9 VAC 25-260-10 A, which requires that water quality be supportive of "...production of edible and marketable natural resources, e.g., fish and shellfish".

DEQ's fish screening value of 18 ppb and VDH's value of 100 ppb diverge in part because they serve different purposes. VDH consumption advisories seek to mitigate human health risks once a waterbody has become contaminated, whereas DEQ's fish screening value is designed to mitigate the risk of excess contamination in all of Virginia's waters. With the different programmatic intentions in mind, it is important to note that the derivation of VDH's fish tissue value diverges from EPA guidance in that it inserts additional assumptions into the equation. For example, the equation includes a factor that accounts for how long individuals are expected to live in a certain region. While this is an appropriate assumption for the population in general, not all communities can relocate outside the watershed. Specifically, many communities of lower economic means that supplement their diets with fish from state waters do not have the means to relocate. As such, DEQ's role, consistent with EPA guidelines, is to ensure that excess contamination in fish above 18 ppb shall not be exceeded in order to protect all individuals in the population.

Lastly, DEQ acknowledges the impact of fish tissue impairment listings on the regulated community. Although the fish tissue screening value of 18 ppb is directly linked to the WQC, like the VDH value, it is not listed in code. As such, DEQ outlines the process for determining water quality impairments with the 18 ppb threshold value in the Integrated Report Water Quality Assessment Guidance. This guidance is issued every two years with a 30-day comment period,

a public meeting, and consistent availability on the agency website. Through this, DEQ provides transparency and opportunity for public comment on the use of the 18 ppb fish tissue threshold for impairment listing decisions.

Based on the reasons described above, DEQ intends to use the 18 ppb fish tissue threshold and 640 pg/L WQC as the dual TMDL endpoints that must be protected in order to meet water quality standards. The fish consumption use for impaired waters can either be restored by the 640 pg/L WQC, or by a site-specific endpoint in cases where the WQC is not protective of the 18 ppb fish tissue threshold.

III. There is a Risk that the Detailed Hydrologic and Risk Analysis Components may be Beyond the Accuracy of the Underlying Data

We always consider in these projects the detailed hydrologic, risk analysis and other technical tasks undertaken to be interesting from a technical and risk management standpoint. However, we are concerned that the precision of these analyses may mask the uncertainties inherent in the process. Some of the factors that we believe contribute to uncertainty and to results that should be considered estimates at best are the known inaccuracy of PCB analytical procedures at part per quadrillion concentrations; variations in fish concentration data; the (because of costs and resources) relatively small fish, water column and sediment data sets that form the factual/data basis of this work; and the substantial uncertainty in the air deposition numbers and the mechanics of the air deposition concept itself.

Accordingly, although we recognize the limitations of resources, we recommend that the final TMDL itself recognize and state these reservations.

DEQ Response: The commenter mentions that there do not appear to be enough sample results, which leads to additional uncertainty in the TMDL development process. While the labor and associated analytical costs inhibit the number of fish and water samples that can be collected within a particular watershed, there were more than adequate fish tissue results to list these watersheds as impaired and to maintain those listings. As related to meeting an adequate number of water and sediment samples, having limited data is a very common observation regardless of the impairment and pollutant associated with TMDL development, and is a main reason for employing the use of a fate and transport model. Lastly, a required element within the TMDL process includes the Margin of Safety, which takes into account uncertainties associated with the model and other aspects of TMDL development.

To ensure valid data are generated for use in these studies, strict quality assurance protocols are followed for field collection of fish and water samples and applied to the analytical procedures. First, it was mistakenly assumed that variations in fish tissue tPCB concentrations are based solely on faulty analytical procedures. Variations in fish PCB concentrations can be due to several factors such as fish size, time of year the samples are collected and whether or not the sample result was part of a composite (i.e., 5-10 fish). Regarding the use of method 1668 for ambient water column and sediment samples, DEQ has now been using this analytical method in Virginia for PCB studies since 2005 and has amassed more than 1,000 statewide ambient water samples. DEQ has complete confidence in the tPCB results due to the adherence of the strict collection and analytical guidelines included within TMDL Guidance

Memo No. 09-2001. Guidance for monitoring of point sources for TMDL development using low-level PCB method 1668. DEQ has also competitively selected a laboratory that is capable of routinely meeting the strict analytical guidelines included within the protocol.

Regarding the mechanics of atmospheric deposition, please refer to comment V. below. Recognizing the need to generate better information related to the atmospheric deposition of PCBs, DEQ assembled a team of experts and pursued opportunities to perform such a study during a three-year period beginning in 2011. Unfortunately, these studies were not funded. Alternatively, for TMDL development, it is an accepted practice to use appropriate literature based values in lieu of actual data for loadings development. This is a common practice for Bacteria TMDL development where literature based loading values are applied for a variety of sources.

Lastly and as applicable, uncertainties will be addressed within the final PCB TMDL reports for each project. This will in part occur within the MOS and by managing the TMDL implementation through staged or adaptive management.

IV. We recommend a Focus on Contaminated Sites Rather than Pass-Through Sources. With rare exceptions Publicly Owned Treatment Facilities are pass-through sources of PCBs, meaning that any PCBs are from the potable water systems that feed the POTWs' domestic sewer system and other customers, and in turn from the surface water and ground water raw water supplies that feed the potable water systems. Although the TMDLs must address POTWS and include WLAs, we believe that a more useful exercise involves the examination and consideration of sites from which there is or may be PCB contaminated runoff beyond background concentrations. The depictions of historic and current contaminated sites within the affected watersheds that are included in the current Department public meeting and TAC presentations illustrate the prevalence of such sites in some of these TMDL projects. In light of the recognized inadequacy for human health-based water quality efforts of the federal TSCA-based PCB soil cleanup levels, a primary focus on such sites would be a useful and effective approach.

DEQ Response: Whether or not POTWs are sources themselves of PCBs, each POTW is, a point source loading of PCBs, and as such requires a Waste Load Allocation (WLA) as part of the TMDL. This comment is not a TMDL issue, but rather raises an implementation issue regarding VPDES permitting. With that said, for those POTW systems in Virginia that have monitored their influent for PCB concentrations, anecdotal evidence suggests that in most instances there is at least a magnitude difference in the existing load entering the waste treatment facility than from the load that would be expected from a potable water system. In fact, the usual difference in observed concentration between the influent and treated effluent ranges from an 85% to 95% reduction in effluent (DEQ's PCB Data Base), which is indicative of the elevated loadings entering these facilities. Lastly, POTWs with collection systems that are old and have leaky infrastructure would be prone to receiving PCB contamination from the associated commercial and urban land use areas. PCB trackdown studies within the wastewater collection system can be an effective way to determine the origin of the source(s).

As the commenter is aware, an accounting of all known contaminated sites is also included in PCB TMDL study reports, which is expressed in the LA portion of the equation. While specifically addressing how reductions from contaminated sites will be attained is a topic more suited for TMDL implementation, when opportunities do arise to achieve TMDL based reductions from these sites, there is collaboration between staff from DEQ's Water Planning Division and staff from the Land Division. An example of an on-going collaborative effort is taking place within the Lewis Creek PCB TMDL study area in Staunton, Virginia. In this watershed, the operator of a contaminated site is working with DEQ's Voluntary Remediation Program (VRP) toward achieving reductions that are consistent with the impending TMDL. Similar work is occurring in the James, Maury, Jackson River PCB TMDL study area in Richmond. In collaboration with 6 DEQ's Water Planning Division, DEQ's VRP is working with the developer of a contaminated site to identify opportunities for voluntary remediation of PCBs.

V. The TMDLs Should Fully Consider Atmospheric Deposition

Although we recognize that atmospheric deposition is highly complex and poorly defined, it is also clearly an important factor. We also recognize that atmospheric deposition is probably more an effect of the exchange of PCB loads from soils and surface waters with the atmosphere, than an independent source. As such, the TMDL calculations should consider the reductions in atmospheric loadings and deposition that will certainly occur as PCB loadings in the water column and sediments are slowly reduced through natural processes, further sedimentation, and the correction of the relatively rare active sources of PCBs.

DEQ Response: Atmospheric deposition to land and water and the exchange back to the atmosphere is extremely complex. Atmospheric deposition theoretically occurs both on the land and surface water throughout the watersheds of interest. While the deposition of the dissolved PCB constituent is applied at a steady rate, there is uncertainty with depositional rates associated with different land uses. Studies (Offenburg et al., 1999; Van Ry et al., 2002) have shown a significant depositional gradient can exist between urban/industrial (elevated), commercial and rural areas (lower). A difference in molecular weight PCBs due to re-emission from localized sources between urban (higher molecular) and rural (lower molecular) areas was also identified (Du et. al., 2009).

In the non-tidal watersheds, atmospheric deposition on the water surfaces is modeled as a constantly applied rate of dissolved PCBs deposited evenly across all reaches using the MONTH DATA block in HSPF. Atmospheric deposition of PCBs on the land surfaces adsorb to soil particles. These soil-attached PCBs enter the stream network during runoff events. PCB loadings from the land surfaces to the stream network are modeled using the loading rate associated with the HPSF wash off potency factor (POTFW), which varies by land uses. HSPF does not account for exchange with the atmosphere.

In the absence of more recent information from the tidal portion of the watershed, there are available atmospheric PCB results from the tidal estuary including the Chesapeake Bay. The measured atmospheric deposition on the watersheds in the Chesapeake Bay ranges from 1.6 to 16.3 $\mu\text{g}/\text{m}^2/\text{year}$ of tPCBs (CBP, 1999). This study estimated a tPCB wet deposition of 1.1 kg/year and a dry aerosol deposition of 1.0 kg/year for the James River below the fall line, which

is on the lower end of the deposition rate in the Bay. In general, the atmospheric tPCB deposition rate decreases over the years. Given the water surface area of the James River of 6.81×10^6 m², the estimated total atmospheric tPCB deposition rate is 3.08 (µg/m²/year). Using the same rate, the estimated deposition rate for the watershed is about 26.41 kg/year.

According to the Delaware River watershed study (Totten et al., 2006) an approximate 1% PCB load was discharged to the estuary. VIMS used 3.08 (µg/m²/year) loading as a constant deposition rate for the watershed as background deposition. Only a portion of the deposited tPCB will be discharged to the estuary. The estimated runoff is about 2%, which is about 5% of preliminary estimation of the total PCB loading.

The rate of 3.08 µg/m²/year will be the deposition rate to the surface of the James River estuary. The James River PCB model is an organic carbon-based model that includes algae particulate 7 and dissolved carbon sorbed PCBs, and free dissolved PCBs. The dissolved PCB phase, which will be dynamically computed, interacts with the atmosphere by transporting between the James River and the atmosphere. In the regions with the higher water PCB concentrations, PCBs will be modeled as fluxing to the atmosphere. Total PCB gaseous concentrations in Baltimore Harbor region varied seasonally, ranging from 67 to 1400 pg/m³ with a mean concentration of 330 pg/m³ (0.3 pg/l) (Bamford et al., 2002), which is much lower than the mean water column concentration (3,960 pg/l) from the Baltimore Harbor (Shen et al., 2012). The mean and median tPCB concentrations from the tidal James River watershed are 15,560 and 755 pg/l, respectively. The mean gaseous concentration of 0.3 pg/l can reasonably be applied to the tidal James River model. This also suggests that tPCBs will be transported to the atmosphere given high mean tPCB concentration in the James River.

Bamford, H.A., F. C. Ko, J.E. Baker. 2002a. Seasonal and Annual Air-Water Exchange of Polychlorinated Biphenyls across Baltimore Harbor and the Northern Chesapeake Bay. *Environmental Science & Technology*. 2002, 36, 4245-4262.

Chesapeake Bay Program (CBP). 1999. Chesapeake Bay Basin Toxics Loading and Release Inventory. U.S. Environmental Protection Agency. Chesapeake Bay Program, Annapolis, MD. EPA903-R99-006.

Du, S.; Wall, S.J.; Cacia, D.; Rodenburg, L.A. 2009. Passive Air Sampling for Polychlorinated Biphenyls in the Philadelphia, USA Metropolitan Area. *Environ. Sci. Technol.* 2009, 43, 1287-1292.

Offenberg, J.H., J.E. Baker. 1999. Influence of Baltimore's Urban Atmosphere on Organic Contaminants over the Northern Chesapeake Bay. *Journal of the Air & Waste Management Association*. 1999, 49, 959-965.

Shen, J., B. Hong, L. Schugam, Y. Zhao, J. White. 2012. Modeling of Polychlorinated Biphenyls (PCBs) in the Baltimore Harbor. *Ecological Modelling*. 242, 54-68.

Totten, L., Panangadan, M., Eisenreich, S.J., Cavallo, G., Fikslin, T., 2006. Direct and indirect atmospheric deposition of PCBs to the Delaware River watershed. *Environmental Science and Technology* 40, 2171–2176.

Van Ry, D. A.; Gigliotti, C. L.; Glenn, T. R. IV; Nelson, E. D.; Totten, L. A.; Eisenreich, S. J.

2002. Wet Deposition of Polychlorinated Biphenyls in Urban and Background Areas of the Mid-Atlantic States. *Environ. Sci. Technol.* 2002, 36, 3201-3209.

VI. The TMDLs Should Include an Implementation Discussion

Although Implementation Plans are not part of these TMDL projects, each TMDL should include an implementation discussion. Consistent with our comments above, that discussion should focus on any identified actual active sources of PCBs, including in appropriate cases the multiple known historic or current contaminated sites in the watersheds. Consistent with the Department's past and current practice, the implementation discussion should refer to the use of Pollutant 8 Minimization Plans for POTWs discharging PCBs above the applicable WLAs, and leading ultimately to routine monitoring in conjunction with POTW pretreatment programs, rather than permanent separate PMP efforts.

DEQ Response: For PCB TMDL studies, it has been a common practice for DEQ to include a chapter in the report that addresses both TMDL Implementation and Reasonable Assurance. A good example includes Chapter 7 from the New River PCB TMDL (VT-BSE, 2018). The information included in the chapter provides the required Reasonable Assurance element necessary to attain EPA's approval, as well as information that highlights both the implementation of PCB loadings from point sources (WLAs) and non-point sources (LAs). For the impending PCB TMDLs as applicable, DEQ will consider including additional but general information that emphasizes contaminated sites within the LA section of this chapter. As the commenter noted, Implementation Plans are not part of these TMDL projects. As such, DEQ will not address site-specific Pollutant Minimization Plans (PMPs) within the TMDL study report. Specific detail to address this topic is more appropriate within PMP guidance that is currently under development.

VT-BSE, 2018. PCB Total Maximum Daily Load Development for Reed Creek, the Upper New River, Peak Creek, Walker Creek, Stony Creek, and the Lower New River. VT-BSE Document No. 2018-0001, July 2018.

Comments from Andrea W. Wortzel and DEQ responses:
February 11, 2021

1. The guidance [TMDL Guidance Memo No. 14-2004, Procedures for reviewing and deriving total PCB concentrations from samples analyzed using low-level PCB method 1668 to be used in the development and implementation of TMDLs] recognizes the limitations of Method 1668, which has yet to be formally promulgated by EPA. Accordingly, the guidance contemplates flagging and correcting the sampling data collected. Similarly, VMA thinks it is important for any sampling work conducted by DEQ to undergo correction for blank contamination as described in DEQ's own guidance.
- DEQ Response: While DEQ allows VPDES point sources to correct their data consistent with the referenced guidance, DEQ does not support the censoring of ambient PCB data. The rationale for this is based on the defined data quality objectives (DQO), where DEQ collects these ambient PCB data for purposes of 1) PCB source identification, 2) PCB fate and transport model development, and 3) for use in Bioaccumulation Factors (BAF) and the derivation of site-specific TMDL endpoints.*

- *For the first DQO, DEQ mainly collects wet weather flow PCB data to locate and identify potential source areas. Not surprising high flow data tend to have elevated concentrations and are much less susceptible to data correction. For example, corrected PCB concentrations for subset of samples collected during elevated flow conditions ranged from 1,398.01 pg/L to 5,592.33 pg/L and resulted in a corrected concentration that was 0.43% to 4.55% lower than the uncorrected result. In contrast, corrected PCB concentrations for a subset of samples collected during low flow conditions ranged from 89.13 pg/L to 265.28 pg/L and resulted in a corrected concentration that was 50.95% to 88.06% lower than the uncorrected result. With that in mind, there is no benefit to correcting PCB data for purposes of meeting the source identification objective.*
- *The purpose of the second DQO is for DEQ to generate data under low and high flow conditions that is used to assist with the model development through calibration and validation. To address the potential impact or benefit of using corrected data for this purpose, Biological Systems Engineering (BSE) performed an analysis and determined that “using censored [i.e., corrected] tPCB data for model development would result in little change to the model calibration.” This conclusion was a similar to that provided by VIMS in 2014 as it related to model development for the tidal James River PCB TMDL.*
- *The use of corrected ambient data to address the third DQO would be impactful on the outcome. The utilization of blank corrected ambient data would lead to lower BAF derived endpoints, based on the inclusion of low flow ambient data within the calculations. The resulting impact would include greater allocated reductions with the PCB TMDL plus reduced Waste Load Allocations (WLAs).*

It is important to note that for purposes of generating ambient data in accordance with the DQOs described above, DEQ utilizes a laboratory that employs strict controls on the analytical procedures. As a result, for the 2017-2019 PCB sampling effort, the Method Blank PCB median and mean concentrations were 70.13 pg/L and 81.32 pg/L, respectively. Additionally, sampling methods used by DEQ do not use any sampling equipment, thus further limiting the potential for contamination from sources beyond the water sample.

To reiterate, correction of ambient data has a disproportionate impact on samples with lower concentrations compared to samples with higher concentrations. While this has potential to lower TMDL endpoint concentrations derived through the Bioaccumulation Factor (BAF) approach, it has minimal impact on the estimation of TMDL loads. This is because PCBs are hydrophobic and favor bonding to particulates. As a result, PCBs are primarily transported during high flow events when particulate concentrations are high and PCB concentrations are high. DEQ intends to update the TMDL GM No. 14-2004 to reflect this change.

2. VMA urges DEQ to consider the age of the sampling data it is relying upon to develop the TMDL, and whether additional sampling work should be undertaken to ensure that the TMDL is based on the most current, robust and accurate data available.
DEQ Response: In 2017, an analysis of data needs was conducted and a three year monitoring study was developed. As a result, DEQ collected 93 new fish tissue samples and 26 sediment samples to supplement older datasets. Additionally, 157 water column PCB samples were collected at 63 different sites. Each PCB water column sample was matched by samples analyzed for Total Organic Carbon, Dissolved Organic Carbon, and Suspended Sediment concentrations. Therefore, we believe that we have a robust representation of the watershed both spatially and temporally.
3. Given the ubiquitous nature of PCBs, and recognizing that the presence of PCBs is largely due to historic usage rather than current activities operations, it is important that the TMDL allow for flexible and adaptive implementation measures. Development of pollutant minimization plans is an important tool for achieving any wasteload allocations established in the TMDL.
DEQ Response: DEQ agrees that flexible adaptive implementation measures are important for the implementation of PCB TMDLs. As such, development of pollutant minimization plans are the intended means for achieving wasteload allocations established in the TMDL.
4. VMA requests that DEQ include David Blye, with Environmental Standards, Inc. and Kerry McAvoy with One Environmental Group on the technical advisory panel for the TMDL development.
DEQ Response: Thank you for your interest. David Blye and Kerry McAvoy have been added to the TAC.

Response to Comments from the Second Public Comment Period for the PCB Total Maximum Daily Load Development for the James River, Maury River, and Jackson River Watersheds

The second and final Public Meeting to present the draft PCB TMDL report for the James River study area was held on February 15, 2024, and more than 30 people attended the meeting. The public comment period for the second public meeting was held from February 15, 2024 - March 18th, 2024. During the public comment period, comments were received from Kristin Carter (University of Virginia - MS4), Scott N. Mortimer (Aegis Environmental Inc. on behalf of Cooper Steel, VA (VAR050737)), Tom Dunlap and Joseph D. Wood (James River Association and Chesapeake Bay Foundation), Patricia Greene (Tenaska Virginia Partners, L.P. (VA0090905 and VAR0523056)), Darrell Shier (Dominion Energy (VA0004138)), Michelle Ashworth (Virginia Municipal Stormwater Association (VAMSA)), and Jamie Heisig-Mitchell (Virginia Association of Municipal Wastewaters Agencies (VAMWA)). The full text of the original comments and VDEQ's response to those comments are provided below.

Comments from Kristin Carter and DEQ responses:
March 14, 2024

1. Comment: Should construction activity be included in Section 7.3.2 or is it considered an insignificant discharge? If the former, add a subsection on construction stormwater permits. The CGP currently has requirements addressing PCBs that are applicable to construction activities that include demolition of any structure with at least 10,000 SF of floor space built or renovated before 1/1/1980 discharging stormwater to PCB impaired waters.

*DEQ Response: DEQ agrees that language should be included in Chapter 7 (Implementation and Reasonable Assurance) of the TMDL Report. To account for relevant construction activities as described in the Construction General Permit, **Section 7.3.3 (Insignificant Dischargers)** was modified by inserting a paragraph that accounts for this potential loading source. The language was incorporated into the Insignificant Dischargers section based on the uncertainty associated with this possible source (i.e., the unknown loading rate and the infrequent occurrence). The paragraph addition is as follows:*

Building Demolition and Associated Construction Stormwater. Given the uncertainty of PCB loading from this source, and in considering the transient nature both spatially and temporally of demolition projects for buildings that are at least 10,000 square feet of floor space and built or renovated before January 1, 1980, WLAs have not been developed and assigned under this TMDL. However, to mitigate the possible stormwater conveyance of PCBs from demolition debris, the Construction General Permit No. VAR10 requires the operator to develop, implement, and maintain a Stormwater Pollution Prevention Plan (SWPPP) for demolition activities of old buildings that contribute stormwater discharges to PCB impaired waters such as those described in this TMDL. Moreover, a SWPPP would be applicable where these demolition activities may occur within MS4 areas assigned a WLA.

2. Comment: Section 7.4.4 discusses potential funding sources for TMDL implementation. Please ensure some funding sources are accessible to state agencies/institutes of higher education that are VPDES permit holders.
DEQ Response: Funding sources for TMDL implementation as described in Section 7.4.4 highlight a select group of potential funding sources that, under the right circumstances, could be used to support implementation activities associated with reducing PCB contamination. Conversely, federal funding sources such as 319 funds that are used to fund the installation of Best Management Practices (BMPs) to attain pollutant reductions from non-point sources included on the Load Allocation (LA) side of the TMDL equation, can only be used on projects that are not governed by a VPDES permit. As you are aware, MS4s associated with institutes of higher education would fall into the VPDES permit category. There are other opportunities worth exploring such as

the Bipartisan Infrastructure Law (BIL), which includes funding that is aimed at improving infrastructure and includes a component that addresses ecosystem services.

Comments from Scott Mortimer and DEQ responses:
March 15, 2024

Predetermined Applicability

CS and Aegis understand that CS has been identified as a potential point source of PCB contributions to the Upper James River watershed based on their SIC codes for Fabricated Structural Metal Manufacturing (i.e., 3441, 3449) and registration of their VPDES Industrial Stormwater General Permit (ISWGP), number VAR050737. Applicable SIC codes were determined by a February 2016 study by the VDEQ associating PCBs with VPDES permitted wastewater and stormwater facilities and their SIC codes. The study identified the major SIC code group 3400: Fabricated Metal Products as a potential contributor based on effluent PCB screening of 30 samples collected from facilities identified by this broad category. CS would note that SIC group 3400 includes manufacturers of:

- Metal Cans and Shipping Containers
- Cutlery, Hand Tools and Hardware
- Plumbing and Heating
- Fabricated Metal Products (Structural, Sheet, and Ornamental metal, Prefab buildings, etc.)
- Machine Product, Bolts, etc.
- Metal Forgings and Stamping
- Metal Services, Not Elsewhere Classified (NEC)
- Ordinance and Accessories, NEC
- Misc. Fabricated Metal Products (Valves, Springs, Wire products, Pipe and fittings, Foil, etc.)

Certainly some industrial activities within this broad SIC category have been historically associated with PCB use and contamination; however, a large number of subcategories and facilities within this group have no historical association with PCBs.

Revised Applicability Standard

Before the VDEQ applies a prescribed PCB screening requirement, as referenced in the JMJR_PCB_TMDL study, to such broad industrial categories, CS and Aegis suggest that identified facilities may be given the opportunity to provide historical documentation or other site-specific evidence demonstrating why PCB screening should not be applicable to their individual industrial operation. Readily available historical site use documentation (e.g., aerial photography, Sanborn maps, city directories, etc.) and documented institutional knowledge of the subject industrial operations would likely exclude a significant number of identified sources within each major SIC category. Cooper Steel is a prime example of this analysis.

Cooper Steel Site History

An environmental database report from Environmental Risk Information Services (ERIS) targeting the CS property, and surrounding properties in Monroe, VA support that the CS operations would not suggest the potential for the presence or use of PCBs.

- Review of Federal, State and local data records do not identify any reports of spills, leaks, contamination, or incidents in applicable databases.
- Historical aerial photographs demonstrate the CS property existed as undeveloped farm land into the 1970's, with the 1st aerial depicting the industrial property occurring in 1982. Interviews with CS management staff confirm the facility was constructed in the late 1970s as Lynchburg Steel. PCBs were being phased out and ultimately banned in 1977.
- A review of Sanborn fire insurance maps did not identify any information concerning the target property.

(Copies of this ERIS database report can be provided on request)

As documented by CS management staff, throughout its history as Lynchburg Steel and now CS, site operations have involved the fabrication of structural metal. Sheet metal and formed metal components (e.g., I-beam, bar, etc.) are provided by others and fabricated into structural metal building components by: cutting, welding, grinding, bending, etc. PCBs have not been identified in any raw materials, oils, or other products used by the operations. Furthermore, no PCB-containing transformers, past or present, are identified on the subject property; and no historical transformer spills or incidents have been reported.

Based on this historical site use documentation and institutional knowledge of the industrial processes conducted at the CS property, the site should not be considered a potential source of PCBs and therefore exempt from PCB TMDL screening. This same approach may be applied by other identified sources that began industrial operations during or after this time frame, and who's operations are known not to have involved the use of PCB-containing materials.

DEQ Response: As the industrial operations began in the late 1970s, PCBs were still in use even though the production had been banned. Therefore It is prudent to screen the effluent for tPCBs to confirm Cooper Steel is not contributing to the PCB fish impairment. The rationale to include Cooper Steel in the TMDL is as follows:

1. *The (2016) SIC study performed by DEQ revealed that there were three Virginia facilities within the 3441-category that were found to discharge tPCBs at a mean concentration of 2,255 pg/L and a median concentration of 3,469 pg/L. For comparison, DEQ's Water Quality Criterion (WQC) is 580 pg/L and the site-specific TMDL endpoint was set at 120 pg/L for the applicable portion of the study area that receives the discharges.*
2. *Inclusion of a WLA within a TMDL enables the Cooper Steel facility to have an allocated PCB load to the watershed; if excluded from the TMDL, the allocation is automatically set to "0", which means Cooper Steel would be in violation of the TMDL if PCBs were detected in effluent released from any of the four outfalls as determined through the use of a low-level PCB method such as EPA Method 1668.*
3. *Unspecified point sources contribute to the PCB load associated with the TMDL study category known as the "Unregulated Surface Load". As part of the TMDL study, extensive effort was expended on identifying contributing sources which is a reason DEQ reached out to certain SIC based permit holders to obtain PCB data in advance of the TMDL. Lacking this effluent information leads to uncertainty whether Cooper Steel is contributing an elevated PCB load to the impaired watershed. Lastly, it is difficult to*

justify the exclusion of an industrial facility with an SIC median tPCB concentration that exceeds the WQC by a factor of six when a direct comparison is made. Upon approval of the TMDL, the first step would be for Cooper Steel to screen the effluents for total PCBs from the four outfalls (001, 002, 004, and 005) using a PCB low level analytical method such as EPA method 1668. If the PCB screening demonstrates that any existing PCB load carried off-site via stormwater is below the assigned Waste Load Allocation (WLA), no additional monitoring would be required. Conversely, if the existing load exceeds the WLA then a Pollutant Minimization Plan (PMP) would be required for the purpose of reducing tPCBs through an adaptive management approach. With the generation of low level PCB screening data from Cooper Steel, assurance would be provided to DEQ and other stakeholders that the facility is not a source of PCBs.

Comments from Tom Dunlap and Joseph D. Wood and DEQ responses:
March 18, 2024

Comment 1: Following the multi-year effort aimed at establishing a necessary Total Maximum Daily Load (TMDL) for PCBs in the James River, we applaud this advancement toward achieving that objective. Once the TMDL plan for the non-tidal James is finalized, we encourage the prompt release of the corresponding plan for the PCB TMDL in the tidal James River, which has undergone a similar years-in-development process and would be anticipated to be at a comparable level of development as this plan.

DEQ Response: *DEQ agrees with the comment. Given the large watershed area associated with the non-tidal portion of the James River, which encompasses the boundary areas from three DEQ regional offices, it took a large team effort from both DEQ and Biological Systems Engineering (BSE; from Virginia Tech), to develop this draft study. Moreover, with the near completion of this study, DEQ is in a better position to move forward with the tidal James River especially since the PCB loadings from the upper James River watershed are available for use in the model development for the tidal portion of the river that will lead to eventual TMDL completion.*

Comment 2: Of note, in the draft PCB TMDL plan for the non-tidal James River, the Best Management Practice (BMP) based Water-Quality-Based-Effluent-Limitations (WQBELs) have been selected by DEQ as the mechanism for achieving the TMDL for all permitted entities identified in this plan. While a BMP-based WQBEL may be appropriate for many of the permitted entities identified therein, DEQ should still retain the ability to institute a numeric criteria-based approach for the WQBELs to achieve the necessary TMDL Waste Load Allocations from difficult sources. For instance, facilities with highly concentrated sources or facilities with consistent non-compliance issues may be better suited to be addressed through numeric criteria-based WQBELs. To that end, we recommend amending the language in the plan in section 7.3 to allow for the numeric criteria-based WQBEL approach to be used if the BMP-based WQBEL approach does not yield the necessary results.

DEQ Response: *Municipal and industrial facilities that are regulated under the Virginia Pollutant Discharge Elimination System (VPDES) must be consistent with the TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)). For PCBs, the most feasible approach is accomplished by using BMP based, WQBELs to comply with the WLA provisions of the TMDL (40 CFR 122.44(k)). For many pollutants WQBELs are presented as numeric within a permit; however, in the case of PCBs, DEQ applies the BMP approach due to the challenges associated with persistently low-level PCB contaminants (parts per quadrillion [ppq] or 1×10^{-15}) making numeric limits infeasible. In most cases, utilizing BMPs is the most practical method to reduce PCB concentrations because no known treatment technologies can achieve the extremely low concentrations of the PCB Water Quality Criterion (WQC) or TMDL endpoint. To address highly concentrated sources or facilities with continued non-compliance issues, Pollutant Minimization Plans (PMPs) are developed, approved by DEQ, and implemented using an Adaptive Implementation approach. This iterative approach is intended to control or abate the release of PCBs to achieve water quality with full restoration of the fish consumption use. DEQ maintains oversight of this process until the goal of the PMP is achieved.*

Comment 3: As laid out in this draft TMDL plan, many of the anticipated sources of PCBs in the non-tidal James are likely permitted entities, through the Virginia Pollution Discharge Elimination System (VPDES) program, that are point sources that will address their respective PCB loads through Pollutant Minimization Plans (PMPs). However, it is highlighted in this TMDL plan that nonpoint, unknown, or otherwise unidentified sources are potential contributors to the PCB concentrations in the James River. As such, these sources will most likely continue to go unidentified without the development of an Implementation Plan and sole reliance on PMPs for permitted facilities in order to meet the thresholds of the TMDL. After the approval of this plan, we recommend the swift development of an Implementation Plan for the PCB TMDL for the non-tidal James River, ensuring that unknown or unpermitted sources of PCBs in the non-tidal James have a management strategy consistent with the TMDL.

DEQ Response: *In response to comments received during the 30-day comment period from other stakeholders, DEQ had to revisit the TMDL model with a recalibration and subsequent re-allocation of the PCB loads. This effort was required due to 1) inclusion of the full allocation of contaminated sites which now also includes terminated permits, and 2) the discovery of an error that overestimated the spatial areas associated with Industrial Stormwater General Permits, thereby inflating the PCB loads from this source.*

The TMDL PCB source category referenced within this comment describes the TMDL study category known as the “Unregulated Surface Load”. This source category comprises unregulated stormwater, unidentified contaminated sites, loads from small tributaries, atmospheric deposition to land surfaces, and unspecified point sources. In particular, the waterbodies from the upper reaches of the study area have a larger contributing PCB load from the Unregulated Surface Load when compared to all other sources from that portion of the watershed. The estimated revised contributions included in the study is 77% (original 65%) for the Jackson River, 84% (original 83%) for the Maury River, and a lessor amount of 55%

(original 50%) to the Upper James River, and five percent (5%; original <1%) for the Lower James River.

The updated allocated PCB load reductions only call for a reduction in the Jackson River from the Unregulated Surface Load. However, consideration in the development of an Implementation Plan to help pinpoint these unknown sources of PCBs would be a prudent management strategy in leading to reduced PCB loads. An important component of this could be a more in-depth analysis of the existing PCB congener data collected during TMDL development that can be evaluated for insights on possible sources as well as providing direction in the design for additional PCB monitoring. Upon identifying areas contributing PCBs from previously unknown sources, additional analytical characterization of the PCB source(s) would take place that would lead to identifying appropriate management actions needed to attain reductions.

Comment 4: Furthermore, for permitted entities identified in the non-tidal James PCB TMDL plan, a primary best management practice of PCB PMPs is the monitoring and backtracking of sources of contamination. Backtracking has yielded high returns on reducing PCB loading in other watersheds² and should be anticipated to be a valuable pathway for identifying sources of PCBs inside permitted entities in the watershed. However, in many instances, VPDES permit holders may go without the development of a PMP until their respective permits expire, which itself occurs at five-year intervals. This may lead to a significant lag between the finalization of this TMDL plan and the development of PMPs, and even more elapsed time before tangible progress is made in reducing contamination in the landscape through monitoring and backtracking. Conceivably, these delays could result in a delay in the identification of significant sources of PCBs impacting the river for more than 6 years. We strongly encourage DEQ to utilize existing permit reopener authority to expedite the PMP development process for facilities identified in the PCB TMDL plan for the non-tidal James River, ensuring that on-the-ground progress in meeting the goals of this TMDL plan can occur in a reasonable and appropriate timeframe.

DEQ Response: *There is agreement that backtracking of PCBs is a key strategy needed to reduce or eliminate these contaminants. If the source(s) of contamination to effluents can be located within a municipal collection system, or at an industrial site where the origin could be from legacy spills and/or industrial processes that use products that may contain inadvertently produced PCBs, then the appropriate management strategies can be implemented to attain reductions.*

The commentor is correct in mentioning that active permits can be re-opened as needed to address TMDL WLAs (see the examples below). As such, DEQ is in the process of developing PMP guidance that includes recommendations to expedite the inclusion of management actions in situations where prompt actions are needed to reduce or eliminate the on-going release of elevated PCB concentrations (e.g., $\geq 10,000$ pg/L). In these circumstances, the high concentrations translate to a large on-going PCB load that is contaminating the fish and should be addressed as soon as possible. While many permitted facilities have a much smaller concentration than 10,000 pg/L and the PCB loading may be less impactful on an individual

basis it is recognized that when the facilities are considered collectively they are contributing to instream contamination. However, based on challenges with DEQ staff capacity, these facilities may be prioritized lower and therefore addressed upon reissuance of the permit.

Permit Special Condition that is included in all permits:

Reopeners

Section 303(d) of the Clean Water Act requires that total maximum daily loads (TMDLs) be developed for streams listed as impaired. This special condition is to allow the permit to be reopened if necessary to bring it into compliance with any applicable TMDL approved for the receiving stream. The re-opener recognizes that, according to section 402(o)(1) of the Clean Water Act, limits and/or conditions may be either more or less stringent than those contained in this permit. Specifically, they can be relaxed if they are the result of a TMDL, basin plan, or other wasteload allocation prepared under section 303 of the Act.

Reopeners

This permit may be modified or, alternatively, revoked and reissued:

- a. If any approved waste load allocation procedure, pursuant to Section 303(d) of the Clean Water Act, imposes waste load allocations, limitations or conditions on the facility that are not consistent with the permit requirements;*

Comments from Patricia Greene and DEQ responses:
March 18, 2024

- I. TVP requests that VDEQ exclude cooling water from the TMDL under VDEQ's longstanding practice of not incorporating cooling water from electric generating facilities within TMDLs.
It is our understanding that VDEQ historically has excluded electric generating facilities whose water was used for once-through cooling from TMDL development. This arrangement was and is appropriate as this cooling water passes through the electric generating system and discharges into the same water body from which it was withdrawn without meaningful contributions of contaminants. This sensible approach does not force facilities to discharge water with lower concentrations of a given contaminant than is present in the water when taken from the water source or impose the cost of pollutant reduction on innocent withdrawers who do nothing to increase PCB loads in the river.
The cooling water discharged from TVP's electric generating facility, Tenaska Virginia Generating Station (TVGS), is not from a once-through cooling process, but from a non-contact cooling recirculation (cooling towers) process. Cooling water is recirculated and cycled through the non-contact cooling system typically between six (6) to twelve times prior to discharge. TVP obtains its cooling water from the James River. Any PCBs in the non-contact cooling recirculation discharge can be directly attributed to the source water. Therefore, TVP requests that VDEQ exclude TVP as an "Individual Industrial Permitted" (IP) facility from the PCB TMDL in the lower James River.

DEQ Response: While not specifically stated in DEQ's TMDL Guidance Memo No. 09-2001, Guidance for monitoring of point sources for TMDL development using low-level PCB method 1668, Section V.A. of the guidance allows for certain outfall exclusions from PCB monitoring and incorporation into PCB TMDLs. An example would be the exclusion of PCB loads associated with outfalls that discharge once-through non-contact cooling water from facilities such as power generating operations into the same waterbody from which it was withdrawn.

Existing PCB TMDL studies where outfalls were comprised of once-through non-contact cooling water and were excluded from being assigned a WLA include the Roanoke River and New River PCB TMDLs. The exemption also applies in the James, Maury, Jackson PCB TMDL study. During the early phases of this study, DEQ performed an assessment of all municipal and industrial permitted dischargers located within the watershed, to be considered for inclusion as potential PCB sources within the James PCB TMDL study. The Tenaska Virginia Generating Station (VA0090905 and VAR052356) was included in this assessment and was subsequently assigned a WLA for each permit.

In response to this comment, DEQ closely reviewed materials associated with the 2024 permit reissuance (e.g., VPDES Permit VA0090905 Fact Sheet) with emphasis on outfall 004. Information gathered from the fact sheet indicated internal outfall 401, which discharges through outfall 004, receives stormwater treated through an oil/water separator. The addition of effluent from an oil/water separator eliminates the non-contact definition of the cooling water. Moreover, present day petroleum products including motor oil, hydraulic fluids, etc. can contain inadvertently produced PCBs (see City of Spokane, 2015). Additionally, oil associated with electrical transformers can also contain PCBs even when identified as “Non-PCB” as the Toxics Substances Control Act (TSCA) defines non-PCB as less than 50 ppm. Secondly, influent to outfall 004 comes from the James River but discharges to the Rivanna River which nullifies the contention that the effluent is discharged “into the same water body from which it was withdrawn.” If PCBs are detected in the waste stream at appreciable levels, then a load is being taken from the James River and added to the Rivanna River. For the reasons described herein, DEQ does not define effluent discharged from outfall 004 as once through non-contact cooling water that is consistent with the exception.

Citation: City of Spokane, Wastewater Management Department. 2015. PCBs in Municipal Products. Ecology Municipal Stormwater Grants of Regional or Statewide Significance. Grant No. G1400545.

II. TVP requests that VDEQ include language in the TMDL explaining that cooling water is not considered process water for the purposes of characterizing the PCB loads to the James River.

Because non-contact cooling water discharged from electric generating facilities should not be included within the PCB TMDL, TVP requests that VDEQ include the following language in section 5.3.2.1 of the TMDL, pages 54–55 of the draft study, describing sources of PCBs included in the TMDL:

Water that is withdrawn from a waterbody, utilized as non-contact cooling water at an electric generating facility, and is discharged directly or indirectly back to the waterbody does not contribute meaningful net loadings of PCB to waterbodies on a mass basis. Accordingly, facilities that discharge cooling water under a valid VPDES permit were excluded from the PCB TMDL based on the assumption that the net mass load of PCBs discharged from these facilities is equal to or less than zero.

This language will clarify the development of the TMDL and provide assurance to electric generating facilities that the study is not assigning an inflated PCB load to non-contact cooling

water discharges. Moreover, we understand that the suggested language above is consistent with VDEQ's position for facilities utilizing once-through cooling systems. Expressly noting this position in the TMDL could avoid misunderstandings during future VPDES permit reissuances for facilities such as TVGS.

DEQ Response: DEQ does not believe the above language such as that provided by Tenaska should be included in the TMDL. Rather, the concept of excluding once-through non-contact cooling water is better placed within a TMDL guidance document. More specifically, language addressing this concept can be included in TMDL Guidance Memo No. 09-2001. Guidance for monitoring of point sources for TMDL development using low-level PCB method 1668, as this guidance document is in the queue to be updated as it was developed in 2009 and has never been updated.

III. TVP requests that VDEQ lower the estimated tPCB concentration in TVP's stormwater or explain why it attributed a higher tPCB concentration in TVP's stormwater flows compared to other facilities with the same SIC code.

The TMDL study appears to have misidentified or incorrectly entered the mean tPCB concentration for SIC Code 4911 facilities when evaluating the PCB load in TVP's stormwater. The 2016 study assigned a mean and median total PCB (tPCB) concentration to SIC-coded facilities but did not specifically report separate PCB concentrations for industrial wastewater discharges and stormwater.¹ The current version of the PCB TMDL; however, reports two different estimates of tPCB concentration for TVP's industrial wastewater discharges and stormwater. It estimates a mean tPCB concentration of 17,923 pg/L (Table 5-5) in TVP's stormwater flow but only 125.4 pg/L (Table 5-6) in TVP's industrial wastewater discharges. This is inconsistent with how the TMDL study addresses similar facilities. For example, the TMDL study estimated tPCB concentrations of 125.4 pg/L for both stormwater and industrial wastewater discharges at Dominion's Bear Garden facility, even though the facility has the same SIC code as TVP. See Table C-6, Appendix C at C-7². TVP requests that VDEQ lower the potential tPCB concentration in TVP's stormwater according to the 2016 study, as it has done for Dominion's Bear Garden facility, or provide an explanation as to why the tPCB was estimated at such high concentrations of in TVP's stormwater relative to other facilities with the same SIC code.

DEQ Response: TVP is correct regarding the inconsistency in how the default values from the 2016 SIC study were applied in the TMDL report. As the TVP facility began operation well past 1985, the default PCB concentration applied to the stormwater outfalls should have included the median tPCB value presented for the 4911 SIC category in Attachment 1 of the 2016 study as 125.4 pg/L. As such, Table 5-5 in the report has been updated to reflect this change (i.e., deleted 17,923 pg/L and replaced it with 125.4 pg/L). The calculated baseline load presented in Table 6-4 has also been updated to reflect this change (i.e., deleted 1,518 mg/yr and replaced with 5 mg/yr; the percent reduction was also changed from 98% to 60%). Of note, while discussed at greater length in IV. below, the baseline loading and the WLA for the ISWGP were recalculated due to the discovery of an error associated with site acreage conversions found

throughout this permit type. No changes were applied to the loadings for the individual permit (VA0090905) as the information included in the draft report was correct. Please note that while the information was updated in the TMDL report, the default values from the SIC study only serve as a placeholder until such time effluent derived tPCB results from existing outfalls are generated to calculate accurate existing PCB loadings. If the revised baseline loadings are less than the assigned WLA, no PCB reductions would be required and therefore would eliminate the need for a PMP.

IV. TVP requests that VDEQ clarify its calculations of existing PCB loads and waste load allocations so that regulated parties can properly evaluate how VDEQ estimated their PCB loads and how VDEQ determined the necessary reductions under the TMDL.

The TMDL Study does not provide sufficient information for potentially regulated parties to understand how VDEQ calculated existing tPCB loadings from their process wastewater or stormwater or how it allotted PCB reductions. TVP was not able to duplicate the estimated existing tPCB loads VDEQ reported in Tables 6.4 and 6.5. The inability to reconstruct VDEQ's calculation of existing PCB loads is important as these estimates drive, at least in part, the wasteload allocations for facilities. See TMDL Study § 5.3. TVP requests that VDEQ: (1) review the TMDL study to more clearly describe how it estimated existing PCB loads; (2) describe how the study estimated a facility's mean stormwater and industrial wastewater flow from the facilities it included in the study; and (3) provide data in a form that allows facilities to easily evaluate the accuracy of VDEQ's PCB loading estimates and waste load allocations (for both industrial wastewater and stormwater).

¹ MARK RICHARDS & WILL ISENBERG, VA. DEPT OF ENV'T QUALITY, THE RELATIONSHIP BETWEEN POLYCHLORINATED BIPHENYLS (PCBS), VPDES WASTEWATER/STORMWATER FACILITIES, STORMWATER INDUSTRIAL GENERAL PERMITTED FACILITIES, AND THE STANDARD INDUSTRIAL CLASSIFICATION SYSTEM (SIC), (Feb. 1, 2016).

² TVP also notes that the tPCB concentration used to estimate TVP's existing stormwater tPCB load to the James River coincides with the tPCB concentrations presented for SIC Code 4212, local trucking without storage, in Appendix 1 of the 2016 report. TVP requests that VDEQ confirm that data was not incorrectly entered when estimating its existing stormwater tPCB load.

As an example, the TMDL study appears to have estimated the existing mass of tPCB discharges (in mg/year) from stormwater runoff from industrial facilities "by calculating the annual runoff from the facility (gal/yr), which is an attribute of the drainage areas associated with the industrial activity and impervious acreages[,] and multiplying it by the PCB concentration at the outfall." TMDL Study at C-3; see also TMDL § 5.3.2.1 ("Mean flows for ISWGP's were calculated from the facility drainage areas."). This description suggests that the TMDL Study multiplied the estimated stormwater runoff from the facility, i.e. the mean flow reported in Table 5.5, by the estimated tPCB concentration reported in Table 5.5 to calculate each facility's existing load of tPCB from stormwater.

Yet, when the mean flow provided in Table 5.5 for TVP, 0.620 mgd, is converted into the appropriate units, liters per day, and multiplied by VDEQ's estimated tPCB concentration for TVP in Table 5.5, 17,923 pg/L (which we believe should be estimated at 125.4 pg/L), and then further converted into mg/year, the final figure does not match VDEQ's estimated PCB load of 1,518 mg/year in Table 6.4 but would instead be ~15,000 mg/year.³ If the estimated PCB loadings from a facility are a function of mean flow and concentration, See TMDL Study § 6.4.2

(pg 70), then TVP should be able to use the figures VDEQ provided for mean flow and tPCB concentration in Table 5.5 to approximately replicate the estimated loading recorded in Table 6.4.⁴ The inability to do so raises questions about the accuracy of the model VDEQ used to assign load reductions.

³ We note that if VDEQ had used the tPCB concentration estimate based on TVP's actual SIC Code, i.e. 125 pg/L instead of 17,923 pg/L, then the final estimate of annual PCB loading should have been ~107 mg/year.

⁴ TVP notes that although TVP maintains its cooling water should not be included in the TMDL, we were also not able to duplicate the estimated tPCB load the study reported in Table 6.5 based on the mean flow, 0.306 mgd, and tPCB concentration, 125.4 pg/L, that VDEQ provided in Table 5.6

DEQ Response: To answer the first and second parts of the comment, Section 5.3 provides a high-level overview on how the point source loading calculations were developed. For further clarification, language was added in Section 5.3 to direct the reader to Appendix C, which was enhanced with greater detail on the approaches used to derive the PCB loads.

Considered essential to load development, the defined flows used in the loading derivation process for the different types of permits can be found in Table 1 below. The equations used to calculate the existing loads and WLAs for continuous outfalls such as municipal WWTPs, or from industrial IPs including treated process and/or co-mingled wastes, and contact-cooling water (or non-contact cooling water that receives potentially contaminated internal wastestreams) are as follows:

Eq. 1 $Existing\ Load\ (mg/yr) = Monthly\ Ave\ Flow\ (MGD) \times Ave.\ tPCB\ Conc.\ (pg/L) \times Conversion\ Factor$

Eq. 2 $WLA\ (mg/yr) = Design\ Flow\ (MGD) \times TMDL\ Endpoint\ (pg/L) \times Conversion\ Factor$

Where: $Monthly\ Average\ Flow = Calibration\ period\ for\ TMDL\ Model$

$MGD = Million\ Gallons\ per\ Day$

$Conversion\ Factor\ (mg/yr) = 1.38$

The approach used for calculating tPCB loads from the ISWGP follows that described in the VPDES General Permit Regulation for Discharges of Stormwater Associated with Industrial Activity (9VAC25-151-70). Figure 1 includes the detail that is described in the VPDES General Permit Regulation, with a series of equations used to calculate the existing load for Tenaska Virginia Generating (VAR052356).

Table 1. Flow matrix applicable to the different types of permits.

Permit Type		Flow Used in Load Calculations
Municipal WWTps		For Existing Load: Monthly Ave Flow (2008-2019)
		For WLA: Design Flow
Industrial Storm Water General Permits (ISWGP's)		Flow calculations based on outfall drainage acreage and impervious acreage
Individual Industrial	Process Water OR	For Existing Load: Monthly Ave Flow (2008-2019)
	Comingled Process Water + Storm Water	For WLA: Average of Daily Max Flow (2008-2019)
	Storm Water	Flow calculations based on outfall drainage acreage and impervious acreage

Figure 1. Description of the approach used to calculate the ISWGP PCB loadings.

outfall	A, acres	A, sq.ft.	Ia	Rv	Annual Runoff- R _i in/yr	R _i cu.ft./yr	R _i Gal/yr	R _i Uters/yr	Censored Mean Conc. PCB pg/L	PCB pg/year	PCB mg/ year																								
Indus. Area	28.0	1219680.0	0.3	0.3	13.0	1322814.8	9895316.4	37453772.4	125.4	4.7E+09	4.70																								
									Total		4.70																								
P = annual rainfall (in/yr) = per GCM 14-2011 the Virginia annual average rainfall of 44.3 inches/year Pj = fraction of annual events that produce runoff (usually 0.9) RV = runoff coefficient, which can be expressed as: RV = 0.05 + (0.9 x Ia) where: Ia = the impervious fraction (the ratio of impervious area to the total industrial area) Ia = Impervious Acreage/Industrial Activity Acreage The R is annual runoff (in/yr), calculated as: R = P x Pj x RV																																			
<table><tr><th colspan="2">Background Information</th><th>Acres</th><th>iPCB Conc. pg/L</th></tr><tr><td>Site Acreage:</td><td></td><td>28</td><td></td></tr><tr><td>Industrial Activity:</td><td></td><td>28</td><td></td></tr><tr><td>Impervious:</td><td></td><td>8.6</td><td></td></tr><tr><td>Outfall 001</td><td></td><td>28</td><td>125.4</td></tr><tr><td colspan="2">**Mean Conc</td><td></td><td>125.4</td></tr></table>												Background Information		Acres	iPCB Conc. pg/L	Site Acreage:		28		Industrial Activity:		28		Impervious:		8.6		Outfall 001		28	125.4	**Mean Conc			125.4
Background Information		Acres	iPCB Conc. pg/L																																
Site Acreage:		28																																	
Industrial Activity:		28																																	
Impervious:		8.6																																	
Outfall 001		28	125.4																																
**Mean Conc			125.4																																
* Concentration is based on a mean of all available censored iPCB data from outfall																																			

For the larger and more complex industrial facilities that are regulated under an individual permit (IP), a hybrid approach is used that includes a combination of calculations to address both the continuously discharging outfalls (see Eq. 1/Eq. 2) and the SW based outfalls (Figure 1). The loadings derived from these calculations are then summed to generate an existing load and a WLA that are applicable to the entire facility.

To further address the second part of the comment (i.e., the mean SW flow and industrial wastewater flow), the guidelines that were used can be found in Table 1 above. The annual precipitation of 44.3"/yr was used along with the outfall drainage acreages and site imperviousness. Once calculated, the Gals/yr were divided by 365, and the quotient was divided by 1,000,000 which equals the Mean Flow (mgd) for ISWGP's. Tenaska site example (9,895,316 gals/yr /365 = 27,110 gals/d or 0.027 mgd).

Lastly to address the third part of the comment, the flow data used in deriving the loading calculations for ISWGP's and IPs was updated and more accurately presented in Tables 5-5 and 5-6 of the draft TMDL.

To address the remaining portion of the comment, DEQ closely examined all the point source calculations in the draft TMDL including Tables 6-3, 6-4, and 6-5. The review provided confirmation that the calculated results in Table 6-3 for Municipal WWTPs and Table 6-5 for Industrial IPs were accurate. For the Industrial Stormwater General Permits loadings presented in Table 6-4, an error associated with converting acreages to square feet was discovered in the calculations that resulted in a loading overestimation. The error was corrected, the existing loads and WLAs were recalculated and incorporated into the revised Table 6-4. Lastly, the existing loads and WLAs in all the point source tables were expressed as two significant figures to be consistent in how the PCB WQS is expressed in the VA Code - 9VAC25-260-140. The PCB TMDL equations are also expressed as two significant figures.

V. TVP requests that VDEQ clarify its expectations for Pollutant Minimization Plans. The TMDL Study and Implementation Plan should provide details on how VDEQ intends to implement Pollutant Minimization Plans (PMPs) for permitted industrial stormwater discharges. TVP assumes that PMPs will consist primarily of source identification and best management practices (BMPs) to reduce loadings. Although TVP does not anticipate any material sources of PCBs in its stormwater discharges, we note that a BMP implementation process will take time to be completed. For that reason, we request that VDEQ acknowledge that any BMP-based PMPs may take more than one permit cycle to properly implement.

DEQ Response: DEQ is in the process of developing Pollutant Minimization Plan (PMP) Guidance to assist the regulated community in the development of PMPs as well as to guide DEQ's Permitting and TMDL staff in the process oversight. While there are numerous PMPs in process where TMDLs have been completed, a PMP is a site-specific plan to address PCB contamination using an adaptive implementation approach. The BMP based process can include a review of historic, on-site PCB management practices as well as implement an educational component. To determine the presence and/or degree of PCB contamination, all permitted sites will include effluent/influent monitoring as an initial step. If the baseline load is established as exceeding the WLA, then additional monitoring can be performed which EPA considers a BMP, and when applicable the use of track-back monitoring to identify prospective sources. With the improved knowledge base on prospective source areas, the implementation of management actions can then be targeted to attain reductions. After steps like these the effluent load is then reevaluated for comparison with the assigned WLA. If the approach was not successful, through adaptive implementation the next iterative step is formed and utilized based

on what was previously learned. DEQ acknowledges that PMPs can take more than one permit cycle to be successful.

Comments from Darrell Shier and DEQ responses:
March 18, 2024

Dominion Energy requests the mean tPCB concentration, existing tPCB load, and WLAs for the Breomo Power Station (VA0004138) be recalculated using only the data for Outfall 002 that was submitted to DEQ in 2020. In the TMDL Report, the default concentration for SIC 4911 (2461.4 pg/L) was used for all other outfalls at Breomo Power Station to calculate the mean tPCB concentration. Outfalls 203 and 504 are internal outfalls discharging through Outfalls 002 or 006 and should not be given a concentration of 2461.4 pg/L and counted separately. Outfalls 006 and 008 are non-contact stormwater outfalls (not associated with industrial activity) and also should not be given the default concentration for SIC 4911.

DEQ Response: In light of the comments received on March 18, 2024 and in follow-up and clarifying correspondence dated 3/28/2024 (see below), DEQ has refined the existing loading and the Waste Load Allocation (WLA) included in the draft TMDL. Specifically, outfalls 002, 006, and 008 were included in the updated WLA, whereas several outfalls were removed from the calculation with the most notable consisting of outfall 001 which releases fire-suppression water taken directly from the James River. The outfall has also been described as consisting of non-contact once through Condenser Cooling Water (system was not chemically altered by the addition of biocides, corrosion inhibitors or other cooling water treatment additives as part of station operations). In support of removing outfall 001 from the loading calculations, it has been long standing policy for DEQ to exclude once-through cooling water from being assigned a PCB WLA as the discharge is not adding to the existing load within an impaired water. Lastly, a careful analysis of the original loading calculation determined that some outfalls no longer exist or were comprised of internal outfalls (e.g., 203 and 205) and were erroneously included. Therefore as described below, the revised baseline loading calculation included in the updated draft TMDL was estimated at 1,074 mg/yr and the WLA was calculated at 167.6 mg/yr. When calculating the existing PCB load, tPCB (total PCB) data provided by Dominion (mean concentration of 67.6 pg/L) was utilized for outfall 002. However, as low level tPCB data were not provided for outfalls 006 or 008, default values (2,461.4 pg/L) from the 2016 SIC based PCB study were used to represent the baseline load. Aroclor data were provided with the 3/28/2024 correspondence and were all non-detect but were generated using a method with a limit of detection (LOD) of 0.2 ug/L (i.e., 200,000 pg/L) and a limit of quantitation (LOQ) of 0.5 ug/L (i.e., 500,000 pg/L). Virginia's Water Quality Criterion (WQC) for tPCBs is set at 0.00058 ug/L. New PCB data using a low-level analytical approach such as EPA Method 1668 will be necessary to screen effluents from 006 and 008 for tPCBs, and then a re-evaluation of the existing PCB load can be performed.

PCB TMDL for the James River, Jackson River, and Maury River Watersheds

Email Correspondence cited above:

From: Richards, Mark (DEQ) <Mark.Richards@deq.virginia.gov>
Sent: Thursday, March 31, 2024 1:23 PM
To: Jennifer J. Rogers (Services - 6) <jennifer.j.rogers@dominionenergy.com>
Cc: McKee, Neisha (DEQ) <Neasha.McKee@deq.virginia.gov>
Subject: [EXTERNAL] Re: MAUR PCB TMDL Comment Letter

CAUTION! This message was NOT SENT FROM DOMINION ENERGY
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Hi Jen,

Thanks for submitting your comments for the James, Maury, Jackson PCB TMDL.

As I explore the Dom Energy - **Begood** facility, I have not been able to find the PCB data from outfall 002. Would you happen to have that to share (again - sorry about that)? Also, relative to how that outfall existed when the PCB data were collected as compared to now, is it consistent with current conditions or were changes still in the works? I found information in the most recent fact sheet for the 2023 permit revision that suggests the old Outfall 002 consisted of internal outfall 205, but more recently consists of internal outfalls 205 and 504. Do the PCB results from outfall 002 reflect the combination of both internal outfalls?

Aug for clarity, I understand outfall 001 takes river water in to serve exclusively as fire suppression. In other words, river water comes in and goes out without any contact with a process. Can you elaborate please. Also, are there screening **PCB** data from Outfalls 006 or 008? Relative to any current/historical (on-site) in-use electrical equipment (transformers, etc.), are there any current outfalls that include associated drainage areas? What about from a historical perspective including the storage of electrical equipment (transformers).

Hopefully answers to these questions will help reconcile the PCB loadings included in the TMDL study for the **Begood** facility. Thanks Jen!

Mark
Mark Richards
Team Lead, Watershed Programs
Virginia Dept. of Environmental Quality
1111 East Main Street, Suite 1400
Email: Response

From: Jennifer.J.Rogers@dominionenergy.com

Thu 3/28/2024 11:16 AM

Tollrichards, Mark (DEQ)
McKee, Neasha (DEQ)
84609 Project Number - **Begood** PCB Sampling Report.pdf

2 Attachments (24 MB) Save All to OneDrive - Commonwealth of Virginia

Mark,

The lab report from the 2020 sampling is attached. The sample ID's for 002 are VA0004138-DW-002-03312020 and VA0004138-DW-002-00012020. Page 11 shows the concentrations for Total PCBs. The PCB data from Outfall 002, as well as the PCB data from Outfall 001, are included in the report for 007. I have not been able to find the PCB data from Outfall 002. The report for 007 represents any configuration of the internal outfalls, so 205 was reflected. Outfall 504 was no longer discharging when the 2020 sample was collected, but it is in the 2023 permit as an internal discharge to 002.

You are correct about 001, there is no process water associated with Outfall 001, the river water comes in and goes out without any contact with a process. The current permit states it is exclusively for fire suppression but in the 2016 permit it was described as Non-Contact once through Condenser Cooling Water and the system was not chemically altered by the addition of biocides, corrosion inhibitors or other cooling water treatment additives as part of station operations.

The 2016 permit only required **PCB** sampling (5668 method) from 002. I have not found any screening **PCB** data from Outfall 002. Also, as a supplement of PCB data using EPA8208.1 from Outfall 001 (all results below detection) that was submitted with the most recent permit application. The power block (now decom) and most electrical equipment was/is in the 002 drainage area. There currently are transformers and some electrical equipment in the 006 and 008 drainage area, but it is certified non-PCB equipment. Historically no electrical equipment was stored in the 006 and 008 drainage areas.

Hopefully that helps clear things up! Let me know if you have any other questions.

Jen Rogers
Environmental Specialist III
Dominion Energy Environmental Services
110 Tredgar Street, Richmond, VA 23219



Comments from Michelle Ashworth and DEQ responses:
March 18, 2024

1. **The TMDL Study Should Reference the MEP Standard**

Congress has adopted a different standard in the Clean Water Act for municipal separate storm sewer systems (MS4s) than for other dischargers. 33 U.S.C. § 1342(p)(3)(B)(iii). Instead of requiring strict water quality-based effluent limitations, MS4s must instead adopt “controls to reduce the discharge of pollutants to the maximum extent practicable[.]” 33 U.S.C. § 1342(p)(3)(B)(iii).

VAMSA therefore requests that DEQ revise the Draft TMDL Study to reflect the MEP standard. In particular, we ask DEQ to revise the following language in the portion of section 7.3.2 addressing MS4s (page 87):

For MS4 individual and general permits, DEQ expects that MS4 permittees will address the requirements of their wasteload allocations through iterations of programmatic best management practices (BMP) which are consistent with the maximum extent practicable (MEP) standard. DEQ will work during permit renewal to ensure that permit requirements are consistent with the assumptions and requirements of the permittee's waste load allocation and ensure reasonable progress during the next permit term.

For MS4 individual and general permits, DEQ expects the permittee to address the TMDL wasteload allocations for stormwater through the identification and iterative implementation of BMPs within their local TMDL Action Plan. These expectations have been discussed with MS4

permittee's in the James River study area (e.g., City of Lynchburg, City of Richmond, VDOT) throughout the TMDL development process. Permittee implementation of an individual control strategy includes determining BMP effectiveness. If BMPs are showing not to be effective, then the permit must require the MS4 to expand or better tailor its stormwater management program to address applicable reductions. to achieve the TMDL wasteload allocation. MS4s have the flexibility to optimize reductions in stormwater pollutants by implementing BMPs and other requirements of the MS4 permit in an iterative process. Successive permits continually adapt to current conditions, BMP effectiveness and technology, on a location-by-location basis, taking into consideration such factors as condition of receiving waters, specific local concerns, a comprehensive watershed plan, MS4 size, current ability to finance the program, beneficial uses of receiving water, hydrology, geology, and capacity to perform operation and maintenance. Permittees will be strongly encouraged to participate in the development of PCB TMDL Implementation Plans, which are mechanisms used to address non-point sources, as recommendations from stakeholder input may provide a basis for modifications to their stormwater management plan that may be able to provide more effective approaches in meeting the TMDL.

This language clarifies that DEQ will not impose stringent numeric or end of pipe PCB limits or fixed compliance schedules on MS4 permittees. This is appropriate for MS4s, who are passive receivers of PCBs, which can shift over time as sources emerge or become exposed. Likewise, such implementation will allow DEQ and MS4s to work cooperatively and responsibly with taxpayer funds to address PCB sources within an MS4 region. This approach will not impose burdensome and costly requirements on MS4s, to the detriment of other pressing stormwater initiatives and system-wide improvements that may not be related to PCBs, while still ensuring meaningful reductions in PCB discharges.

VAMSA asks that DEQ also incorporate the MEP standard anywhere else in the Draft TMDL Report that references MS4s and appropriate wasteload allocations. For example, on p. 71 the Report states: "MS4 permit holders are responsible for reducing existing PCB loads to the WLA levels." VAMSA asks that DEQ revise this text to reference MEP (e.g., "MS4 permit holders are responsible for reducing existing PCB loads to the WLA levels to the maximum extent practicable.")

DEQ Response: DEQ has updated the language in Chapter 7 (TMDL Implementation and Reasonable Assurance of the TMDL) to include the Maximum Extent Practicable (MEP) concept. Inclusion of this language is consistent with existing MS4 permits and is defined in DEQ's existing Guidance Memo No. GM-16-2006, TMDL Action Planning for Local Total Maximum Daily Loads as Required in the Small MS4 General Permit (VAR04) Effective July 1, 2013 and MS4 Individual Permits, (November 21, 2016):

"MEP is an iterative standard, which evolves over time as urban runoff management knowledge increases. As such, the operator's MS4 program must continually be assessed and modified to incorporate improved programs, control measures, BMPs, etc., to attain compliance with water quality standards (From 9 VAC 25-870-10)."

The language was revised on pages 42, 58 and, 71 within the draft TMDL but the MEP concept was not incorporated into these sections since they are not focused on TMDL Implementation.

Rather, the MEP concept is presented in Chapter 7, Section 7.3. where WLA implementation is highlighted. In addition, MEP has been included in the Glossary of Terms on page 100.

2. Footnote

VAMSA also notes that the Draft TMDL Study references “calibration segments” of the James River watersheds that it used to calibrate its model of the existing PCB loads into the James River. See TMDL Study § 6.4.2; Table 2.5; Appendix E, F. The Study defines a “calibration segment,” as “[a] defined subdivision of the Lewis Creek watershed.” TMDL Study p. 98. This does not seem correct, given that this a small tributary to the James and not a calibration segment itself. The definition explains that, “[c]alibration segments were used to allow for easier modeling and to isolate sources and hydrologic features. Eight calibration segments were used. The calibration segments are interconnected meaning the model outputs from some segments were inputs for other segments.” *Id.* In some locations, however, the study equates these eight “calibration segments” with the four TMDL watersheds (i.e. the Jackson, Maury, Upper James, and Lower James). See, e.g. Table 2-5 (pg 39) (referring to samples “in each calibration segment” but presenting the data by each “TMDL Watershed”); TMDL Study § 6.4.2 (referring to a calibration segment’s endpoint concentration, as opposed to TMDL watershed’s endpoint concentration, as the relevant point for PCB allocations). VAMSA asks DEQ to clarify the definition of a “calibration segment,” to ensure that the term is used correctly throughout the TMDL document, and to appropriately distinguish it from the TMDL watersheds for which the Study developed PCB endpoint concentrations. Otherwise, regulated parties cannot understand how DEQ developed the model and thus whether the model appropriately estimated existing PCB loads and allocated PCB reductions, particularly between point and nonpoint sources. *DEQ Response to the footnote – The definition for Calibration Segment in the Glossary of Terms on page 99 (see revised draft TMDL) has been revised as follows:*

Calibration Segment

A defined subdivision of the James River study area. Calibration segments were used to allow for easier modeling and to isolate sources and hydrologic features. Fifty-six calibration segments were used for calibration. The calibration segments are interconnected meaning the model outputs from some segments were inputs for other segments.

The erroneous inclusion of Lewis Creek occurred due to a carryover from another PCB project from which the report served as a template. Other sections of the draft TMDL report were also updated as appropriate to provide further clarity.

3. The TMDL Study Should Assign Reductions to Known Contaminated Sites in Each Watershed

The Draft TMDL Study reports PCB contaminated sites in each James River TMDL Watershed. See Draft TMDL Study §§ 3.2.1; 5.3.2.2; 5.4.3; 6.5; 6.6.1; see also Tables 5-8; 6-11; C-10.¹ The Draft TMDL Study claims to have assigned PCB load reductions to these known contaminated sites before assigning loads to unregulated surface loads. Draft TMDL Study § 6.6.1 (pg. 78) (“Reductions were applied to sources from known contaminated sites first.”).

However, in contrast to the statements above, when allocating PCB reductions across sources in the TMDL watersheds, the Draft TMDL Study declares that three of the four watersheds in the study contained “no known contaminated sites” and neglects to assign a PCB reduction to the contaminated site in the fourth watershed. See TMDL Study §§ 6.6.1–6.6.5 (pgs. 77-80). As a result, the **Draft TMDL Study never directly assigns a PCB reduction to known contaminated sites in any watershed** despite the acknowledgment of their presence and the assignment of reductions to unregulated surface load sources. Draft TMDL Study pg. 82; Table ES-5 (pg X); Table 5-8 (pg 59) (listing contaminated sites); Table C-10 (pg C-10).

Instead, the PCB loads estimated for MS4 regions “were derived based on impervious surface acreage within each MS4 region and their intersection with nonregulated surface load sources **and contaminated sites**, which have defined PCB loading rates.” TMDL Study § 6.4.2 (emphasis added). Thus, the TMDL Study appears to have assigned PCB reductions from known contaminated sites in MS4 regions to the MS4s.

VAMSA requests that DEQ assign PCB reductions for each identified contaminated site to the responsible party. MS4s, who are passive receivers of PCBs, should not bear this clean up responsibility instead of known PCB sources.

DEQ Response: The PCB model was recalibrated and rerun in part to address this comment. As such, a 99% reduction was applied for all contaminated sites and is now consistent with the approach used in other PCB TMDLs such as the New River PCB TMDL. The report has been updated accordingly in Tables 6-8 and 6-11 where PCB allocation and load information is presented as well as the language (§ 6.6.1) where an explanation is provided.

4. The TMDL Study Should Include Potential PCB Sources Relating to Construction Activity and Inactive Commercial Facilities

Alternative sources of sediment and/or PCBs exist within the James River watershed that were not included in the Draft TMDL Study. For example, inactive industrial and commercial spaces can serve as sediment and/or PCB sources either directly into surface waters or through MS4s. See TMDL Study at C-3 to C-5; Table C-5. Although a list of inactive industrial stormwater permits is provided, the Draft TMDL Study does not describe whether it assigned these industrial sites with a PCB load during model calibration or PCB reductions during allocation. Similarly, construction sites, particularly of former commercial or industrial locations, could serve as significant sediment sources that contain adsorbed PCBs which were not captured in the Study. As with the contaminated sites for which DEQ did not assign a PCB allocation, the failure to estimate and include these potential industrial and construction related stormwater PCB loads places the burden of addressing additional sediment and PCB reductions on MS4s. DEQ is already positioned to limit sediment and/or PCB sources from these sources. Prior TMDLs have estimated and incorporated the existing sediment load from construction into their study. See, e.g., BENTHIC TMDL DEVELOPMENT FOR THE NORTH FORK RIVANNA RIVER WATERSHED AND TRIBUTARIES, VA. DEPT ENV'T QUALITY 50, 75, 85 (April 2019) (assigning a load allocation to construction activity within each sub watershed of the TMDL).

As such, VAMSA requests DEQ to reevaluate its model and incorporate alternative sediment and PCB sources from stormwater into the James River that might otherwise be assigned to MS4s.

DEQ Response: DEQ has updated the PCB model, and the report has been revised to reflect the application of allocated reductions for the terminated permitted sites as well as the previously identified contaminated sites. While acreages associated with inactive permits have been converted to contaminated sites with reductions set at 99%, it is unknown if the former permitted sites are actual PCB sources. Rather, these facilities were selected primarily based on SIC classification that happened to be operational during the 10-year calibration period. Furthermore, there are no available PCB data from these sites as the opportunity to screen the effluents for PCBs did not occur when they were operational.

Lastly, to address the expressed concern regarding PCB contaminated sediment from construction sites, language has been included in § 7.3.3. of the draft report to address construction sites that are > 10,000 square feet and were built or renovated prior to 1980. This requirement is consistent with the Construction General Permit No. VAR10 that requires the operator to develop, implement, and maintain a Stormwater Pollution Prevention Plan (SWPPP) for demolition activities of old buildings that contribute stormwater discharges to PCB impaired waters such as those described in this TMDL. An allocated load was not attributed to these sites based on the uncertainty associated the infrequent occurrence and an unknown loading rate.

Comments from Jamie Heisig-Mitchell and DEQ responses:
March 18, 2024

I. VAMWA requests the TMDL Study specifically acknowledge that POTW effluent PCBs are generally a pass through from surface waters.

For most if not all Virginia POTWs, the PCBs in their effluent water stem from potable water sources passing into their wastewater systems. If the water source for a potable water system contains PCBs, those PCBs will pass through public water systems into the wastewater system and ultimately end up in POTW effluent. The PCB load therefore does not stem from controllable sources within the wastewater system. Experience during the implementation of other PCB TMDLs in the New, Roanoke, and Lower Potomac Rivers corroborates this understanding, as POTW's along those rivers have almost universally not identified sources of PCBs under their control while carrying out a Pollutant Minimization Plan.

We therefore request that DEQ include the following language as a separate paragraph in section 7.3.1 (page 86) of the TMDL Study:

In most cases, the PCBs in Virginia municipal WWTP effluent are a pass-through from potable water systems and their surface water sources. Accordingly, WWTPs have not typically found significant PCB sources that are under their control during the implementation of prior PCB TMDL's. As such, it is appropriate that POTW PMP implementation will in most cases primarily involve determinations as to whether the collection system includes any identifiable, controllable sources, and if it does not routine corroboration thereafter. The VPDES permit would continue to specifically require a PMP.

DEQ Response: DEQ does not agree that most of the PCBs discharged through POTWs in Virginia originate from potable water systems or surface water sources. Generally, the total PCB

concentrations found in the ambient river data that serve as the sources to potable water systems are well below the WQC of 580 pg/L and are often in the concentration range of 100-300 pg/L tPCBs. For comparison, the mean concentration of final effluent from WWTPs is 1,707 pg/L as determined by DEQ's 2016 SIC analysis. The concentrations of influent coming into these WWTPs are clearly much higher than what would originate from existing ambient concentrations especially since PCBs are largely removed by the reduction of solids through the waste water treatment processes often at a level of 80-90%, but result in an average concentration of 1,700 pg/L. Moreover, in a 2019 study performed by Needham and Ghosh in an urban WWTP in Baltimore, Md, it was determined that the loading to the treatment plant was 170 g/d and 5.2 g/d was discharged to a nearby waterbody, therefore representing a 97% reduction. As Baltimore is a highly industrialized area, the PCBs did not originate from potable water systems or nearby ambient water. The same is true in Virginia.

To further support DEQ's position that the bulk of the PCB load observed in POTWs does not originate from the potable water systems or ambient water, DEQ reviewed Pollutant Minimization Plan Annual reports from three large POTWs in the Potomac River and one in the New River watershed. For the Potomac River, as a component of their Pretreatment Program two facilities performed surveys of potential sources that may be contributing PCBs although they did not provide supporting PCB analytical data. The third facility did provide PCB results from three landfills, of which two landfills delivered a calculated average load of 5.3 g/yr of PCBs to the plant. Furthermore, the New River facility did include results in their 2023 PMP annual report from 18 locations in the collection system that yielded a mean PCB concentration of 4,773 pg/L (range 135 pg/L – 10,600 pg/L). Lastly, DEQ is not aware of PMP work performed in the Roanoke River PCB TMDL area as the largest POTW discharges PCBs at a concentration below the WLA, thereby eliminating the need for a PMP. A small WWTP in the Staunton River discharges PCBs from a well-documented industrial source. Lastly, it is important to note that solutions for controlling PCB sources can only be determined once sources are identified and in reviewing the existing annual PMP reports suggests more investigative work needs to be performed to support the contention that nothing can be done to control the sources. DEQ does not support including the prescribed language in the TMDL but can consider inclusion within the draft PMP Guidance Memo that is under development.

Citation: Needham, T.P., U. Ghosh. 2019. Four decades since the ban, old urban wastewater treatment plant remains a dominant source of PCBs to the environment. Environmental Pollution. 246, 390-397.

II. VAMWA requests that DEQ assign reductions to known contaminated sites in each watershed of the TMDL.

The TMDL Study reported sites contaminated with PCBs in each James River TMDL watershed. See TMDL Study §§ 5.3.2.2 (identifying railroad yards, rail spurs, former manufacturing facilities, and electrical substations as “known contaminated sites” and listing such sites in each TMDL watershed in Table 5-8); 5.4.3 (discussing the estimated load from contaminated sites during model validation); 6.6 (Table 6-11 providing an estimated existing PCB load from contaminated sites in each TMDL watershed); C-10 (Table C-10 listing known

contaminated sites in each TMDL watershed and the acres associated with the site). The study's methods claim to have assigned reductions in PCB loads to these known contaminated sites before assigning loads to unregulated surface loads. TMDL Study § 6.6.1 (pg. 78) ("Reductions were applied to sources from known contaminated sites first").

When allocating PCB reductions, however, the study stated that three of the four watersheds in the study contained "no known contaminated sites" and neglected to assign a PCB reduction to specifically identified contaminated sites in the fourth watershed. See TMDL Study §§ 6.6.1–6.6.5 (pgs. 77-80).¹ As a result, the study failed to assign a PCB reduction to identified contaminated sites in any watershed despite recording their presence and assigning reductions to unregulated surface load sources. TMDL Study § 6.6 (Tables 6-8 and 6-11 show that the study assigned no PCB load reductions to known contaminated sites but still assigned reductions to unregulated surface loads in the Maury and James River TMDL watersheds). VAMWA requests that DEQ assign PCB reductions for each identified contaminated site and to those that are postulated to exist. Many and possibly most of the TMDL-identified sources of PCBs to the watershed are in our view illusory. We are concerned that a plan that relies on load reductions from POTWs, other VPDES permittees, runoff sources either regulated or non-regulated, air deposition and sediment interchange, when in fact nearly all of the represented load is a pass through from the affected surface waters themselves or is otherwise part-and-parcel of the ubiquitous nature of this legacy pollutant, is not focused on meaningful results. Contaminated sites, even though we recognize the low loadings that the TMDL Study estimates, are among the few controllable sources, and in our view should be addressed with reduction targets.

DEQ Response: The draft TMDL has been updated to include a 99% reduction from all contaminated sites within each study area. Additionally, inactive permits were included on the contaminated site list and assigned a 99% reduction. The text in the report has been updated to reflect these changes.

A. Footnote

¹We note that the TMDL Study stated that the Maury and Upper James River "calibration segments" contained no known contaminated sites but that the Jackson River "TMDL watershed" contained no known contaminated sites. See TMDL Study §§ 6.6.2-6.6.4. VAMWA requests that DEQ clarify the distinction, if any, between a calibration segment and a TMDL watershed and ensure the two terms are used consistently throughout the document. Regardless, DEQ's identification of contaminated sites in each TMDL watershed, in combination with the difficulty and expense DEQ knows regulated parties will have identifying other contaminated sites to remediate, strongly favors DEQ assigning PCB load reductions on the contaminated sites identified in the study as such reductions will have definitive reductions in PCB loading to the TMDL study system.

DEQ Response: Clarifying language has been included in the draft TMDL to ensure the use of the terms "calibration segment" and "TMDL watershed" are applied correctly and consistently throughout the document. As noted in the preceding comment response, DEQ has included a 99% reduction for all the contaminated sites.

III. We request that DEQ review its calculations of existing PCB loads and waste load allocations so that POTWs and other regulated parties are certain DEQ estimated their PCB loads and PCB load reductions correctly.

VAMWA followed the methods described within the TMDL Study in sections 5.3.2 and 6.4.2 to calculate the existing PCB loads and waste load allocations for a subset of POTWs listed in Tables 5-3 and 6-3. Unfortunately, we found significant errors in a few estimates. We therefore request DEQ recalculate and verify the estimated PCB loads and waste load allocation from each point source to ensure the TMDL model ran with the proper estimates of existing PCB loads from point sources and to ensure that each facility's waste load allotments were appropriately calculated.

DEQ Response: As requested, DEQ reviewed all the calculations for baseline PCB loads and WLAs applicable to the POTWs (Table 6-3) and the industrial permitted facilities (ISWGP's and IPs; Tables 6-4 and 6-5, respectively). Of note, the existing loads and WLAs in all the point source tables have been updated to be expressed as two significant figures to be consistent in how the PCB WQS is expressed in the VA Code - 9VAC25-260-140. The PCB TMDL equations are also expressed as two significant figures.

The information for Municipal WWTP facilities included in Table 5-3 and the calculated loads included in Table 6-3 were closely reviewed for accuracy and updated as necessary. No errors associated with the calculated loadings were found in Table 6-3 although one facility in the Maury River study area (Buena Vista, VA0020991) was modified to be consistent with all the other WWTP loads. The equations used to calculate the existing loads and WLAs from continuous dischargers such as a municipal WWTPs are as follows:

$$\text{Eq. 1 } \text{Existing Load (mg/yr)} = \text{Monthly Ave Flow (MGD)} \times \text{Ave. tPCB Conc. (pg/L)} \times \text{Conversion Factor}$$

$$\text{Eq. 2 } \text{WLA (mg/yr)} = \text{Design Flow (MGD)} \times \text{TMDL Endpoint (pg/L)} \times \text{Conversion Factor}$$

Where: Monthly Average Flow = Calibration period for TMDL Model

MGD = Million Gallons per Day

$$\text{Conversion Factor (mg/yr)} = 1.38$$

Table - 1. Flow matrix used to calculate PCB loads from VPDES Permits.

Permit Type		Flow Used in Load Calculations
Municipal WWTPs		For Existing Load: Monthly Ave Flow (2008-2019)
		For WLA: Design Flow
Industrial Storm Water General Permits (ISWGP's)		Flow calculations based on outfall drainage acreage and impervious acreage
Individual Industrial	Process Water OR Comingled Process Water + Storm Water	For Existing Load: Monthly Ave Flow (2008-2019)
		For WLA: Average of Daily Max Flow (2008-2019)
	Storm Water	Flow calculations based on outfall drainage acreage and impervious acreage

Calculated loadings were also reviewed in the draft TMDL report Tables 6-4 and 6-5. The loadings were accurately calculated for the industrial Individual Permits (IPs) as presented in Table 6-5 of the draft TMDL as the correct approach was utilized in those calculations (see Table – 1 above). DEQ did consider two separate requests from industrial facilities regulated under an Individual Permit (IP) for an enhanced review of the outfalls that comprised the basis of their calculated baseline loads. That review led to modified baseline loading for one of the two industrial facilities. Of note, the baseline and WLA loadings presented in Table 6-4 for the Industrial Storm Water General Permits (ISWGP) were recalculated due to a conversion error from acreages to square footage that led to an overestimation in PCB loads. The loadings in table 6-4 have been updated in the draft report and were calculated following the approach specified in the VPDES General Permit Regulation for Discharges of Stormwater Associated with Industrial Activity (9VAC25-151-70). The resulting consequence of this error, along with the 99% allocation of the contaminated sites, led to the recalibration and rerun of the PCB model. The TMDL has been updated accordingly.