Bull Creek Draft Phased TMDLs
for a Benthic Impairment
Buchanan County, Virginia

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Bull Creek Draft Phased TMDLs
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Buchanan County, Virginia

Prepared by:

Virginia Tech Department of Biological Systems Engineering

In cooperation with:

Virginia Department of Environmental Quality

and

Virginia Department of Mines, Minerals, and Energy

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Table of Contents

List of Tables

List of Figures

List of Acronyms

AML	Abandoned Mine Land
AVGWLF	ArcView Generalized Watershed Loading Functions
BMP	Best Management Practices
BSE	Biological Systems Engineering
COD	Chemical Oxygen Demand
DCR	Department of Conservation and Recreation
DEQ	Department of Environmental Quality
DGO	Division of Gas & Oil
DMLR	Division of Mined Land Reclamation
DMME	Department of Mine, Minerals, and Energy
DO	Dissolved Oxygen
E&S	Erosion and Sediment Control Program
GIS	Geographic Information Systems
GWLF	Generalized Watershed Loading Functions
HRU	Hydrologic Response Unit
HSPEXP	Expert System for Calibration of HSPF
HSPF	Hydrological Simulation Program - FORTRAN
LA	Load Allocation
MDL	Minimum Detection Limit
MFBI	Modified Family Biotic Index
MOS	Margin of Safety
MPID	Monitoring Point Identification Number
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
PEC	Probable Effect Concentrations
RBP	Rapid Bioassessment Protocol
RBP II	Rapid Bioassessment Protocol 2
RESAC	Regional Earth Science Application Center
SMC	Unsaturated Soil Moisture Capacity
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
VaSCI	Virginia Stream Condition Index
VBMP	Virginia Base Mapping Project

VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System
VT	Virginia Tech
WLA	Waste Load Allocation

PREFACE

Virginia's Phased Resource Extraction TMDLs: Bull Creek

In order to meet the U. S. Environmental Protection Agency's (EPA) May 1, 2010 deadline, Virginia agencies have been working diligently to complete a Total Maximum Daily Load (TMDL) study for Bull Creek. The following draft report represents the product of the state's efforts to date. During development, uncertainties and differences of interpretation regarding report narrative, report format, data, and predictive tools were identified. Assistance with the TMDL was solicited from the U. S. Office of Surface Mining, U. S. EPA, and private contractors. This TMDL was developed with the best available data and information to determine pollutant load reductions. Additional monitoring is recommended to resolve any uncertainties in pollutant sources. Therefore, the report is being presented as a "phased" TMDL in accordance with EPA guidance and the state will utilize an adaptive management approach.

Phased TMDL

A revised TMDL document will be developed by the Virginia Department of Environmental Quality (DEQ) and the Virginia Department of Mines, Minerals, and Energy's Division of Mined Land Reclamation (DMLR). The revised TMDL is planned for submittal to EPA two years from the date that both the U. S. EPA Region III has approved and the Virginia State Water Control Board (SWCB) has adopted the "phased" Bull Creek TMDL. DMLR will take the lead role with the revisions.

Adaptive implementation is an iterative implementation process that moves toward achieving water quality goals while collecting, and using, new data and information. It is intended to provide time to address uncertainties with TMDLs and make necessary revisions while interim water quality improvements are initiated.

A monitoring plan and experimentation for model refinement will be implemented by the DEQ and DMLR during the period of time beginning with the submittal to EPA of this Draft until the preparation of the revised TMDL submittal to EPA.

Interim Actions

The follow interim actions will be implemented immediately upon both the approval of the TMDL by EPA and adoption of the TMDL by the SWCB:

DMLR will utilize its existing TMDL processes and software to maintain or decrease existing pollution wasteloads from active mining for sediment (TSS) and total dissolved solids (TDS). DMLR will also restrict and minimize impacts of additional mining, through the use of offset requirements, to collective pollution loads equal to or below current wasteloads.

All Waste Load Allocations in this TMDL will be effective and implemented by DMLR. EPA regulations require that an approvable TMDL include individual WLAs for each point source. According to 40 CFR ’122.44(d)(1)(vii)(B), effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, shall be consistent with assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA pursuant to 40 CFR ‘130.7.” DEQ will permit non-coal dischargers in compliance with wasteload allocations included in the TMDL and the agencies' current policies and procedures.

It is DMME's intentions to gather additional monitoring data, conduct modeling refinements, and revise this TMDL if warranted within two years of the approval of this TMDL. Therefore, DMME recommends that the waste load allocations for active mining in this TMDL be implemented in a staged approach. On-going, long-term efforts to improve the watershed as described below will continue.

- The elimination or reduction of pollution loads from abandoned coal mined lands (AML) is typically necessary for the state to meet the allocations prescribed in Virginia's resource extraction TMDLs.

DMLR's efforts to eliminate and reduce pollution from AML will continue in the TMDL watershed.

- DMLR will utilize AML Program Funding, including the U. S. Office of Surface Mining's annual AML grants, Clean Streams Initiative, and Acid Mine Drainage set-aside provisions, to remediate AML problems within the watersheds.
- DMLR recognizes that assistance is needed with AML reclamation and will encourage assistance from Virginia's active coal mining industry. Several approaches, consistent with this recognition, will be implemented including re-mining, Rahall permits, AML enhancements, and TMDL offsets.
- TMDL offsets will provide for mine discharge permit applicants to reclaim existing AML features within the watershed to create a water pollution offset for proposed coal mining activities. The offsets will be required to contain a positive ratio for pollution reduction and to eliminate permanent pollutant sources for temporary pollution credit.
- The Federal effluent guidelines for the coal mining point source category (40 CFR Part 434) provide various alternative limitations for discharges caused by precipitation. Under those technology-based guidelines, effluent limitations for TSS may be replaced with an alternative limitation for settleable solids during certain magnitude precipitation events that vary by mining subcategory. The water quality-based WLAs in this TMDL report preclude the applicability of the alternative precipitation provisions of 40 CFR Part 434. During the 2-yr phased TMDL, efforts will be made to perform TSS monitoring during the full range of storm events occurring in that time period. This will improve the assessment of sediment loads from active mining areas.

Please note that sections of the draft TMDL report, *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia*, have been revised. Refer to the attached amendment which provides the revised contents of the TMDL document. The TMDL allocations and the methods used to compute the TMDL allocations presented in the attachment will supersede those that are presented in the draft report. Written public comments received on the amendment to the report are attached and will be considered and addressed during the second phase of TMDL development.

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EXECUTIVE SUMMARY

Background

The purpose of this report is to describe the Total Maximum Daily Loads (TMDLs) developed to address the benthic impairments on Bull Creek. A part of the Big Sandy River basin, the Bull Creek watershed comprises state hydrologic unit Q08 (National Watershed Boundary Dataset BS14), and is located west of Harman Junction and US Highway 460 in Buchanan County, Virginia, Figure ES-1. The watershed is 3,128.5 ha (7,731 acres) in size. The main land use in Bull Creek is forest, 88% of the total watershed area. The remaining land uses include 6.5% in mining-related land uses, 4.5% in urban/residential, and 1% in agriculture. Bull Creek flows east and discharges into Levisa Fork, which flows northwesterly into Kentucky, where it enters the Big Sandy River. The Big Sandy River is a tributary of the Ohio River which flows into the Mississippi River and then to the Gulf of Mexico.

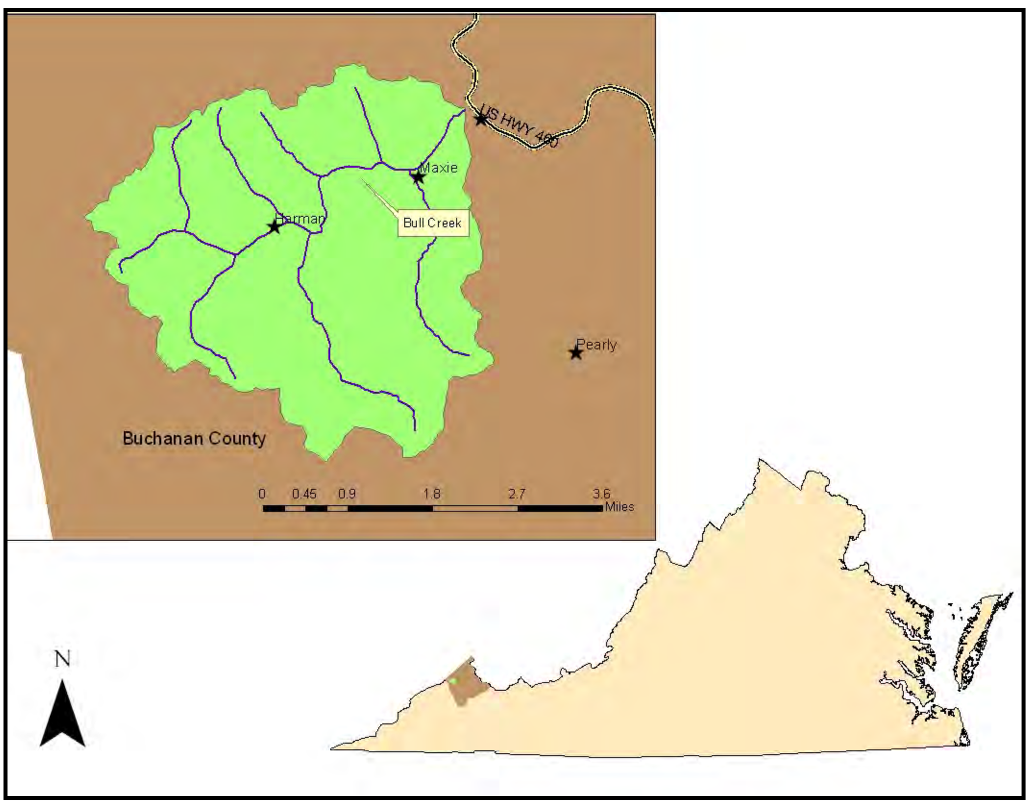


Figure ES- 1. Location of Bull Creek Watershed

Aquatic Life Use Impairment

Bull Creek and its tributaries – Left Fork Bull Creek (Convict Hollow), Belcher Branch, Deel Fork, and Cove Hollow − were originally listed as impaired on Virginia's 1998 Section 303(d) TMDL Priority List and Report due to water quality violations of the general aquatic life (benthic) standard. As a result, the U.S. Environmental Protection Agency (USEPA) added Bull Creek to the 1998 consent order requiring a TMDL by May 2010.

The Virginia Department of Environmental Quality (DEQ) has delineated the benthic impairment as 16.84 miles on Bull Creek and its tributaries (stream segment VAS-Q08R_BLC01A98). The impaired stream segment begins in the headwaters and extends to the confluence of Bull Creek with Levisa Fork.

Benthic Stressor Analysis

TMDLs must be developed for a specific pollutant. Since a benthic impairment is based on an assessment of the stream's biological community, rather than on a physical or chemical water quality parameter, the pollutant is not explicitly identified, as is the case with physical and chemical parameter-based impairments. A stressor analysis was conducted to identify the sources of stress on the biological community in Bull Creek. The candidate stressors considered in this analysis were ammonia, hydrologic modifications, nutrients, organic matter, pH, sediment, total dissolved solids (TDS) and related parameters, temperature, and toxics. The information in this report was adapted from the Stressor Analysis Report for Bull Creek (Yagow et al., 2007).

Bull Creek (VAS-Q08R_BLC01A98) is severely to moderately impaired, with individual Virginia Stream Condition Index (VaSCI) scores varying between 26.1 and 43.2 (a score of 60 or above is considered non-impaired on a 0 to 100 scale). Biological and ambient monitoring within this watershed is sparse with limited biological monitoring conducted in 1996, 2001, and 2006. Ambient DEQ water quality data has been collected only since May 2005. The available Virginia Department of Mines, Minerals, and Energy's (DMME) Division of Mined Land Reclamation (DMLR) in-stream monitoring concentration data for TDS and related parameters are all frequently greater than the DEQ screening values used for selection of reference conditions. Although a mixture of possible stressors are present in the watershed, TDS and excess sediment were identified as the most probable stressors to the benthic community in Bull Creek and its tributaries. Bull Creek is impacted by abandoned mine land (AML), mining activities, logging, gas well activities, stream bank instability, and hydrologic modification in the watershed.

The case for sediment as a stressor is supported by the consistently low proportion of haptobenthos organisms (those requiring clean substrates) and the poor habitat metrics (the result of increased embeddedness) both due to excess sediment deposition in Bull Creek. Additionally, poor metrics scores were reported in earlier samples for bank stability and riparian vegetation. A few elevated total suspended solids (TSS) measurements were reported by DEQ during the 1998 assessment period. Since storm runoff is not typically monitored, a lack of elevated TSS concentrations does not provide evidence to rule out sediment as a stressor. Elevated TSS concentrations have been more widely and more frequently reported through DMLR's in-stream monitoring. Sediment is also supported by the high degree of embeddedness noted in the 1996 habitat assessment, and AML sites that exist in the area that have yet to be remined/reclaimed. The high levels of in-stream TDS and its correlates are also likely contributors to the stress evidenced by the benthic community.

Coal mining activities, including surface, auger, and deep mining, have been conducted in the Bull Creek watershed since the 1930's. Most of the mining was conducted prior to the current Surface Mining Control and Reclamation Regulations and resulted in over 1,000 acres of pre-law abandoned mined lands (AML) within the watershed. Five deep mines operated in the watershed prior to 1996. Although currently AML and barren areas (including active surface mining) are the major suspected sources of impairment in Bull Creek, prior to the first benthic sample taken in 1996, no surface mines were active in the watershed and so, surface mining activities could not have been the cause of the original impairment. One of the deep mines ceased operation in 1994, and another was downstream from the biological monitoring station, 6ABLC002.30. Additionally, during the 1998 assessment period, a coal processing plant operated adjacent to Bull Creek around stream mile 3.0, just above its confluence with Starr Branch (and upstream from biological monitoring station 6ABLC002.30, whose initial measurement resulted in the "impaired" listing). This plant loaded coal out of the watershed on a rail spur, which ran alongside Bull Creek from the plant to the mouth of the watershed. Stakeholders reported that Bull Creek often ran black from the processing plant discharges. The coal processing plant ceased operations in the late 1990s and the rail spur has since been removed.

Prior to 1996, approximately 10 gas wells were producing above station 6ABLC002.30 and one abandoned mine contributed discharge on Belchers Branch, which enters Bull Creek just downstream from 6ABLC002.30. From DMLR monitoring, repeated low pH values were reported for Jess Fork in the mid-1990s, together with high values of conductivity, TDS, and sulfates from Jess Fork, Deel Fork, Starr Branch, and Belcher Branch. Therefore, the initial cause of the impairment appears to have been a combination of low pH, high TDS and sediment, and to be attributable to the coal processing plant discharge, with additional impacts from AML runoff and deep mine discharges. Although the major suspected source of the 1996 impairment no longer exists and pH values all currently fall within an acceptable range, the TDS and sediment stressors continue to be elevated and are most likely the cause of the present day impairment. The location of the impaired segments of Bull Creek and its tributaries are shown in Figure ES-2.

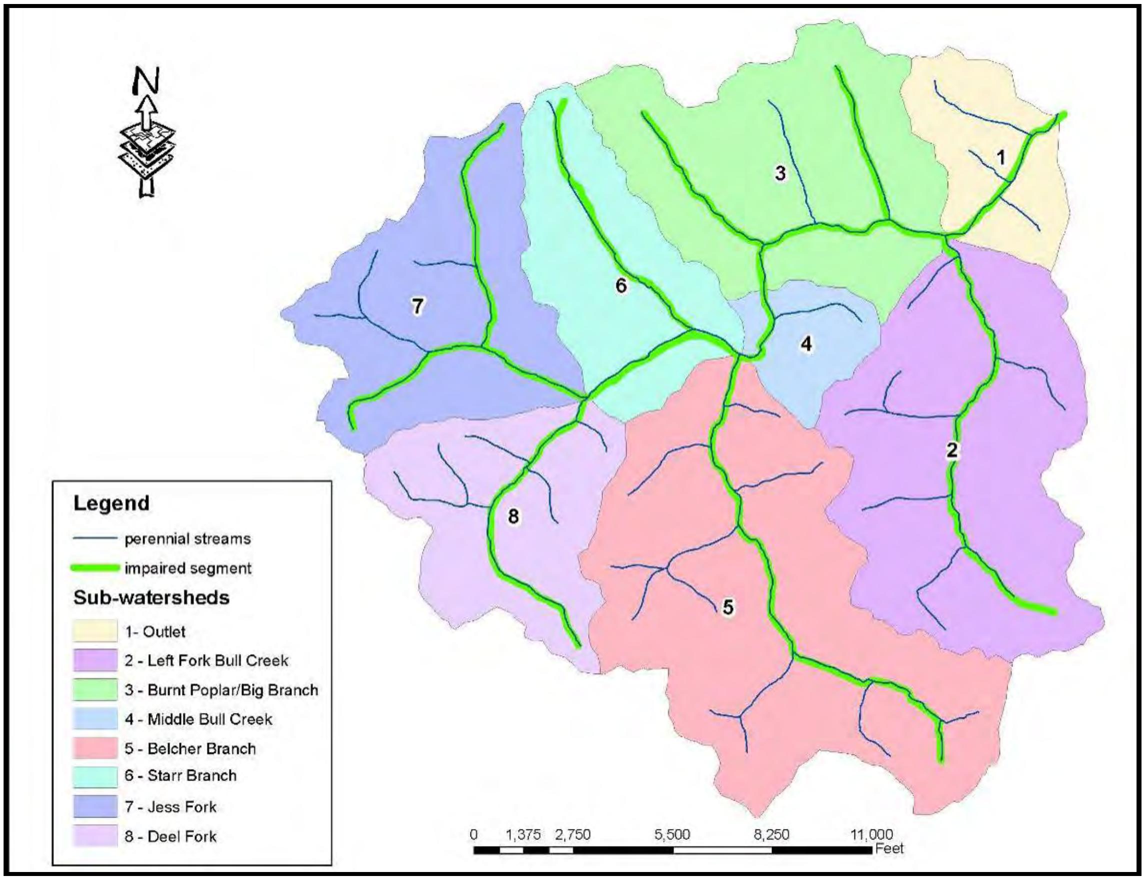


Figure ES- 2. Impaired Segments in Bull Creek

Bull Creek biological monitoring metrics have shown a slight improvement over time. At the same time, TDS concentrations have shown a slight decrease. This further supports the association between the biological metrics and TDS and/or its constituents. Although mining activities appear to be the source of the increased TDS concentrations, it is not possible at this time to discriminate between contributions from surface and deep mining sources. Sediment and TDS were selected as the most probable stressors based on the repeated poor scores for sediment metrics in the habitat assessment and elevated observed TSS and TDS concentrations.

Changes to the Bull Creek TMDLs since the 09/23/08 Public Meeting

Changes to the Bull Creek sediment and TDS TMDLs since the last Public Meeting on September 23, 2008 include:

- TMDLS were designated as "phased" TMDLs due to uncertainties in pollutant load distribution among identified sources.
- Correction to the classification of the "barren" land use as a non-mining land use, as originally intended.
- Sediment TMDL
    - Used "existing" loads as the basis for reductions, rather than "future" loads that assumed unlimited disturbed areas within each mining permit.
    - Changed simulation period to 1995-2007, which corresponds with the period after which DMLR began electronic record keeping. Previously, the simulation period was 1985-2003.
    - Calibrated the GWLF model using DMLR observed flow and TSS data to ensure closer comparability with DMLR accounting procedures for regulated permit waste loads.
- TDS TMDL
    - Corrected the representation of direct mine discharges in the Bull Creek TMDL model. This change resulted in increased TDS load from this source.
    - Separated background loads arising from interflow for non-mining land uses from permitted mining waste loads.

Sediment TMDL Development

Sources of Sediment

Sediment is generated in the Bull Creek watershed through the processes of surface runoff, in-channel disturbances, and streambank and channel erosion. Sediment generation is accelerated through human-induced land-disturbing activities related to a variety of agricultural, forestry, mining, transportation, and residential land uses.

Modeling

The sediment TMDL was developed using a “reference watershed” approach to establish the allowable load in the impaired watershed, because Virginia has no numeric in-stream criteria for sediment. The reference watershed approach uses one watershed whose streams are supportive of their designated uses (the TMDL reference watershed) to establish the target TMDL load for the watershed whose streams are impaired (the TMDL watershed). Upper Dismal Creek, which is not impaired (biological reference station 6ADIS017.94), was selected as the TMDL reference watershed.

The Generalized Watershed Loading Function (GWLF) model (Haith et al., 1992) was selected for comparative modeling for the sediment TMDL study. All parameters were initially evaluated in a consistent manner between the reference and impaired watersheds, in order to ensure their comparability for the reference watershed approach. All GWLF parameter values were evaluated from a combination of GWLF user manual guidance (Haith et al., 1992), AVGWLF procedures (Evans et al., 2001), procedures developed during the 2002 statewide NPS pollution assessment (Yagow et al., 2002), and best professional judgment. Parameters for active mining and AML land uses were evaluated from available literature sources.

Historically in Virginia, the GWLF model has been used in a variety of TMDLs to address sediment as a stressor in streams with benthic impairments. In these previous TMDLs, sediment has only been subject to accounting and reductions from non-permitted sources, and the successful restoration of the impaired stream was to be judged solely by the recovery of the benthic macro-invertebrate population and associated metrics, not by measured in-stream sediment. This is clearly not the case in Bull Creek, where permitted waste load allocations for sediment are closely monitored and tracked by DMLR, and will serve as the basis for determining existing waste load allocations for new mining permits. Although GWLF was originally developed for use in non-gaged watersheds and, therefore, did not require calibration, calibration was performed for flow and sediment in both Bull Creek and its reference watershed, in order to obtain a greater correlation with available observed data, and to achieve a greater degree of consistency with DMLR's tracking software for Waste Load Allocations.

Calibration endpoints were set as unit-area TSS measures developed using the observed data at available DMLR monitoring stations in both the reference and TMDL watershed. Unit-area measures allow for comparison between watersheds of different sizes. The GWLF model was calibrated for both hydrology and sediment, using sub-watersheds defined by the above-mentioned DMLR stations in Bull Creek and Upper Dismal Creek. The hydrology parameters adjusted during calibration included: monthly evapotranspiration (ET) coefficients, the seepage coefficient, and the curve number by landuse. The sediment parameters adjusted during calibration included: sediment pond efficiency, and the curve number by landuse. The calibrated reference and TMDL watershed models yielded simulated results, each within 4% of the calibration targets. These calibration adjustments were then applied to models of the full Bull Creek and Upper Dismal Creek watersheds and model simulations run for the 1995-2007 period.

Bull Creek was sub-divided into eighteen sub-watersheds for representation in the GWLF model, while Upper Dismal Creek was represented as a single watershed. TMDL modeling was then performed using weather input data sets for the 13-yr (1995-2007) period from stations representative of each watershed. The existing sediment loads (both point and nonpoint sources) were modeled and averaged over the 13-year period to account for both wet and dry periods in the hydrologic cycle, which were affected by seasonal variations in model inputs such as precipitation, temperature, evapotranspiration, and erosivity. The 13-yr average annual sediment loads (metric tons per year, t/yr) for both the Bull Creek and Upper Dismal Creek watersheds are listed in Table

ES-1 by source category. Unit area sediment loads (metric tons per hectare, t/ha) are also shown for individual land use categories.

Table ES- 1. Existing Sediment Loads (t/yr) and Unit-Area Loads (t/ha) in Bull Creek and its Reference Watershed

Sediment Sources	Bull Creek		Area-adjusted Upper Dismal Creek	
	(t/yr)	(t/ha)	(t/yr)	(t/ha)
Cropland	11.7	4.2	1.1	3.4
Pasture	8.2	0.3	34.5	0.7
Hay	0.1	0.1	0.0	
Forest	398.9	0.1	374.3	0.1
Barren	1,226.4	19.5	280.3	11.2
Mining				
Extractive	428.3	28.5	21.8	5.6
Reclaimed	8.4	0.9	1.4	0.5
Released	23.9	1.2	4.1	1.4
AML	3,890.3	18.3	2,017.6	13.5
Pervious Urban	9.9	0.2	7.5	0.1
Impervious Urban	6.1	0.2	2.7	0.1
Channel Erosion	26.0		14.4	
Watershed Totals	**6,038.3**		**2,759.7**	

The Phased Sediment TMDL

The phased sediment TMDL for Bull Creek was calculated using the following equation:

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

where ∑WLA = sum of the wasteload (permitted) allocations;

∑LA = sum of load (nonpoint source) allocations; and

MOS = margin of safety.

The TMDL is quantified in Table ES-2. The phased sediment TMDL for Bull Creek watershed in metric tons per year (t/yr) was calculated as the average annual sediment load from the area-adjusted Upper Dismal Creek watershed for existing conditions (Table ES-1). The WLA was calculated for individual permits based on their area in the Bull Creek watershed, simulated runoff from their respective land uses, and permitted maximum TSS concentrations, with allowances for future growth of the coal mining and gas and oil industries. The margin of safety (MOS) was explicitly specified as 10% of the TMDL, and the load allocation (LA) −the allowable sediment load from nonpoint sources− was calculated as the TMDL minus the MOS minus the WLA. The phased sediment TMDL for Bull Creek is 2,759.7 t/yr.

Table ES- 2. Bull Creek Phased Sediment TMDL (t/yr)

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

Sediment TMDL Reductions and Allocations

For development of the allocation scenarios: pasture and hay were grouped into the "pasture/hay" category; and all residential sources were grouped together as "residential/urban". The modeling target sediment load is the TMDL minus the MOS (2,759.7 - 276.0 = 2,483.7 t/yr), so that the overall reduction required for sediment is 58.9%, from 6,038.3 to 2,483.7 t/yr. Several TMDL allocation scenarios were developed based on reductions from different combinations of sediment sources under existing conditions (Table ES- 3). The first scenario calls for equal percent reductions from all permitted and non-permitted mining and disturbed land use categories. The last two scenarios use reductions from only non-permitted sources. TMDL Alternative 2 calls for equal percent reductions from the two largest sources - barren and AML, while TMDL Alternative 3 calls for reductions only from AML. TMDL Alternative 2 is recommended as a starting point for consideration by a local watershed steering committee during the implementation phase.

Table ES- 3. Phased Sediment TMDL Load Allocation Scenarios for Bull Creek

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

AML and barren areas were assessed as the primary sources of sediment in the Bull Creek Watershed. AML reclamation and improved erosion control management and minimization of disturbed area footprints are recommended as the primary targets of implementation efforts. Barren land uses result from construction of access roads and drilling sites for gas and oil wells, logging, and from residential activities.

Components of the Phased Sediment TMDL

The sediment TMDL for Bull Creek is being developed as a phased TMDL because of uncertainties in contributions of simulated loads from various land uses, including permitted sources. Additional monitoring will be conducted during the 2-year phased TMDL period, including TSS monitoring during storms currently allowed to meet an alternate standard for settleable solids. At the conclusion of the 2-year phased TMDL period, TMDL modeling will be revised based on the additional monitoring data.

Modeling of the Bull Creek watershed produced monthly flow volumes and total suspended sediment (TSS) loads, with major contributions from abandoned mine land (AML) and barren areas. This modeling relied on land use-based parameters that governed surface runoff and erodibility, with limited data available in the literature to evaluate and differentiate between these two major sediment sources. Furthermore, the trapping efficiencies of sediment ponds are highly variable, and sufficient data were not available in Bull Creek to evaluate site specific values, leading to the use of debatable values obtained through calibration. In addition, the limited TSS data available at the calibration station in Bull Creek, with a limited range of rainfall-runoff response, made it difficult to judge the reasonableness of modeled load estimates and of relative loads from various mining sources.

The Bull Creek Phased TMDL for sediment will be developed in accordance with EPA's 2006 Guidance on Phased TMDL and will include the following components:

1. The TSS load from permitted mining areas will be calculated from the maximum daily TSS permit criterion of 70 mg/L and the simulated average annual surface runoff volume from extractive areas for all storms, and will comprise the permitted mining component of the WLA.
2. Consistent with current permit conditions, no additional reductions will be required from permitted mining sites below a maximum daily TSS concentration of 70 mg/L, pending further data collection and analysis during the next phase.
3. To address the TSS data deficiency for storm events, TSS monitoring during the 2-yr phased TMDL will be performed during the full range of storm events occurring below the 10-yr, 24-hr design storm. This will improve the assessment of sediment loads from active mining areas.

DMME's March 30, 2009 Memorandum will assist the phased TMDL monitoring effort, by requiring additional TSS sampling for all National Pollutant Discharge Elimination System (NPDES) discharges in TMDL watersheds where TSS is a stressor and in impaired watersheds where resource extraction is listed as causing the impairment. It is important that TSS monitoring be performed because TSS loads are not currently tracked when alternate effluent limits are utilized.

Total Dissolved Solids (TDS) TMDL Development

Sources of TDS

TDS loads are generated in the Bull Creek watershed through surface runoff, interflow, groundwater, and direct discharge. The majority of TDS appears to be related to a mixture of current and historical mining activities, together with background groundwater loads. TDS are coming from both active and abandoned mining areas during surface runoff events, and in-between storms through loading from interflow, groundwater, and pre-law mine discharges. Residential TDS sources within the watershed include failing septic systems and straight pipes. Road salt application is another source of TDS within the watershed during the winter.

Modeling

Virginia has no numeric in-stream criteria for TDS. Lower Dismal Creek was selected as the reference watershed to set an in-stream concentration endpoint for the TDS TMDL. Lower Dismal Creek is in the same county (Buchanan) and physiographic sub-region (Central Appalachians, Cumberland Mountain) as Bull Creek, is currently non-impaired, and has available DEQ-monitored TDS concentration data. While the Lower Dismal Creek watershed is larger than the Upper Dismal Creek watershed which was used as the sediment TMDL reference, it has similar physical characteristics (landuse distribution, soils and slopes), has some mining activity, and has had several bioassessment samples taken which show healthy aquatic communities at stations 6ADIS003.52 and 6ADIS013.73. In addition, TDS data from station 6ADIS0001.24 in Lower Dismal Creek has been used previously to set the TDS TMDL endpoint for the Knox Creek TMDL (MapTech, 2006). The TDS TMDL concentration endpoint for Bull Creek was set at 369 mg/L, the 90th percentile of 34 DEQ-monitored TDS samples taken at station 6ADIS001.24.

The model selected for development of the TDS TMDL was Hydrological Simulation Program–FORTRAN (HSPF), version 12 (Bicknell et al., 2001; Duda et al., 2001). Model development for Bull Creek was performed by assessing the sources of TDS in the watershed, evaluating the necessary parameters for modeling, calibrating to observed data, and running the model to simulate in-stream TDS concentrations and loads. Sources of TDS accounted for in the model include surface disturbances related to mining activities (extractive, AML, reclaimed, and released land uses), pre-law mine discharges, road salt runoff, and failing septic systems and straight pipes. TDS was simulated as a conservative pollutant with load contributed from the various sources through surface runoff, interflow, groundwater, and direct mine discharges. TDS parameter values in the model were initially estimated and then adjusted to match observed in-stream concentrations through calibration.

Because no continuous hydrology data is available on Bull Creek, a detailed hydrology calibration was performed for nearby Cranes Nest River based on flow data from the USGS monitoring station 03208950, and the calibration adjustments transferred to Bull Creek. Simulated mean daily flow was then visually compared to the available instantaneous DMLR-monitored flow data at multiple (7) points throughout the Bull Creek watershed and further adjusted. The calibrated simulated mean daily flow for one of these monitoring points near the outlet of Jess Fork is shown in Figure ES- 3.

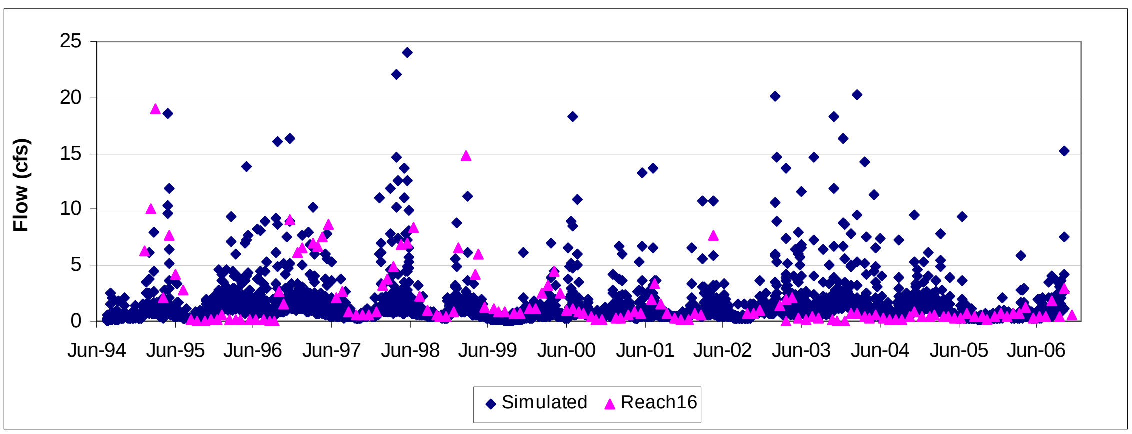


Figure ES- 3. Simulated flow and DMLR observed flow in Bull Creek sub-watershed 16 (Jess Fork) after calibration

Parameters for active mining and AML land uses were initially evaluated from available literature sources, but only limited information was available to differentiate between these sources. Because of the uncertainties in the exact distribution of these loads, a phased TMDL was determined to be appropriate for the TDS stressor in Bull Creek.

Although the distributions among the various pathways of surface transport, interflow, and groundwater contributions to stream loads and between permitted mining and AML sources are somewhat uncertain, the total TDS loads from the watershed appear reasonable in relation to observed in-stream concentrations, and loads from the other sources of TDS – residential, road salt, and pre-law mining – have been estimated with a degree of confidence. To calculate TDS loads generated for each mining permit, the model was first run with loads calculated from individual sub-watersheds with TDS sources from AML, road salt, pre-law mine discharges and residential septic sources turned off. Individual WLAs for each mining permit were based on the proportionate area of each permit within each of the 18 modeling sub-watersheds multiplied times the TDS load from permitted mining sources in each sub-watershed. The watershed load for each permit was then calculated by summing all sub-watershed loads from that permit.

During TDS calibration, parameters values for each sub-watershed were adjusted until simulated in-stream mean daily TDS concentrations and patterns agreed with available instantaneous DMLR TDS data collected in Bull Creek for the period January 2000 – December 2005. TDS calibration was performed at four of the DMLR flow monitoring points within the Bull Creek watershed, where TDS concentrations were also monitored. Inputs for TDS loads from road salt applications, failing septic systems, straight pipes and pre-law mine discharges were quantified, and were not adjusted during calibration. Calibration focused on parameters affecting the largest components of the TDS loads that were less certain: surface runoff, interflow, and groundwater. A multi-point calibration was performed by adjusting appropriate parameter values starting with upstream sub-watersheds and working progressively downstream. Calibrated TDS concentration comparisons are shown in Figure ES- 4 for Bull Creek near the watershed outlet.

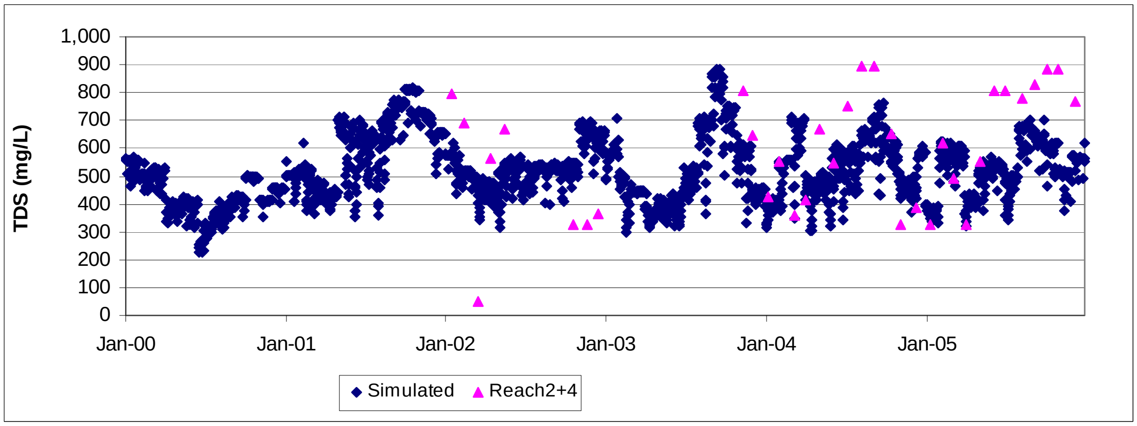


Figure ES- 4. Simulated TDS concentrations and DMLR observed TDS concentrations in Bull Creek sub-watersheds 2+4 (Bull Creek near outlet) after calibration.

A visual comparison of simulated and observed in-stream TDS concentrations and best professional judgment were used to assess when a reasonable model calibration had been achieved. Additionally, the range and average of TDS concentrations were considered during calibration. Taken together, the visual data comparison and the descriptive statistics were evidence of a reasonable calibration of this highly variable parameter.

Average annual TDS loads were simulated using the calibrated model for the existing conditions in the Bull Creek watershed, as reported in Table ES- 4. A 6-year period (January 2000 - December 2005) was used for the Bull Creek simulation.

Table ES- 4. Sources of Existing TDS Loads in Bull Creek

TDS Sources	**Bull Creek Existing TDS Load** (kg/yr)
Permitted Mining	2,976,342
Mine Discharge	1,834,292
AML	600,924
Background	563,863
Road Salt	18,565
Residential	28,063
Total	**6,022,048**

TDS Allocation Scenarios

The TDS concentration endpoint for Bull Creek was achieved by making incremental reductions from various anthropogenic sources of TDS and then simulating the corresponding TDS concentrations and loads. Residential sources of TDS were reduced first, followed by elimination of AML TDS sources. After that, one successful scenario (Scenario 3) was achieved by applying various percent reductions equally to all active mining source categories and mine discharges until the maximum daily average TDS concentration goal of 369 mg/L was achieved. A second successful scenario (Scenario 9) was achieved by also reducing mine discharges by 100% and then applying equal percent reductions to the active mining categories until all daily average TDS concentrations were below the concentration goal. Scenario 9 is recommended as a starting point during implementation, since it requires reductions from all controllable sources before requiring reductions from permitted sources. However, since Scenario 9 requires a larger overall reduction, a comparison of costs and benefits may lead back to the Scenario 3 as a more cost-effective means of achieving the TMDL goal. A summary of the reduction percentages, the resulting maximum daily average concentration, the corresponding annual TDS load, and the overall percent load reduction for a number of scenarios are shown in Table ES- 5.

Table ES- 5. Allocation Reduction Scenarios for Bull Creek

Allocations can be found in the amendment attached to the end of this document:
Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia*
(Initially submitted to VADEQ April 2010)

The Phased TDS TMDL

The TDS TMDL was developed as the load corresponding to Scenario 9 in Table ES- 5. The TDS TMDL for Bull Creek was calculated using the following equation:

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

where ∑WLA = sum of the waste load (permitted) allocations;

∑LA = sum of load (nonpoint source) allocations; and

MOS = margin of safety.

The LA component load was calculated as the TDS load from road salts, from pre-law direct mine discharges, and from background sources in interflow. The MOS used in this TMDL was implicit, based on the use of the conservative 90th percentile of observed TDS concentrations in the reference watershed for setting the TMDL TDS concentration endpoint. In Lower Dismal Creek, the 90th percentile values were actually 15.5% lower than the maximum observed values. The WLA was calculated as the TMDL minus the LA. The WLA includes the combined allocations for mining sources from a combination of surface runoff, interflow, and groundwater loads. Individual WLAs for each mining permit were based on the proportionate area of each permit within each of the 18 modeling sub-watersheds multiplied times the TDS load from permitted mining sources in each sub-watershed. The distribution of permit areas by sub-watershed is given in Appendix Table D.1. The TMDL and its component loads are shown in Table ES- 6 for Scenario 9.

Table ES- 6. Bull Creek Phased TDS TMDL (kg/yr)

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

In this watershed, after source characterization and modeling were completed, AML areas, pre-law mine discharges, and active mining sources were assessed as the primary contributors of TDS. AML reclamation and improved TDS source reduction and site management of active mining areas should be the primary targets of implementation efforts.

Components of the Phased TDS TMDL

The Bull Creek Phased TMDL for TDS will be developed in accordance with EPA's 2006 Guidance on Phased TMDL and will include the following components:

1. For the phased TDS TMDL, TDS loads will be calculated for each mining permit based on simulated loads with all TDS sources turned off except those related to permitted mining. The TDS loads from each sub-watershed will then be apportioned on an area-basis to all permits within each sub-watershed. TDS loads attributed to each permit will be summed from all sub-watersheds that included part of each permit's area.
2. Expanded DMLR requirements, as noted in a March 30, 2009 Memorandum to coal mining permittees, will include TDS monitoring at all outfalls in watersheds where an Aquatic Life Use impairment has been identified, in addition to those where TDS has already been identified as a stressor.
3. Although difficult to quantify, additional monitoring is needed to more accurately distinguish between levels of TDS attributable to permitted mining from surface runoff, interflow and groundwater.

Reasonable Assurance of Implementation

TMDL Compliance Monitoring

DEQ will continue monitoring benthic macroinvertebrates at station 6ABLC002.30 in accordance with its biological monitoring program and TSS and TDS at station 6ABLC000.85 in accordance with its ambient monitoring program. DEQ will continue to use data from this monitoring station and related ambient monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

Additionally, DMME monitoring of the NPDES discharge points for the TMDL stressor pollutants – TSS and TDS – will continue to be in accordance with DMLR's monitoring guidance DMME, 2008.

Since TMDLs are expressed in terms of annual loads, discharge flow rates should be measured concurrently with water quality sampling, and recorded together with existing daily precipitation data monitored by DMLR-approved sources. When monitoring indicates that the TMDL TDS WLAs are being exceeded DMLR will implement the agency's Waste Load Reduction Actions.

Regulatory Framework

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of the first step for the benthic impairment on Bull Creek. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan and to monitor stream water quality to determine if water quality standards are being attained.

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, Virginia Department of Conservation and Recreation (DCR), DMME, and other cooperating agencies.

Implementation

Implementation of this TMDL will contribute to on-going water quality improvement efforts in the Bull Creek watershed. Improvements in the watershed are underway for the control of suspected sources of sediment. These include the on-going efforts to re-mine and reclaim all previously abandoned mine land.

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. One Technical Advisory Committee (TAC) meeting was held on October 10, 2007 followed that evening with a public meeting. The benthic stressor analysis report for Bull Creek was circulated on February 7, 2008 to all members attending both the TAC and public meetings for comment. One comment was received in response, and responses to these comments have been included in the final TMDL report.

The draft sediment and TDS TMDLs report on Bull Creek for the benthic impairment were presented at a public meeting, held on March 20, 2008, at the Harman Memorial Baptist Church in Maxie, Virginia. This public meeting was attended by 12 stakeholders. The public comment period ended on April 20, 2008.

Due to revisions to the draft TMDLs, another public meeting was held on September 23, 2008 to present the revised draft sediment and TDS TMDLs. This meeting was also held at the Harman Memorial Baptist Church in Maxie, Virginia. This public meeting was attended by 8 stakeholders. The public comment period ended on October 22, 2008.

Uncertainties related to the modeling and source differentiation led to the development of phased TMDLs which will be presented at a public meeting scheduled for January 14, 2010. This meeting will be held in conjunction with a TMDL public meeting for a downstream impairment on Levisa Fork.

CHAPTER 1: INTRODUCTION

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 (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to identify water bodies that violate state water quality standards and to develop Total Maximum Daily Loads (TMDLs) for such water bodies. A TMDL reflects the pollutant loading a water body can receive and still meet water quality standards. A TMDL establishes the 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. Impairment Listing

Bull Creek and its tributaries − Left Fork Bull Creek (Convict Hollow), Belcher Branch, Deel Fork, and Cove Hollow − were originally listed as impaired on Virginia's 1998 Section 303(d) Total Maximum Daily Load Priority List and Report due to water quality violations of the general aquatic life (benthic) standard. As a result, the USEPA added this stream to a 1998 consent order requiring a TMDL by May 2010.

The Virginia Department of Environmental Quality (DEQ) has delineated the benthic impairment as 16.84 miles on Bull Creek and its tributaries (stream segment VAS-Q08R_BLC01A98). The impaired stream segment begins in the headwaters and extends to the confluence of Bull Creek with Levisa Fork, a tributary of the Big Sandy River.

1.1.3. Watershed Location and Description

A part of the Big Sandy River basin, the Bull Creek watershed comprises state hydrologic unit Q08 (National Watershed Boundary Dataset BS14), and is located west of Harman Junction and U.S. 460 in Buchanan County, Virginia, as shown in Figure 1.1. The watershed is 3,128 ha (7,731 acres) in size. The main land use category in Bull Creek is forest, which comprises approximately 88% of the total watershed area. The remaining land uses include 6.5% in mining-related land uses, 4.5% in urban/residential, and 1% in agriculture. Bull Creek flows east and discharges into Levisa Fork, which flows northwesterly into Kentucky, where it enters the Big Sandy River. The Big Sandy River is a tributary of the Ohio River which flows into the Mississippi River and then to the Gulf of Mexico.

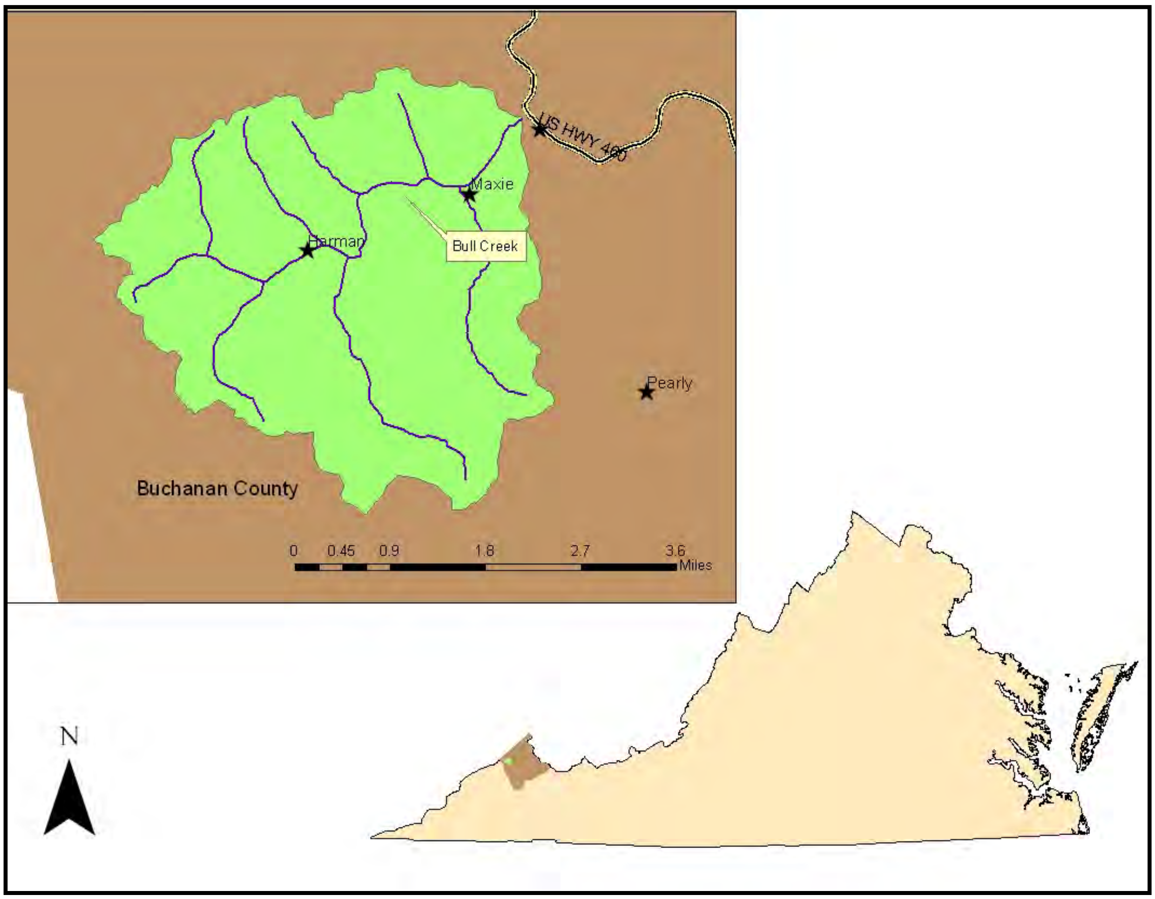


Figure 1.1. Location of Bull Creek Watershed

1.1.4. Pollutants of Concern

Pollution from both point and nonpoint sources can lead to a violation of the benthic standard. A violation of this standard is assessed on the basis of measurements of the in-stream benthic macro-invertebrate community. Water bodies having a benthic impairment are not fully supportive of the aquatic life designated use for Virginia's waters.

Designated Uses and Applicable Water Quality Standards

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

"A. All state waters 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, 2002.

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

The general standard for a water body in Virginia is stated as follows:

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

Specific substances to be controlled include, but are not limited to: floating debris, oil scum, and other floating materials; toxic substances (including those which bioaccumulate); substances that produce color, tastes, turbidity, odors, or settle to form sludge deposits; and substances which nourish undesirable or nuisance aquatic plant life. Effluents which tend to raise the temperature of the receiving water will also be controlled." SWCB, 2002.

The biological monitoring program in Virginia that is used to evaluate compliance with the above standard is run by the Virginia Department of Environmental Quality (DEQ). Evaluations of monitoring data from this program focus on the benthic (bottom-dwelling) macro (large enough to see) invertebrates (insects, mollusks, crustaceans, and annelid worms) and are used to determine whether or not a stream segment has a benthic impairment. Changes in water quality generally result in alterations to the quantity and diversity of the benthic organisms that live in streams and other water bodies. Besides being the major intermediate constituent of the aquatic food chain, benthic macro-invertebrates are "living recorders" of past and present water quality conditions. This is due to their relative immobility and their variable resistance to the diverse contaminants that are introduced into streams. The community structure of these organisms provides the basis for the biological analysis of water quality. Qualitative and semi-quantitative biological monitoring have been conducted by DEQ since the early 1970's. The U.S. Environmental Protection Agency's (USEPA) Rapid Bioassessment Protocol (RBP) II was employed beginning in the fall of 1990 to utilize standardized and repeatable assessment methodology. For any single sample, the RBP II produces water quality ratings of "non-impaired," "slightly impaired," "moderately impaired," or "severely impaired." In Virginia, benthic samples are typically collected and analyzed twice a year in the spring and in the fall.

The RBP II procedure evaluates the benthic macro-invertebrate community by comparing ambient monitoring "network" stations to "reference" sites. A reference site is one that has been determined to be representative of a natural, non-impaired water body. The RBP II evaluation also accounts for the natural variation noted in streams in different eco-regions. One additional product of the RBP II evaluation is a habitat assessment. This is a stand-alone assessment that describes bank condition and other stream and riparian corridor characteristics and serves as a measure of habitat suitability for the benthic community.

Beginning in 2006, DEQ switched their bioassessment procedures. While the RBP II protocols were still followed for individual metrics, a new index, the Virginia Stream Condition Index (VaSCI), was developed based on comparison of observed data to a set of reference conditions, rather than with data from a reference station. The new index was also calculated for all previous samples in order to better assess trends over time.

Determination of the degree of support for the aquatic life designated use is based on biological monitoring data and the best professional judgment of the regional biologist, relying primarily on the most recent data collected during the current 5-year assessment period. In Virginia, any stream segment with an overall rating of "moderately impaired" or "severely impaired" is placed on the state's 303(d) list of impaired streams (DEQ, 2002).

CHAPTER 2: WATERSHED CHARACTERIZATION

Water Resources

The DEQ has delineated the benthic impairment on Bull Creek and tributaries (stream segment VAS-Q08R_BLC01A98) as a stream length of 16.84 miles. The impaired stream segment begins at the confluence of Bull Creek and Levisa Fork and extends to its headwaters. Named tributaries to Bull Creek within the impaired watershed include Left Fork Bull Creek (Convict Hollow), Belcher Branch, Deel Fork, and Cove Hollow. Bull Creek and Left Fork Bull Creek join together near Maxie. Belcher Branch and Starr Branch are tributaries to Bull Creek, entering Bull Creek about 2.73 and 3.01 miles upstream of the confluence of Bull Creek, respectively. Bull Creek begins at the confluence of Jess Fork and Deel Fork, which is approximately located at stream mile 3.97 along the main channel of Bull Creek. The relationship between the impaired segments and major sub-watersheds is shown in Figure 2.1.

Eco-region

The Bull Creek watershed is located entirely within the Cumberland Mountains sub-division of the Central Appalachians eco-region. The Central Appalachians is primarily a high, dissected, rugged plateau which is composed of sandstone, shale, conglomerate and coal. The land cover is mostly forested due to rugged terrain, cool climate and infertile soils which limit agriculture. Bituminous coal mines that may cause siltation and acidification of streams are common in this region (USEPA, 2002).

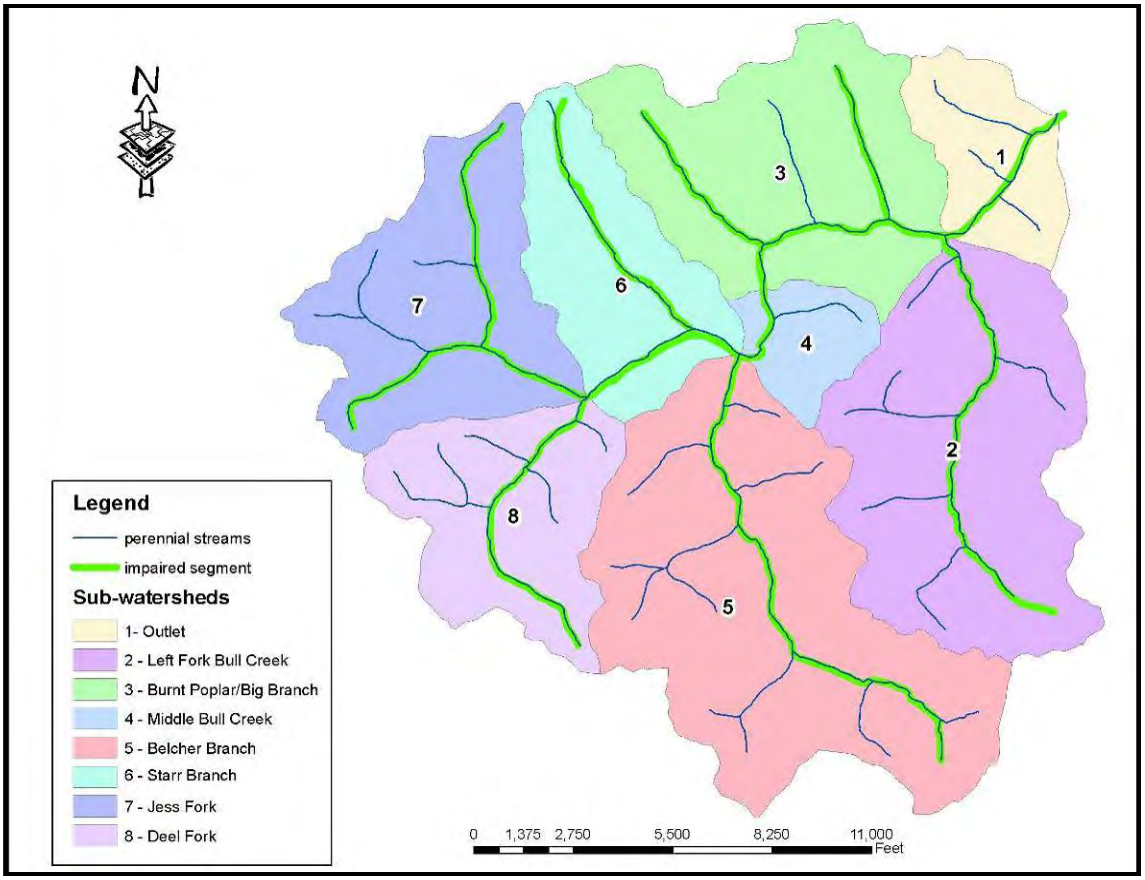


Figure 2.1. Impaired Segments in Bull Creek

Soils and Geology

The soils found in Bull Creek watershed are primarily in the Shelocta, Cloverlick and Matewan series. The Cloverlick-Shelocta complex is a well drained soil comprised of gravelly loam located on mountaintop ridges, spurs, and drainageways. Matewan soils are a flaggy fine sandy loam, shallow, well drained, and contain rock outcrops. These soil types are typically found on ridge tops and side slopes (USDA-NRCS, 2004).

Climate

Climate data for the Bull Creek watershed was based on meteorological observations from the Grundy National Climatic Data Center station (443640) located within Buchanan County, Virginia approximately 4 miles east of the watershed. Average annual precipitation at this station is 45.84 inches. Average annual daily temperature at the Grundy station is 55.3°F. The highest average daily temperature of 87.2°F occurs in July while the lowest average daily temperature of 23.2°F occurs in January, as obtained from the 1971-2000 climate norms (NCDC-NOAA, 2007).

Land Use

Land use for the Bull Creek watershed was derived from the Mid-Atlantic Regional Earth Science Application Center (RESAC, 2000), modified with abandoned mine land (AML) features digitized from USGS 7½-minute topographic maps, and merged with a digital map of current mining permit boundaries from the Virginia Department of Mines, Minerals, and Energy's (DMME) Division of Mined Land Reclamation (DMLR). The RESAC data is available from the Virginia Department of Conservation and Recreation (DCR) upon request and was derived from digital remote sensing and spatial information technologies. Some additional editing was done to reclassify portions of the "barren" and "extractive" classifications which were inconsistent with residential features observed in aerial imagery from the Virginia Base Mapping Program (VBMP, 2002). The 38 land uses in the RESAC data were then categorized into 8 categories. Abandoned mine land (AML) was digitized from USGS topographic maps and added to the RESAC data to identify these historic mining features. A distribution of RESAC and RESAC plus AML land use category areas are shown in Table 2.1. Mining permit areas were then added to this mix to show the broader categories of land uses shown in Figure 2.2. Based on these classifications, the main land use category in Bull Creek is forest (88%). Mining land uses (extractive plus AML) account for approximately 6.5%, while urban/residential land uses (all residential categories plus barren) and agriculture land uses (cropland plus pasture/hay) account for about 4.5% and 1%, respectively.

Table 2.1. Bull Creek RESAC Land Use Category Distribution plus AML

Land Use Category	**RESAC**		**RESAC + AML**	
	Area (ha)	**% of Total**	**Area (ha)**	**% of Total**
Low Density Residential	58.5	1.9%	58.5	1.9%
Medium Density Residential	2.7	0.1%	2.7	0.1%
High Density Residential	29.7	1.0%	29.7	1.0%
Extractive	12.5	0.4%	12.5	0.4%
AML	0.0	0.0%	197.1	6.3%
Barren	49.8	1.6%	49.8	1.6%
Pasture/Hay	24.8	0.8%	24.8	0.8%
Cropland	2.8	0.1%	2.8	0.1%
Forest	2,947.7	94.2%	2,750.7	87.9%
Total Area	**3,128.5**	**100.0%**	**3,128.5**	**100.0%**

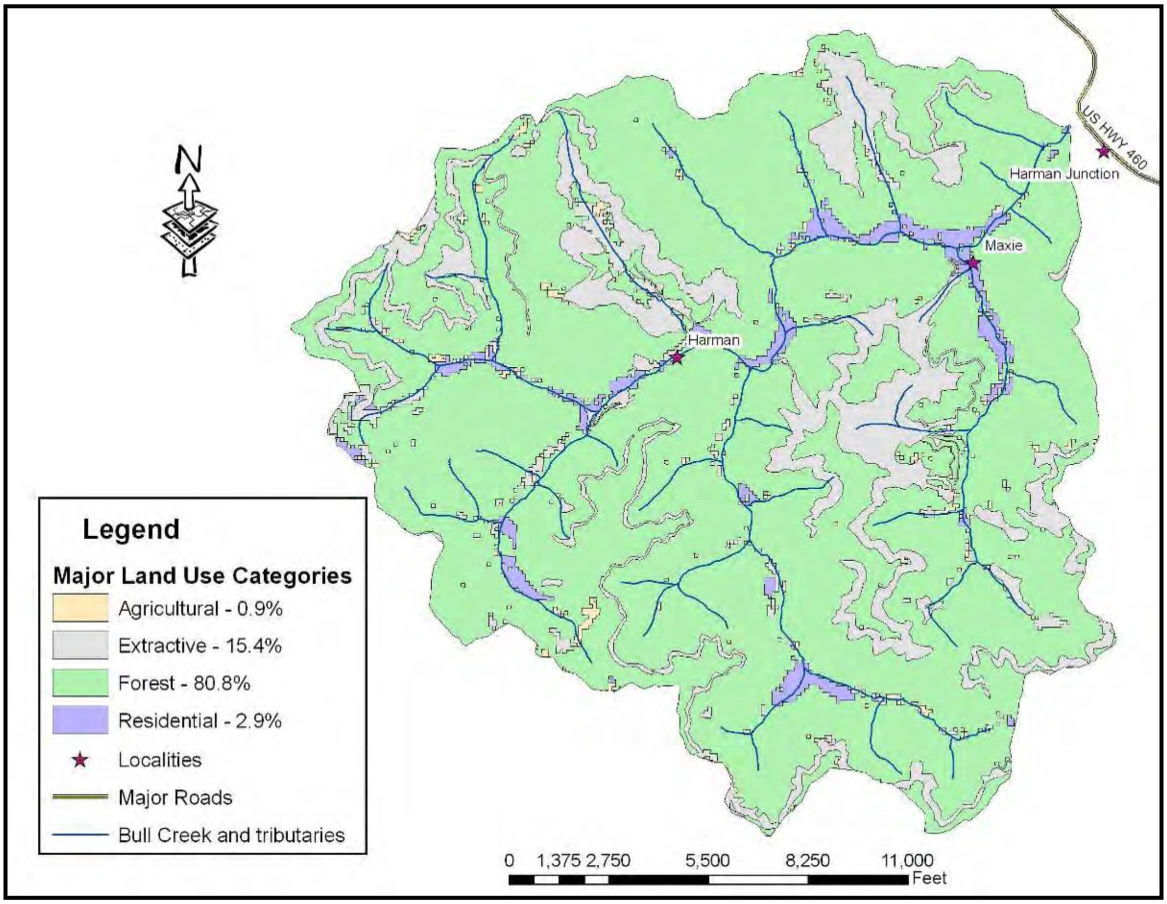


Figure 2.2. Land Use in Bull Creek Watershed

Future Land Use

Land use in Bull Creek for the foreseeable future was assumed to remain similar to existing conditions. Although mining continues within existing permitted areas, the amount of land disturbed at any one time remains approximately the same, since current guidance requires permit holders to minimize disturbed footprints and to reclaim disturbed areas as soon as possible. To account for some additional growth in the mining and gas & oil industries, their respective permitted WLAs for sediment were increased by 10%. The Coalfields Expressway – U.S. Route 121 – is a proposed four-lane highway stretching 51 miles from Pound in Wise County through Dickenson and Buchanan counties to the West Virginia line. An existing Virginia Department of Transportation plan (VDOT, 2006) showed the Coalfields Expressway to run through the center of the watershed (Figure 2.3). Information provided by one stakeholder after the first public meeting, however, placed the location on the eastern ridge of the watershed, so the exact footprint and impact on the watershed is unknown at this time. No other significant land use changes are anticipated.

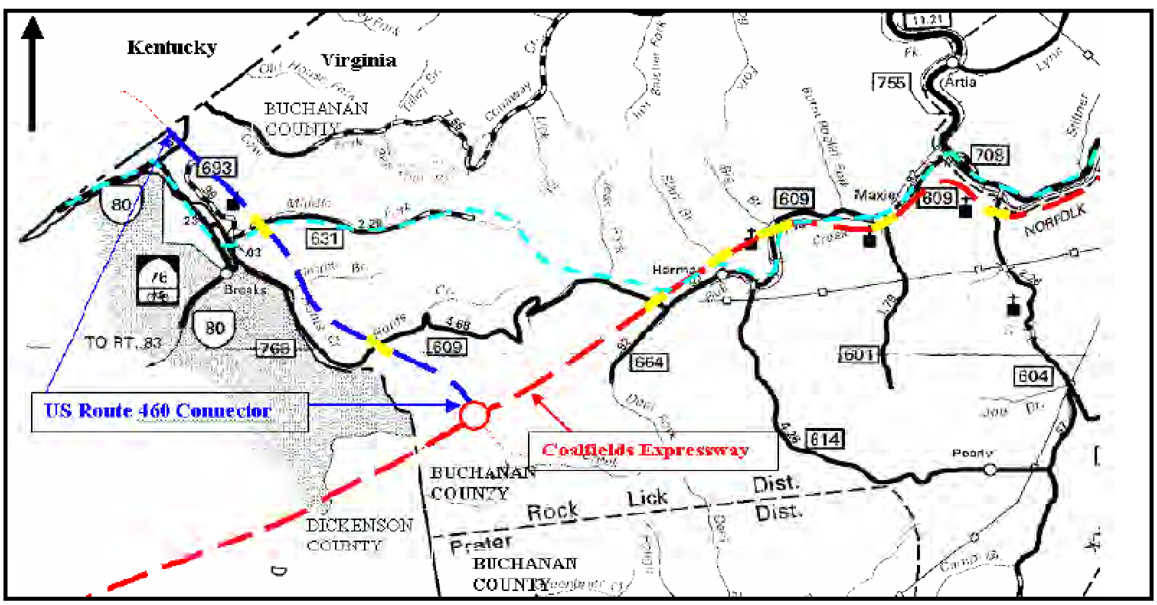


Figure 2.3. Potential Coalfields Expressway Route (VDOT, 2006)

Biological Monitoring Data

Biological monitoring consisted of sampling the benthic macro-invertebrate community along with corresponding habitat assessments. Three biological monitoring stations were located on Bull Creek. The main biological station – 6ABLC002.30 – was monitored four times; once each in 1996 and 2001, and twice in 2006. Two other biological stations – 6ABLC002.77 and 6ABLC003.63 – were each monitored once in 2001. The DEQ 2004 Fact Sheets for Category 5 Waters (DEQ, 2004) state that the 6ABLC002.30 biological station on Bull Creek is severely impaired. The initial listing of Bull Creek and its tributaries was on the 1998 303(d) list which was based on the May 1996 sample, the only sample included in the July 1992 through June 1997 assessment period. The cause of the benthic impairment in Bull Creek was listed as “Resource Extraction”, with the fact sheet indicating other sources of impairment as urban impact. The locations of the DEQ biological and ambient monitoring stations in Bull Creek are shown in Figure 2.4, together with the major tributary sub-watersheds.

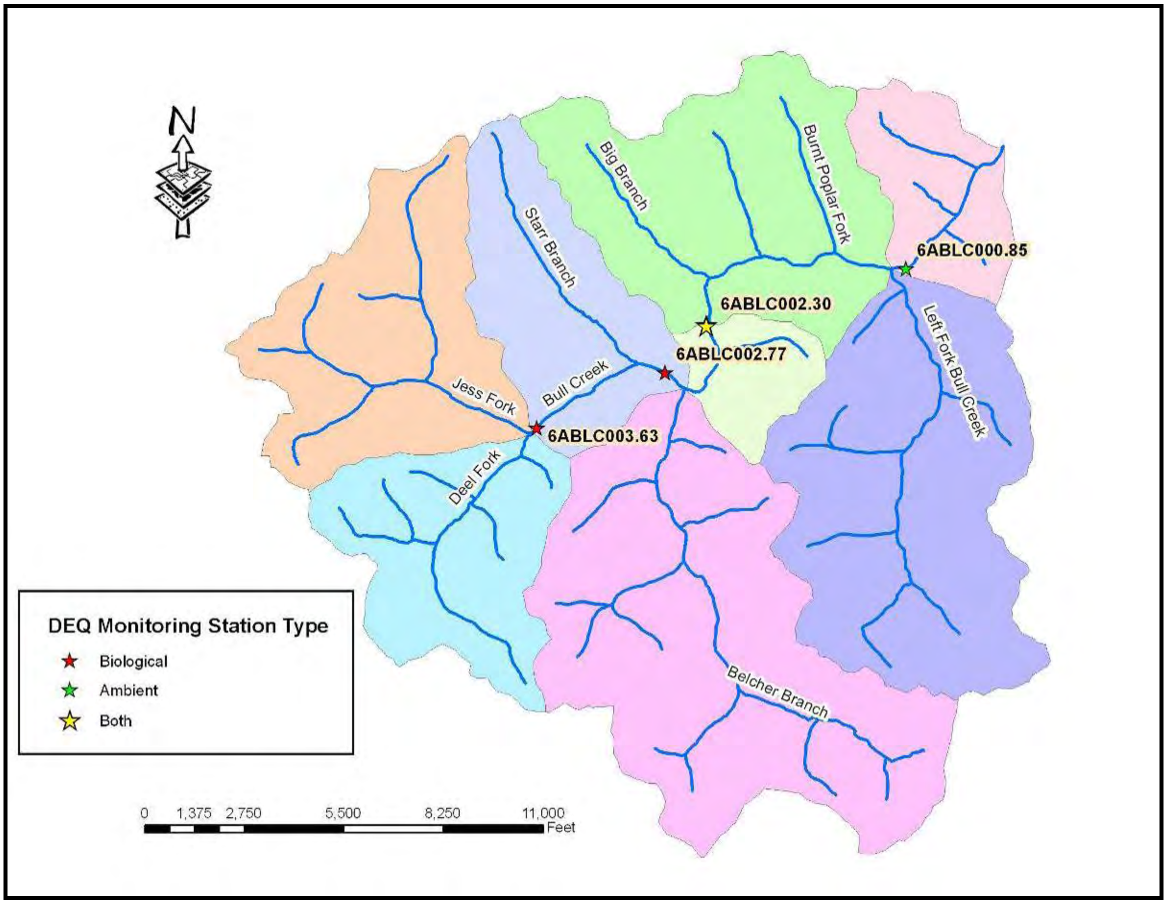


Figure 2.4. Locations of DEQ Monitoring Stations in Bull Creek Watershed

Biological samples were collected from a cross-section of the stream channel and from both pool and riffle environments. The organisms in each sample were separated out into identifiable family or species, and then a count was made of the number of organisms in each taxa. A full listing of the taxa inventory or distribution within each biological sample is given in Table 2.2.

Table 2.2. Bull Creek Benthic Species Distribution by Sample Date

Taxa	Tolerance Value	Functional Family Group	Habit	BLC002.30				BLC002.77	BLC003.63
				05/21/96	09/13/01	05/15/06	11/27/06	09/13/01	09/13/01
Glossosomatidae	0	Scraper	clinger				3		
Capniidae	1	Shredder							
Gomphidae	1	Predator	burrower						
Perlidae	1	Predator	clinger						
Athericidae	2	Predator	sprawler						
Isonychiidae	2	Filterer	swimmer						
Perlodidae	2	Predator	clinger						
Taeniopterygidae	2	Shredder	sprawler						
Philopotamidae	3	Collector	clinger						
Tipulidae	3	Shredder	burrower		2	3	4		6
Baetidae	4	Collector	swimmer		52	46	26	34	9
Elmidae	4	Scraper	clinger	2	4	1	6		1
Ephemerellidae	4	Collector	clinger						
Heptageniidae	4	Scraper	clinger						
Psephenidae	4	Scraper	clinger						
Corydalidae	5	Predator	clinger						
Hydrachnidae	5	Predator				1			
Hydrophilidae	5	Predator							
Ancylidae	6	Scraper	clinger						
Chironomidae (A)	6	Collector			20	67	16	46	46
Empididae	6	Predator	sprawler					3	
Hydropsychidae	6	Filterer	clinger	12	3	9	47	6	24
Simuliidae	6	Filterer	clinger		10	2		7	2
Asellidae	8	Collector	sprawler						1
Corbiculidae	8	Filterer	sprawler						
Corbiculidae	8	Filterer	sprawler						2
Lumbriculidae	8	Collector			1	4		1	2
Physidae	8	Scraper			2		1		
Tubificidae	10	Collector	burrower				2		
No. of Species				**2**	**8**	**8**	**8**	**6**	**9**
Total Abundance				**14**	**94**	**133**	**105**	**97**	**93**

Field Measurements	**Units**						
temperature	(°C)	18.2	16.9	13.7	11.4	17.4	19.3
dissolved oxygen	(mg/L)	8.93	9.7	9.5	11.6	9.4	8.66
conductivity	(µmhos/cm	850	1221	1011	875	1037	792
pH		7.92	8.23	8.6	8.6	8.18	7.83

- Two dominant taxa per sample.

Habit Codes: bur = burrowers; ska = skaters;
cli = clingers; spr = sprawlers;
clm = climbers; swi = swimmers.

The Rapid Bioassessment Protocol II (RBP II) is the official protocol used to assess compliance with the general standard in Virginia (Barbour et al., 1999). The RBP II procedure evaluates the benthic macro-invertebrate community by comparing individual network biomonitoring stations with reference biomonitoring stations on reference streams. Reference biomonitoring stations have been identified by regional biologists that are both representative of regional physiographic and ecological conditions and have a healthy, non-impaired benthic community. Two different reference stations have been used for Bull Creek over time – Upper Dismal Creek (6ADIS017.94) and Fryingpan Creek (6AFRY002.25).

DEQ, with assistance from USEPA Region 3, has recently upgraded its biomonitoring and biological assessment methods to those currently recommended in the mid-Atlantic region. As part of this effort, a study was performed to assist the agency in moving from a paired-network/reference site approach to a regional reference condition approach, and has led to the development of the Virginia Stream Condition Index (VaSCI) for Virginia's non-coastal areas (Tetra Tech, 2002). This multi-metric index is based on 8 biomonitoring metrics, with a scoring range of 0-100, that include some different metrics than those used in the RBP II, but are based on the same taxa inventory. A maximum score of 100 represents the best benthic community sites. The current proposed threshold criteria would define "non-impaired" sites as those with a VaSCI of 60 or above, and "impaired" sites as those with a score below 60 (DEQ, 2006). The VaSCI scores for Bull Creek (Table 2.3) have all clearly fallen within the "impaired" category. Because of the inconsistent use of a single reference station and the incomplete calculation of metrics for one sample, the VaSCI ratings were considered more reliable than the RBP II ratings when attempting to look for relationships between these overall ratings, individual metrics, and potential pollutants in the stressor analysis. The ratings of all of the biological samples taken at all stations within the Bull Creek watershed are depicted graphically in Figure 2.5.

Table 2.3. Virginia Stream Condition Index (Scored against a fixed scale)

	BLC002.30				BLC002.77	BLC003.63	Overall
	05/21/96	09/13/01	05/15/06	11/27/06	09/13/01	09/13/01	Average
VaSCI Metric Values							
TotTaxa	2	8	8	8	6	9	
EPTTax	1	2	2	3	2	2	
%Ephem	0.0	55.3	34.6	24.8	35.1	9.7	
%PT - Hydropsychidae	0.0	0.0	0.0	2.9	0.0	0.0	
%Scrap	14.3	6.4	0.8	9.5	0.0	1.1	
%Chiro	0.0	21.3	50.4	15.2	47.4	49.5	
%2Dom	100.0	76.6	85.0	69.5	82.5	75.3	
MFBI	5.7	4.8	5.3	5.2	5.3	5.7	
VaSCI Metric Scores							
Richness Score	9.1	36.4	36.4	36.4	27.3	40.9	31.1
EPT Score	9.1	18.2	18.2	27.3	18.2	18.2	18.2
%Ephem Score	0.0	90.2	56.4	40.4	57.2	15.8	43.3
%PT-H Score	0.0	0.0	0.0	8.0	0.0	0.0	1.3
%Scraper Score	27.7	12.4	1.5	18.5	0.0	2.1	10.3
%Chironomidae Score	100.0	78.7	49.6	84.8	52.6	50.5	69.4
%2Dom Score	0.0	33.8	21.7	44.0	25.3	35.7	26.8
%MFBI Score	63.0	76.0	69.4	71.1	68.5	62.6	68.5
VaSCI Total Scores	**26.1**	**43.2**	**31.7**	**41.3**	**31.1**	**28.2**	**33.6**
VaSCI Rating	Severe Stress	Stressed	Severe Stress	Stressed	Severe Stress	Severe Stress	Severe Stress
Additional Biological Metrics							
Scraper/Filterer-Collector	0.17	0.07	0.01	0.11	0.00	0.01	
%Filterer-Collector	85.7%	91.5%	96.2%	86.7%	96.9%	92.5%	
%Haptobenthos	0.0%	0.0%	0.0%	0.0%	3.1%	3.2%	
%Shredder	0.0%	2.1%	2.3%	3.8%	0.0%	6.5%	

(pink shading) - Primary biological effects.

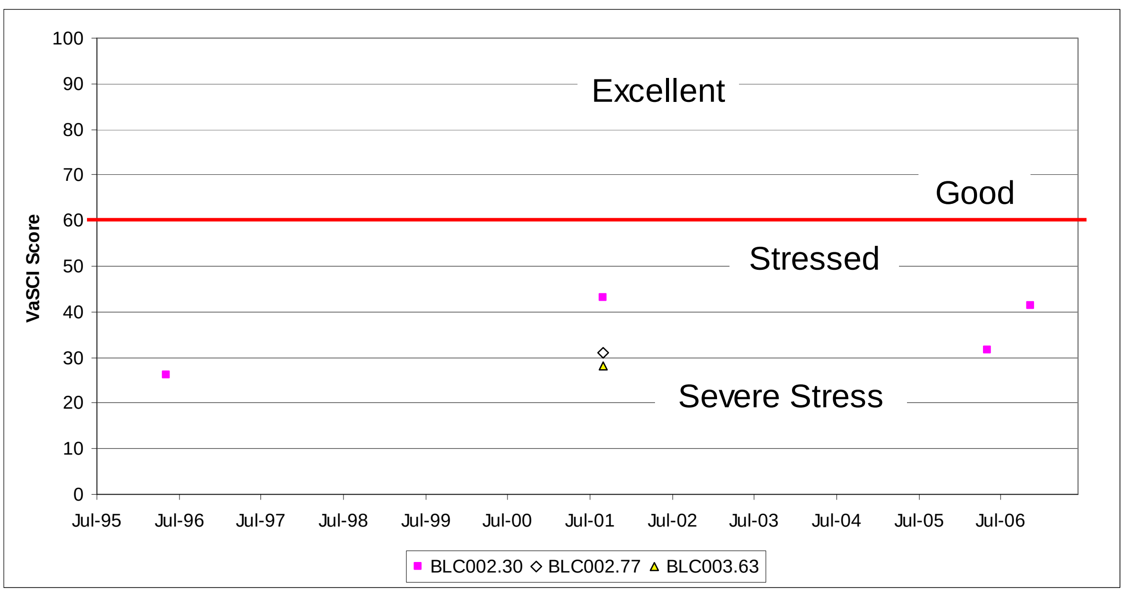


Figure 2.5. VaSCI Scores and Ratings for Bull Creek

A qualitative analysis of various habitat parameters was conducted in conjunction with each biological sampling event. Each of the 10 parameters listed in Table 2.4 was rated on a scale of 0-20, with a maximum score of 20 indicating the most desirable condition, and a score of 0 indicating the poorest habitat conditions. The best possible overall score for a single evaluation is 200. This table shows that bank stability, channel embeddedness, riparian vegetation and sediment deposition metrics have frequently received poor to marginal ratings.

Table 2.4. Habitat Evaluation Scores for Bull Creek

StationID	BLC002.30				BLC002.77	BLC003.63
Collection Date	05/21/96	09/13/01	05/15/06	11/27/06	09/13/01	09/13/01
Channel Alteration	18	15	17	18	14	18
Bank Stability	4	12	14	14	15	14
Bank Vegetation	18	13	11	13	11	12
Embeddedness	6	4	4	7	7	6
Channel Flow Status	17	15	18	19	15	14
Frequency of Riffles	17	18	18	18	18	18
Riparian Vegetation	9	12	10	13	6	6
Sediment Deposition	11	7	8	10	6	4
Substrate Availability	18	16	16	17	11	11
Velocity/Depth Regime	14	9	10	9	9	9
10-Metric Total	**132**	**121**	**126**	**138**	**112**	**112**

[shaded cell] - Habitat metric score assessed as "marginal" or "poor".

RBP Habitat Evaluation Ratings
(Bank Stability, Bank Vegetation, Riparian Vegetation): Poor 0-4; Marginal 6-10; Sub-optimal 12-16; Optimal 18-20.
(All others): Poor 0-5; Marginal 6-10; Sub-optimal 11-15; Optimal 16-20.

Water Quality Data

2.1.1. DEQ Ambient Monitoring Data

DEQ monitored chemical and bacterial water quality in Bull Creek on a monthly basis from July 2005 through the present at station 6ABLC000.85, and from August 2006 through the present at the primary biological monitoring site, 6ABLC002.30. The monthly ambient water quality monitoring data are shown in Figures 2.6 – 2.23. Chemical parameters include various forms of nitrogen and phosphorus – ammonia-N, total kjeldahl nitrogen (TKN), nitrite plus nitrate-N, and total P; dissolved oxygen; various forms of solids – total dissolved solids, volatile solids, total suspended solids, and volatile suspended solids; alkalinity; turbidity; chlorides; and sulfates. Field physical parameters included temperature, pH, and conductivity. Where applicable, minimum and/or maximum water quality standards (WQS) are indicated on the plots, as are minimum detection limits (MDL) of various laboratory analysis techniques.

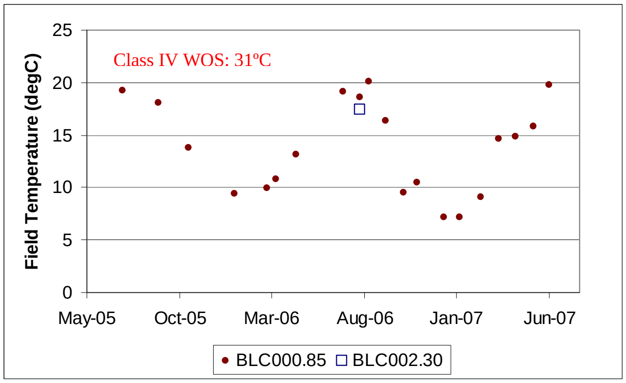


Figure 2.6. Field Temperature

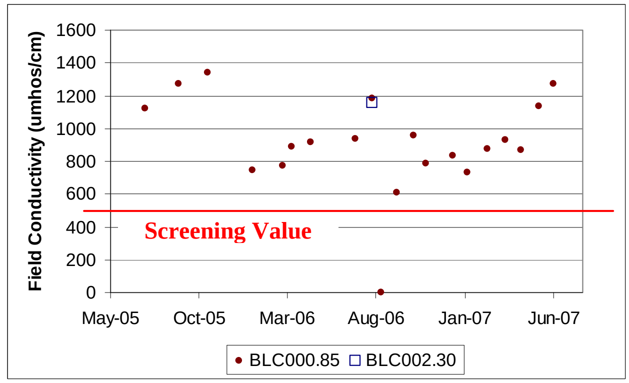


Figure 2.9. Field Conductivity

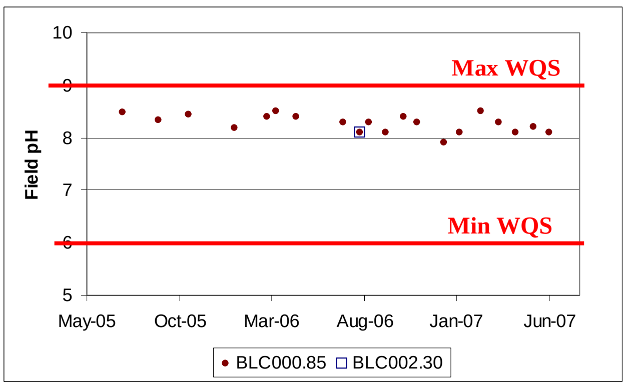


Figure 2.7. Field pH

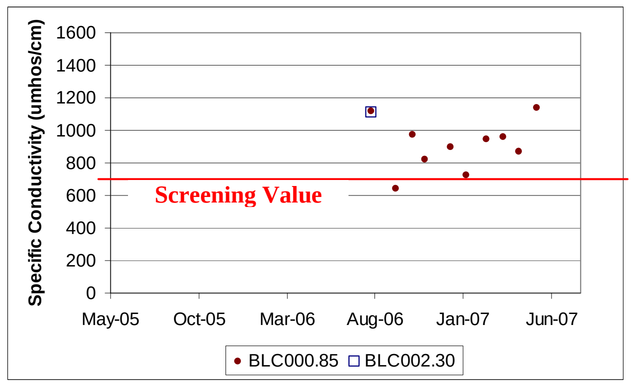


Figure 2.10. Lab Conductivity

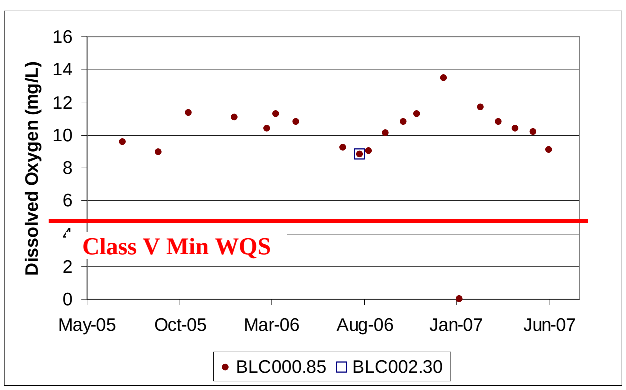


Figure 2.8. Field Dissolved Oxygen (DO)

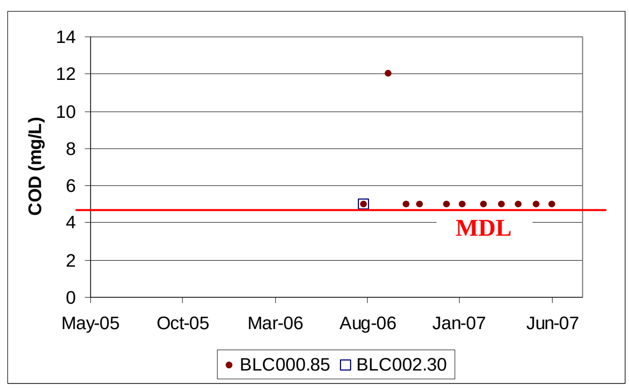


Figure 2.11. Lab Chemical Oxygen Demand (COD)

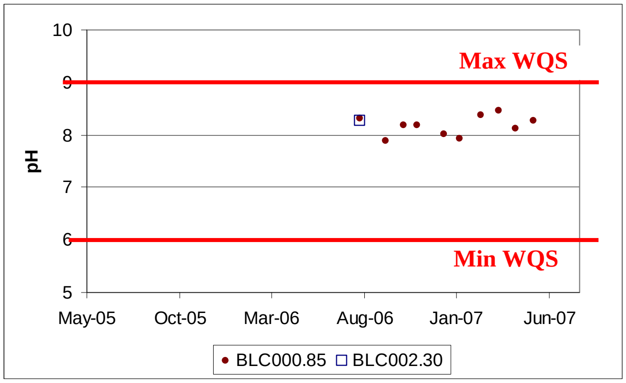


Figure 2.12. Lab pH

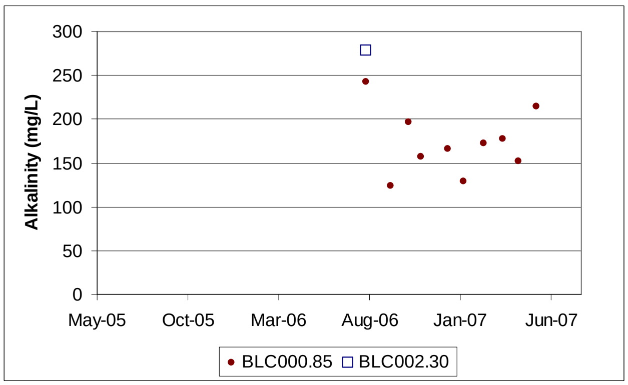


Figure 2.13. Alkalinity

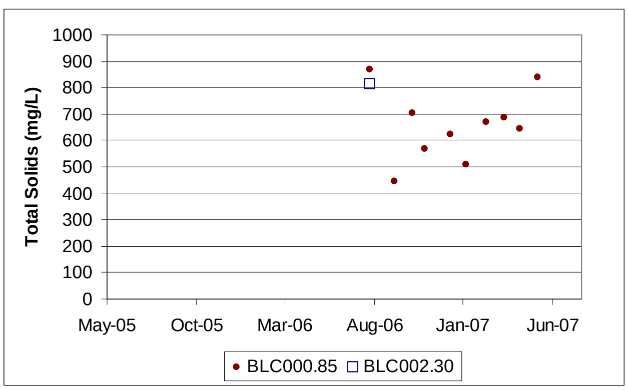


Figure 2.14. Total Solids

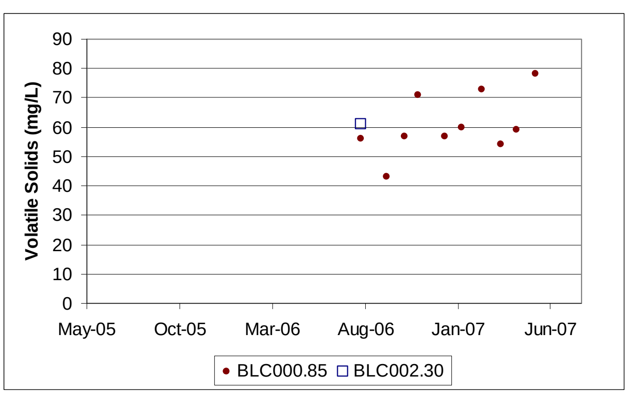


Figure 2.15. Volatile Solids

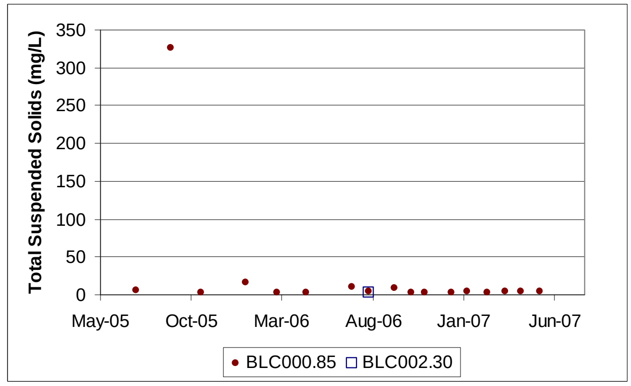


Figure 2.16. Total Suspended Solids (TSS)

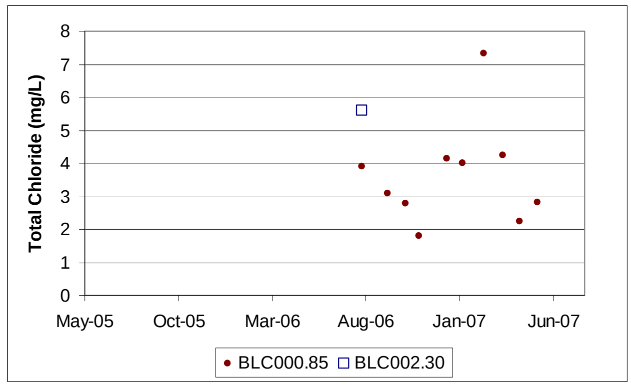


Figure 2.17. Total Chloride

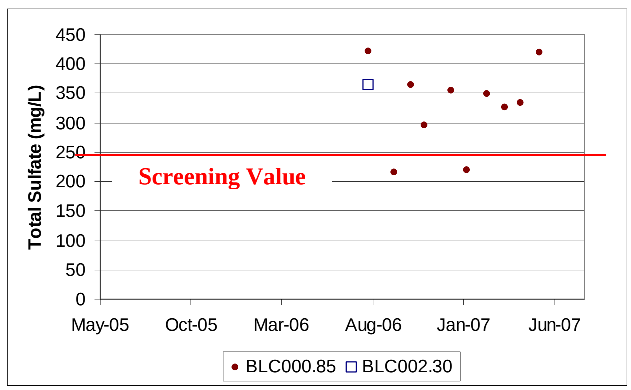


Figure 2.18. Total Sulfate

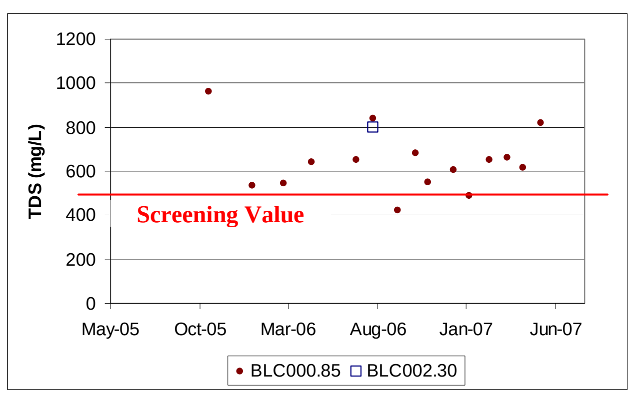


Figure 2.19. Total Dissolved Solids (TDS)

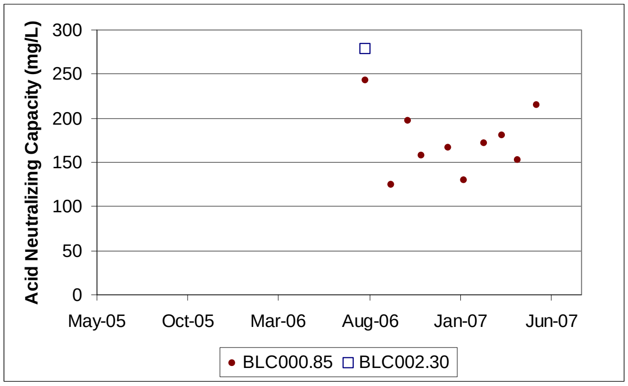


Figure 2.20. Acid Neutralizing Capacity

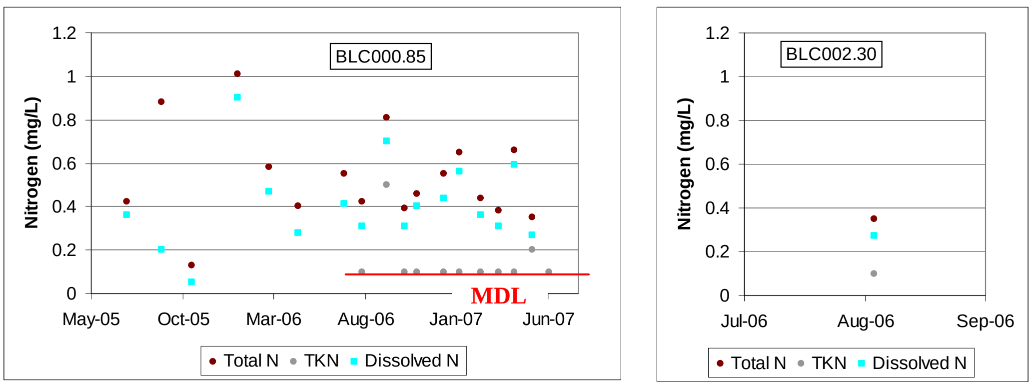


Figure 2.21. Total Nitrogen (TN)

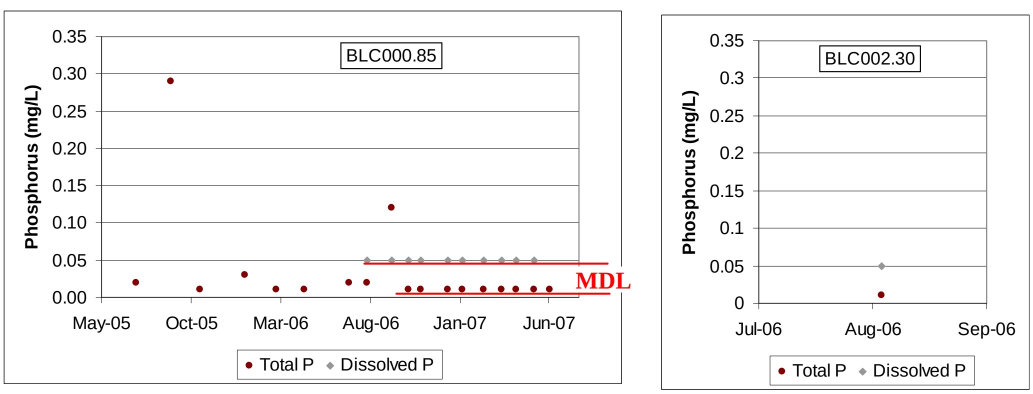


Figure 2.22. Total Phosphorus (TP)

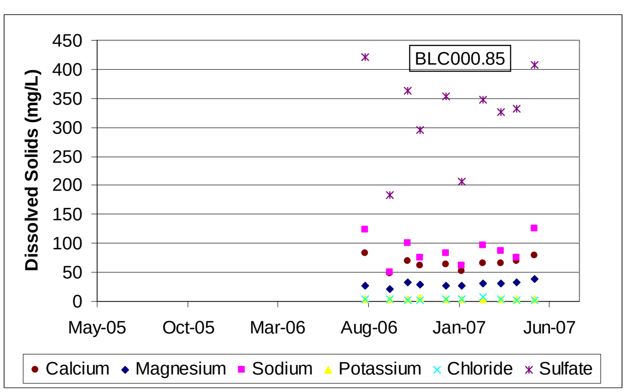
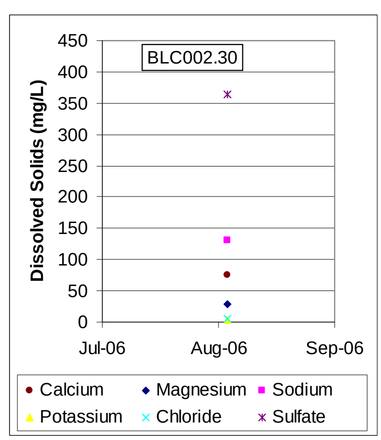


Figure 2.23. Dissolved Solids



2.1.2. DEQ Stream Metals Data

One set of stream sediment and water column samples have been collected and analyzed for a standard suite of metals and toxic substances in August 2006. None of the substances exceeded any known consensus-based probable effects concentrations (MacDonald et al., 2000) or freshwater aquatic life or human health criteria, and many of the substances were not detected above their minimum detection limits (MDL), as shown in Table 2.5.

Table 2.5. DEQ Metals Samples – 6ABLC002.30, August 15, 2006

Parameter Name	Parameter Code	Parameter Value	Minimum Detection Limit	Consensus-Based PECs	Freshwater Aquatic Life Criteria~		Human Health Criteria~	
					Chronic (ug/L)	Acute (ug/L)	PWS (ug/L)	Other (ug/L)
Channel Bottom Sediment Concentrations (mg/kg)								
ALUMINUM, SEDIMENT (MG/KG AS AL DRY WGT)	1108	6510						
ANTIMONY, SEDIMENT (MG/KG AS SB DRY WGT)	1098	5	5					
ARSENIC, SEDIMENT (MG/KG DRY WT)	1003	5.21	5	33				
BERYLIUM, SED (MG/KG AS BE DRY WT)	1013	5	5					
BERYLLIUM, DISSOLVED (UG/L AS BE)	1010	0.1	0.1					
CADMIUM, SEDIMENT (MG/KG DRY WT)	1028	1	1	4.98				
CHROMIUM, SEDIMENT (MG/KG DRY WT)	1029	8.73		111				
COPPER, SEDIMENT (MG/KG AS CU DRY WT)	1043	15.5		149				
IRON, SEDIMENT (MG/KG AS DRY WT)	1170	17300						
LEAD, SEDIMENT (MG/KG AS PB DRY WT)	1052	13.2		128				
MANGENESE, SEDIMENT (MG/KG AS DRY WT)	1053	628						
MERCURY, SEDIMENT (MG/KG AS HG DRY WT)	71921	0.1	0.1	1.06				
NICKEL, SEDIMENT (MG/KG DRY WT)	1068	32.1		48.6				
SELENIUM, SEDIMENT (MG/KG AS SE DRY WT)	1148	1	1					
SILVER, SEDIMENT (MG/KG AS AG DRY WT)	1078	1	1					
THALLIUM, SEDIMENT (MG/KG DRY WT)	34480	5	5					
ZINC, SEDIMENT (MG/KG AS ZN DRY WT)	1093	100		459				
Water Column Concentrations (µg/L)								
ALUMINUM, DISSOLVED (UG/L AS AL)	1106	7.9	1					
ANTIMONY, DISSOLVED (UG/L AS SB)	1095	0.5	0.5				14	4300
ARSENIC, DISSOLVED (UG/L AS AS)	1000	0.4	0.1		150	340	10	
BARIUM, DISSOLVED (UG/L AS BA)	1005	50.5	10				2000	
CADMIUM, DISSOLVED (UG/L AS CD)	1025	0.1	0.1		1.1	3.9	5	
CHROMIUM, DISSOLVED (UG/L AS CR)	1030	2	0.1		74	540	100	
COPPER, DISSOLVED (UG/L AS CU)	1040	1.3	0.1		9	13	1300	
IRON, DISSOLVED (UG/L AS FE)	1046	50	50				300	
LEAD, DISSOLVED (UG/L AS PB)	1049	0.1	0.1		14	120	15	
MANGANESE, DISSOLVED (UG/L AS MN)	1056	14.3	0.1				50	
NICKEL, DISSOLVED (UG/L AS NI)	1065	3.6	0.1		20	180	610	4600
SELENIUM, DISSOLVED (UG/L AS SE)	1145	0.9	0.5		5	20	170	11000
SILVER, DISSOLVED (UG/L AS AG)	1075	0.1	0.1			3.4		
THALLIUM, DISSOLVED (UG/L AS TL)	1057	0.1	0.1				1.7	6.3
ZINC, DISSOLVED (UG/L AS ZN)	1090	2.5	1		120	120	9100	69000

= Below MDL

2.1.3. DMME-DMLR Monitoring Data

The National Pollutant Discharge Elimination System (NPDES) is a federal program designed to eliminate stormwater pollutant discharges to receiving waters of the United States. The DMME-DMLR is responsible for monitoring NPDES discharges for mining permits in Virginia. DMLR NPDES monitoring sites (sediment ponds) and in-stream monitoring points located throughout Bull Creek are shown in Figure 2.24. The average parameter values from DMLR NPDES monitoring points with various sampling period durations and from varying time periods between January 1995 and June 2007 are shown in Table 2.6.

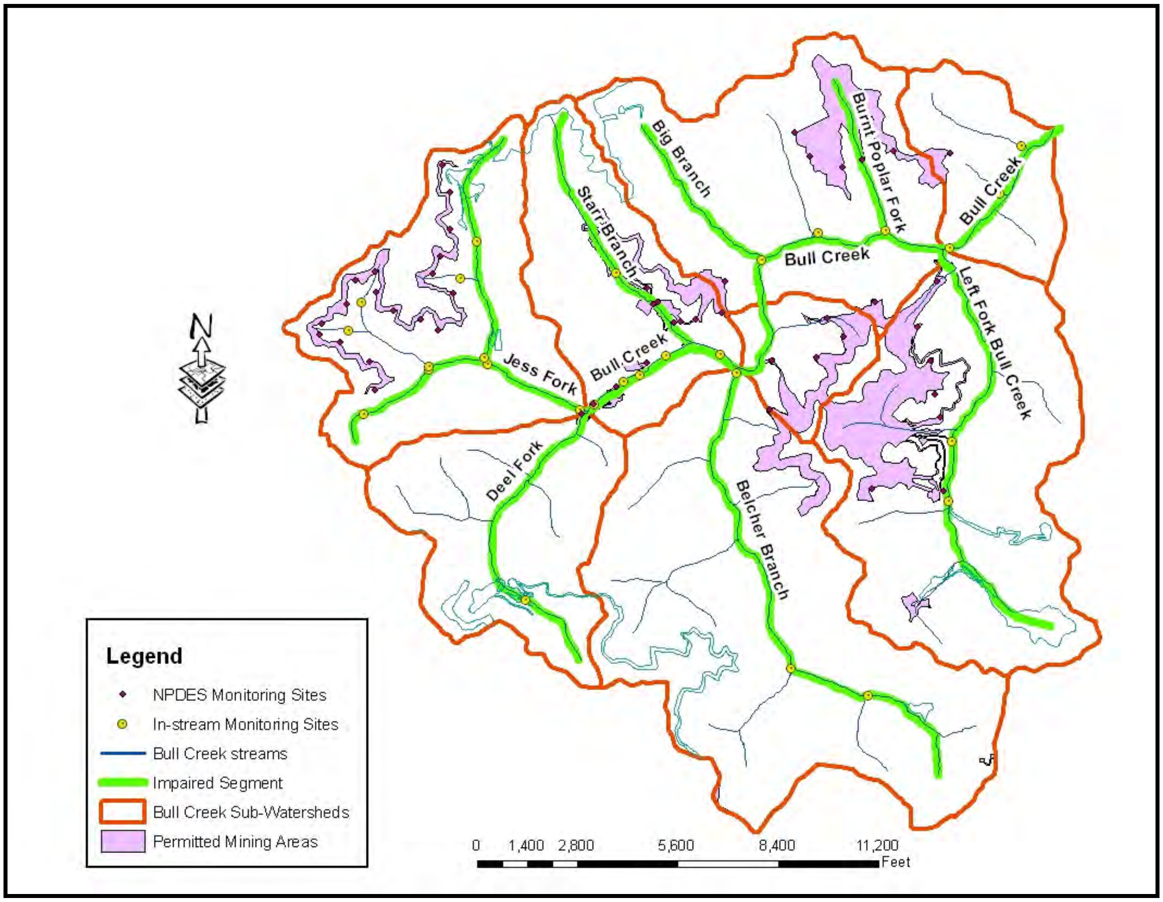


Figure 2.24. DMLR In-stream Monitoring Points in Bull Creek

Table 2.6. Bull Creek NPDES Monitoring Data

Average Concentrations over Period of Record

DMLR MPID	Flow (gpm)	pH	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Settleable Solids (mg/L)	First Sample Date	Last Sample Date	Permit Number	Sub-watershed
0004450	19.55	7.50	0.18	0.31	5.3	0.40	Apr-02	Jun-07	1601788	Left Fork Bull Creek
5670071	17.36	7.26	0.29	0.18	5.7	0.20	Jan-95	Jun-05	1200343	Left Fork Bull Creek
5683337	2.15	7.67	0.18	0.10	8.0	0.10	Jan-95	Apr-03	1201703	Left Fork Bull Creek
5683339	3.38	7.76	0.20	0.10	22.5	0.10	Jan-95	May-02	1201703	Left Fork Bull Creek
5683359	0.32	7.40	0.70	0.20	16.5	0.40	Jan-95	Jun-07	1200281	Left Fork Bull Creek
5683490	1.87	7.12	0.18	0.09	6.1	0.25	Jan-95	Jun-05	1200343	Left Fork Bull Creek
5685197	43.02	7.40	0.33	0.19	7.3	0.10	Jan-95	Apr-03	1301704	Left Fork Bull Creek
0003572	28.81	7.74	0.35	0.12	182.4	0.10	Mar-00	Jun-07	1101736	Burnt Poplar/Big Branch
5670249	11.71	7.53	0.30	0.23	179.3	0.10	Jan-95	Dec-02	1401509	Burnt Poplar/Big Branch
5684453	1.13	7.71	0.34	0.16	5.9	0.10	Jan-95	Aug-98	1201595	Burnt Poplar/Big Branch
5670187	1.28	7.65	1.20	0.10	19.0		Jan-95	Sep-95	1101205	Belcher Branch
5670371	6.91	7.94	0.35	0.17	5.5	0.10	Jan-95	Aug-98	1201363	Belcher Branch
5670372	2.74	7.51	0.35	0.18	6.5	0.10	Jan-95	Aug-98	1201363	Belcher Branch
5670373	216.75	7.53	0.31	0.18	3.4	0.10	Jan-95	Aug-98	1201363	Belcher Branch
5670374	0.93	7.39	0.21	0.11	5.8	0.10	Jan-95	Aug-98	1201363	Belcher Branch
5683782	10.21	7.13	0.29	0.09	12.1	0.10	Jan-95	Mar-96	1200589	Belcher Branch
5684995	12.71	7.62	0.48	0.88	16.0	0.10	Jan-95	Aug-98	1300469	Belcher Branch
0004312	28.02	7.94	0.45	0.16	18.0	0.20	Oct-02	Jun-07	1201922	Starr Branch
0006397	5.67	6.65	14.90	0.20	668.0	0.40	Mar-07	Jun-07	1201922	Starr Branch
5684994	35.25	7.32	0.25	0.79	7.8	0.10	Jan-95	Aug-98	1300469	Starr Branch
5684997	1.56	7.10	0.13	0.57	2.3		Jan-95	Aug-98	1300469	Starr Branch
5684998	17.03	7.99	0.11	0.10	6.1		Jan-95	Jun-96	1300469	Starr Branch
5685401	19.23	7.37	0.27	0.35	8.5		Jul-95	Sep-96	1300985	Starr Branch
5685402	9.13	7.94	0.30	0.13	3.6	0.10	Jan-95	Mar-99	1300985	Starr Branch
5685404	187.97	8.18	0.23	0.13	5.6		Jan-95	Mar-99	1300985	Starr Branch
5685405	0.20	7.73	0.13	0.10	8.0	0.10	Jan-95	Mar-99	1300985	Starr Branch
5685406	37.24	7.97	0.17	0.13	5.0	0.10	Jan-95	Mar-99	1300985	Starr Branch
5685408	1.55	7.73	0.11	0.12	3.0		Jan-95	Mar-99	1300985	Starr Branch
5670231	0.02	7.20	0.30	0.10	5.0		Jan-95	Aug-99	1201615	Jess Fork
5670232	2.97	7.77	1.00	0.18	21.9	0.12	Jan-95	Aug-99	1201615	Jess Fork
5670233	0.68	7.32	0.25	0.10	16.0	0.10	Jan-95	Aug-99	1201615	Jess Fork
5670234	0.03	7.00	0.10	0.10	35.0		Jan-95	Aug-99	1201615	Jess Fork
5670236	0.26	7.25	0.20	0.15	4.0		Jan-95	Aug-99	1201615	Jess Fork
5684527	4.22	7.66	0.36	0.15	16.6	0.11	Jan-95	Jun-07	1201678	Jess Fork

Average by Sub-watershed

Sub-watershed	Flow (gpm)	pH	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Settleable Solids (mg/L)
Outlet	--					
Left Fork Bull Creek	8.9	7.0	0.3	0.1	10.2	0.2
Burnt Poplar/Big Branch	16.2	7.6	0.3	0.2	145.4	0.1
Middle Bull Creek						
Belcher Branch	36.7	6.3	0.3	0.2	6.8	0.1
Starr Branch	29.5	6.4	0.3	0.2	11.4	0.1
Jess Fork	2.0	7.4	0.4	0.1	16.4	0.1
Deel Fork						

Thresholds used for evaluation: Iron (1.0 mg/L); Manganese (1.0 mg/L); TSS (100 mg/L).

The average parameter values from DMLR in-stream monitoring points from various sampling period durations and from varying time periods between January 1995 and June 2007 are shown in Table 2.7. The following relative values were used to indicate higher concentrations which are highlighted in the table: conductivity (> 500 μmhos/cm); TDS (> 500 mg/L); and sulfates (> 250 mg/L).

Table 2.7. Bull Creek In-stream Monitoring Data

Average Concentrations over Period of Record

DMLR MPID	Flow (gpm)	pH	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Temperature (°C)	Acidity (mg/L)	Alkalinity (mg/L)	Conductivity (µmhos/cm)	TDS (mg/L)	Sulfate (mg/L)	Date of First Sample	Date of Last Sample	Permit Number	Sub-watershed
0003583	24.2	7.14	0.27	0.08	7.1	13.88	6.73	30.0	317.9	243.3	259.2	Mar-00	Jun-07	1101736	Outlet
0003584	8.5	7.46	0.24	0.14	45.1	14.68	2.16	53.4	210.5	159.4	99.9	Mar-00	Jun-07	1101736	Outlet
0004468	5,210.2	7.88	3.45	0.22	179.9	14.60	0.85	155.2	785.7	578.0	302.8	Jan-02	Jun-07	1601788	Outlet
5620068	35.8	7.48	0.33	0.15	16.0	14.04	0.43	78.8	548.4	400.6	196.9	May-95	Nov-05	1200343	Left Fork Bull Creek
5620116	49.8	7.15	0.24	0.12	12.3	14.67	0.32	64.2	507.7	422.0	184.7	Jan-95	Sep-05	1201909	Left Fork Bull Creek
5620117	62.8	7.54	0.31	0.14	14.8	14.78	0.19	85.9	636.1	498.0	272.1	Jan-95	Sep-05	1201909	Left Fork Bull Creek
5620130	282.4	7.57	0.58	0.18	20.1	14.26	0.46	96.8	710.0	525.4	283.1	May-95	Jun-07	1200281	Left Fork Bull Creek
5620131	267.5	7.64	0.57	0.16	26.5	14.30	0.31	94.1	723.4	568.1	305.4	May-95	Jun-07	1200281	Left Fork Bull Creek
5620343	71.5	7.51	0.27	0.17	9.7	14.75	0.17	68.8	808.2	628.4	386.4	Jan-95	Sep-05	1301908	Left Fork Bull Creek
0003447	2,228.6	7.98	0.35	0.11	16.2	14.61	0.82	176.8	852.0	606.6	278.5	Nov-99	Jun-07	1101701	Burnt Poplar/Big Branch
0003581	330.4	7.99	0.38	0.09	150.7	15.06	0.54	205.4	1,233.2	948.3	564.2	Mar-00	Jun-07	1101736	Burnt Poplar/Big Branch
0003582	79.0	8.14	0.43	0.11	12.3	15.47	0.54	184.0	996.2	696.7	414.3	Mar-00	Jun-07	1101736	Burnt Poplar/Big Branch
5620257	23.2	7.68	0.33	0.25	225.3	11.12	5.36	111.3	709.3	463.0	264.6	Jan-95	Dec-02	1401509	Burnt Poplar/Big Branch
5620362	227.3	7.81	0.24	0.13	9.0	14.27	--	175.3	974.0	669.9	294.1	Jan-95	Aug-98	1201595	Burnt Poplar/Big Branch
5620363	50.1	7.87	0.23	0.11	8.7	14.20	--	133.8	865.0	522.5	217.2	Jan-95	Aug-98	1201595	Burnt Poplar/Big Branch
5620364	190.7	7.83	0.26	0.11	7.8	14.00	--	149.6	1,142.8	742.5	315.9	Jan-95	Aug-98	1201595	Burnt Poplar/Big Branch
0004469	1,569.6	8.08	0.20	0.08	13.7	14.87	0.83	175.5	835.1	604.3	295.7	Jan-02	Jun-07	1601788	Belcher Branch
0005467	63.0	7.06	0.71	0.06	8.5	13.70	--	75.2	538.5	372.2	167.2	Mar-04	Jun-07	1101903	Belcher Branch
0005468	77.3	6.82	0.81	0.06	41.9	13.10	--	55.0	410.2	289.7	126.5	Mar-04	Jun-07	1101903	Belcher Branch
5620213	138.1	7.42	0.10	0.27	10.2	13.33	--	26.7	1,014.2	812.8	481.7	Jan-95	Dec-95	1200589	Belcher Branch
5620214	150.7	7.43	0.11	0.28	10.3	13.67	--	31.7	989.2	738.2	373.3	Jan-95	Dec-95	1200589	Belcher Branch
5620369	514.0	7.54	0.19	0.13	12.5	13.69	--	59.2	657.8	471.2	199.8	Jan-95	Aug-98	1201363	Belcher Branch
5620370	1,065.7	7.69	0.25	0.15	8.8	14.48	--	134.0	1,018.0	727.2	313.2	Jan-95	Aug-98	1201363	Belcher Branch
5620376	501.8	7.54	0.21	0.13	10.1	13.57	--	60.3	670.0	476.4	237.8	Jan-95	Mar-99	1201364	Belcher Branch
5620377	1,020.7	7.74	0.20	0.14	8.2	14.12	--	140.4	1,042.9	736.5	339.7	Jan-95	Mar-99	1201364	Belcher Branch
5620419	1,841.8	7.97	0.24	0.15	7.7	14.30	--	141.7	918.2	668.1	286.8	Jan-95	Mar-99	1300985	Belcher Branch
5620420	3,768.6	7.93	0.17	0.16	11.2	14.28	--	123.8	844.0	549.4	251.8	Jan-95	Mar-99	1300985	Belcher Branch
0001297	1,826.1	7.93	0.26	0.15	9.6	14.84	--	137.4	882.0	637.3	268.0	Jan-95	Aug-98	1201363	Starr Branch
0004315	1,837.4	7.65	0.25	0.11	6.3	16.15	0.71	184.7	651.3	491.1	212.3	Apr-02	Jun-07	1201922	Starr Branch
0004316	1,840.8	7.66	0.22	0.15	7.2	16.27	0.71	174.6	811.7	607.6	289.7	Apr-02	Jun-07	1201922	Starr Branch
0004317	109.6	7.46	0.16	1.20	7.9	17.33	1.27	100.1	1,625.5	1,486.3	868.9	Apr-02	Jun-07	1201922	Starr Branch
0005966	359.4	7.50	0.29	0.10	7.1	16.28	0.96	209.0	725.0	476.2	131.3	Jun-05	Jun-07	1201940	Starr Branch
0005967	418.0	7.59	0.25	0.10	7.4	15.68	0.96	146.5	693.3	474.9	180.0	Jun-05	Jun-07	1201940	Starr Branch
5620014	2,304.3	7.65	0.21	0.18	9.3	14.36	--	79.4	709.3	616.0	229.6	Jan-95	Aug-98	1300469	Starr Branch
5620015	1,498.0	7.76	0.43	0.17	18.2	14.58	1.01	172.5	750.4	521.9	212.8	Jan-95	Jun-07	1101701	Starr Branch
0006453	45.2	7.37	0.49	0.09	13.4	12.20	1.00	85.8	592.7	393.2	136.4	Sep-06	Jun-07	1101979	Jess Fork
0006454	36.2	7.53	0.39	0.12	7.2	12.70	1.00	92.2	728.9	509.0	206.2	Sep-06	Jun-07	1101979	Jess Fork
0006455	27.8	7.48	0.35	0.01	6.6	11.60	1.40	35.0	232.9	156.2	54.9	Sep-06	Jun-07	1101979	Jess Fork
0006456	32.4	7.49	0.19	0.01	5.2	11.60	1.00	81.0	466.7	282.2	51.3	Sep-06	Jun-07	1101979	Jess Fork
0006457	27.6	7.07	0.37	0.10	7.8	12.60	3.40	54.0	628.2	429.6	197.6	Sep-06	Jun-07	1101979	Jess Fork
5620228	225.4	6.50	0.29	0.54	10.2	13.61	25.95	25.4	779.1	647.1	357.9	Jan-95	Aug-99	1201615	Jess Fork
5620229	237.7	6.80	0.54	0.49	15.5	13.88	21.32	30.5	779.1	629.6	335.0	Jan-95	Aug-99	1201615	Jess Fork
5620365	860.1	7.66	0.50	0.20	15.3	14.19	0.31	72.8	617.7	523.4	262.3	Jan-95	Jun-07	1201678	Jess Fork
5620417	1,059.5	7.39	0.20	0.20	12.7	13.78	--	50.6	665.8	448.5	233.8	Jan-95	Mar-99	1300985	Jess Fork
0005968	161.3	7.43	0.34	0.21	8.0	14.67	8.05	77.6	591.6	403.5	161.8	Jun-05	Jun-07	1201940	Deel Fork
5620418	504.0	7.57	0.28	0.18	7.8	13.71	--	65.7	578.2	410.7	186.6	Jan-95	Mar-99	1300985	Deel Fork

Average by Sub-watershed

Sub-watershed	Flow (gpm)	pH	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Temperature (°C)	Acidity (mg/L)	Alkalinity (mg/L)	Conductivity (µmhos/cm)	TDS (mg/L)	Sulfate (mg/L)
Outlet	1,366.7	7.5	1.1	0.1	66.1	14.4	3.5	71.2	399.8	299.3	211.6
Left Fork Bull Creek	148.9	7.5	0.4	0.2	17.3	14.4	0.3	83.6	669.1	514.5	277.5
Burnt Poplar/Big Branch	716.0	7.9	0.3	0.1	68.9	14.1	1.3	165.5	945.7	659.6	340.8
Middle Bull Creek	--	--	--	--	--	--	--	--	--	--	--
Belcher Branch	1,163.8	7.6	0.3	0.1	13.0	14.0	0.1	105.5	794.0	564.3	260.5
Starr Branch	1,401.2	7.7	0.3	0.3	10.9	15.5	0.8	153.2	859.8	666.0	306.2
Jess Fork	572.7	7.3	0.4	0.3	13.1	13.7	7.8	55.0	663.1	525.3	266.1
Deel Fork	389.8	7.5	0.3	0.2	7.9	14.0	2.7	69.7	582.7	408.3	178.3

Thresholds used for evaluation: Iron (1.0 mg/L); Manganese (1.0 mg/L); TSS (100 mg/L); Conductivity (500 µmhos/cm); TDS (500 mg/L); Sulfate (250 mg/L).

Because TMDL development is concerned with individual monitored concentrations, as well as with overall average concentrations, the following time-series of DMLR in-stream monitoring of pH, TSS, iron, manganese, TDS and sulfate (Figures 2.25 to 2.30) are included to show typical ranges of values and variations over time. In order to show details of the typical range of values, extreme values were omitted from these graphs, but are discussed later. Although DMLR Mining Permit Effluent Limits only apply to NPDES outfalls, and not to in-stream monitoring, these limits were included for perspective in Figures 2.26 to 2.28.

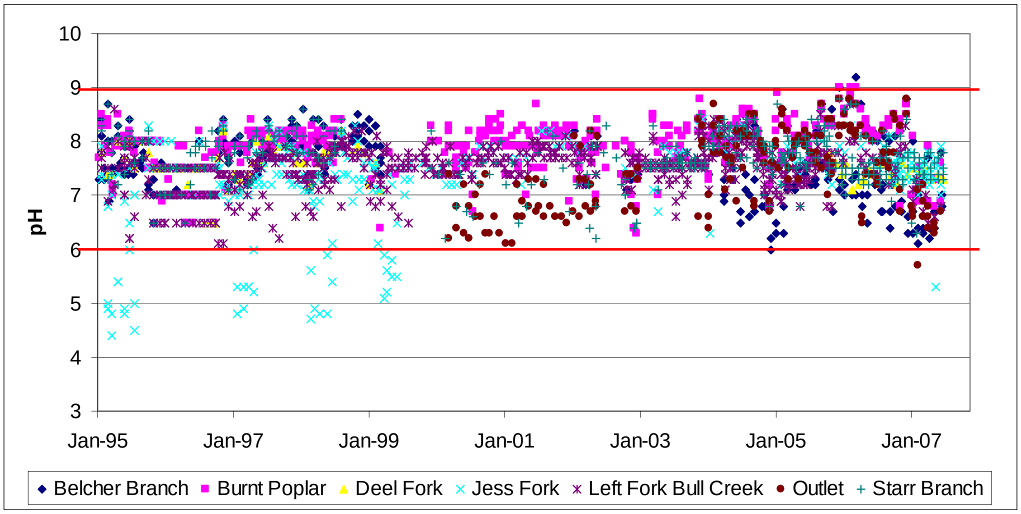


Figure 2.25. DMLR In-stream pH monitoring by sub-watershed

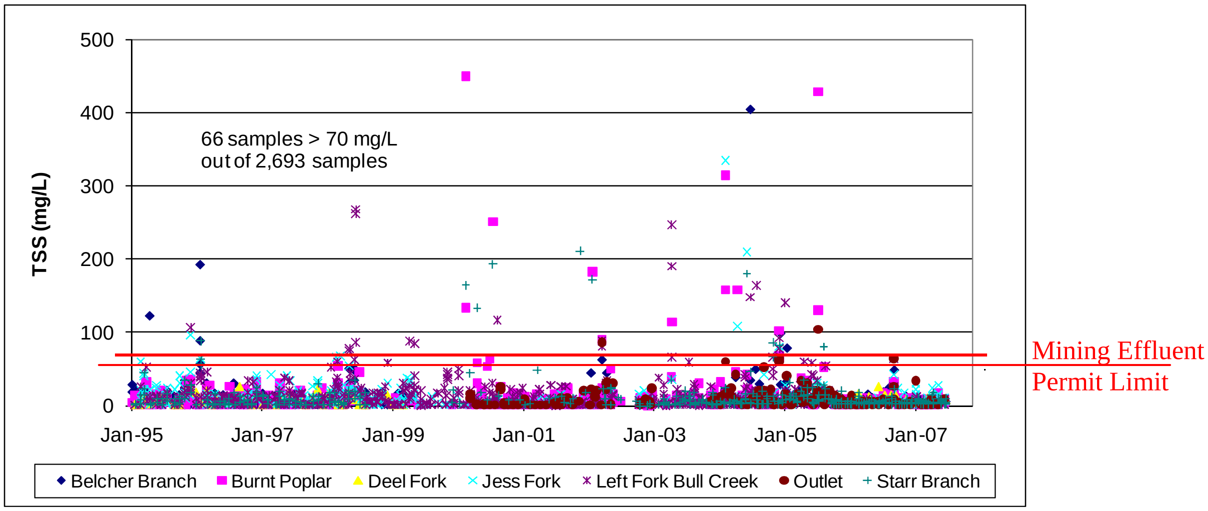


Figure 2.26. DMLR In-stream TSS monitoring by sub-watershed (excludes extreme events)

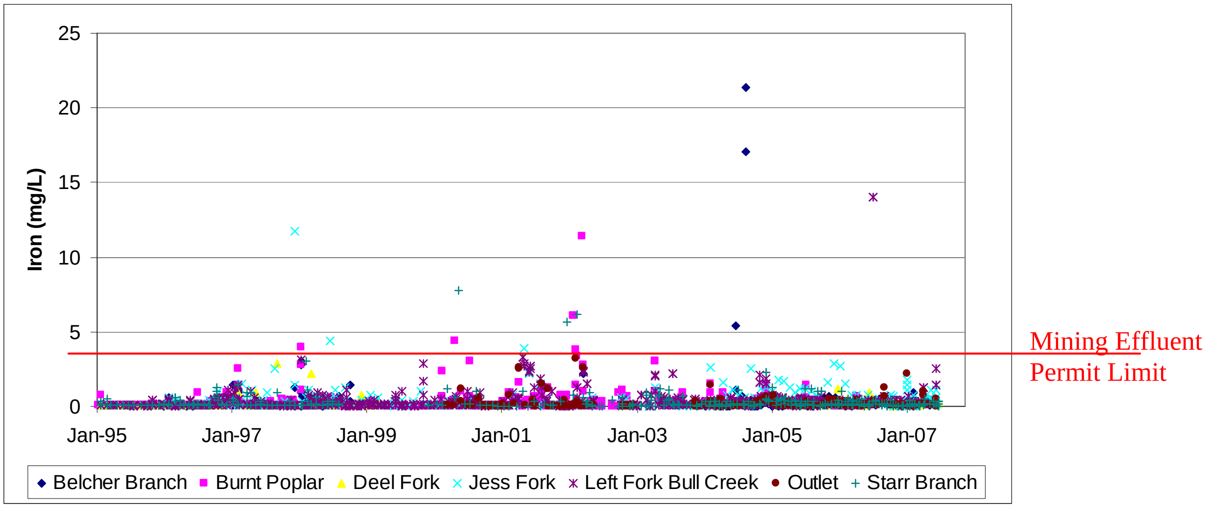


Figure 2.27. DMLR In-stream Iron monitoring by sub-watershed (excludes extreme events)

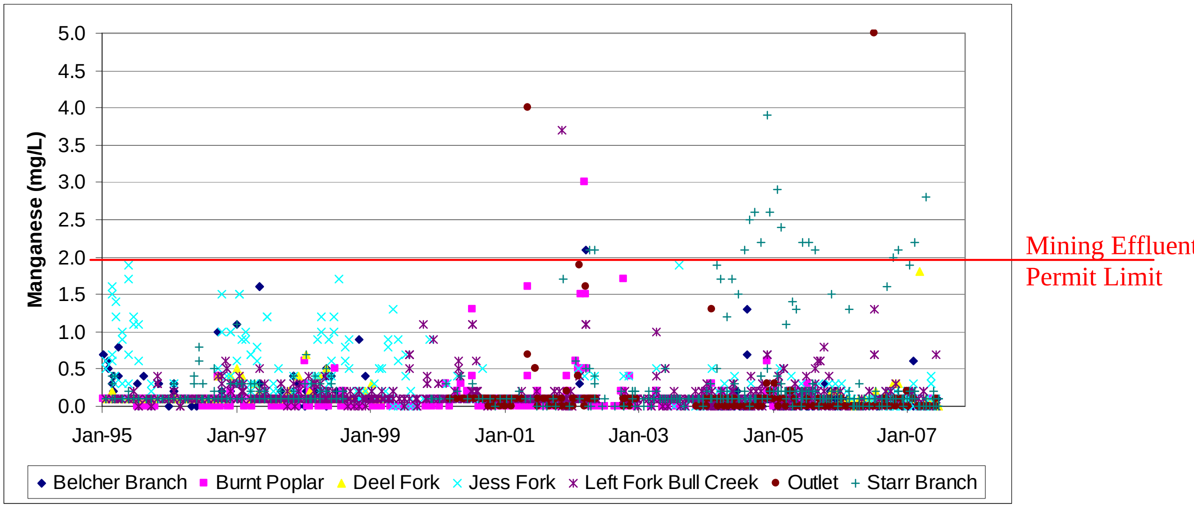


Figure 2.28. DMLR In-stream Manganese monitoring by sub-watershed

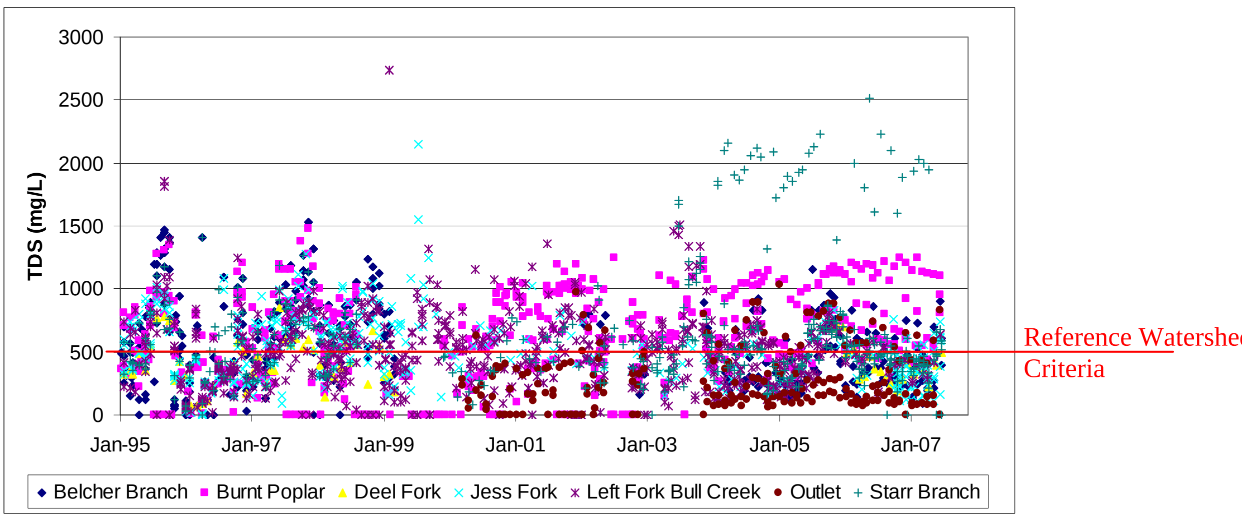


Figure 2.29. DMLR In-stream TDS monitoring by sub-watershed

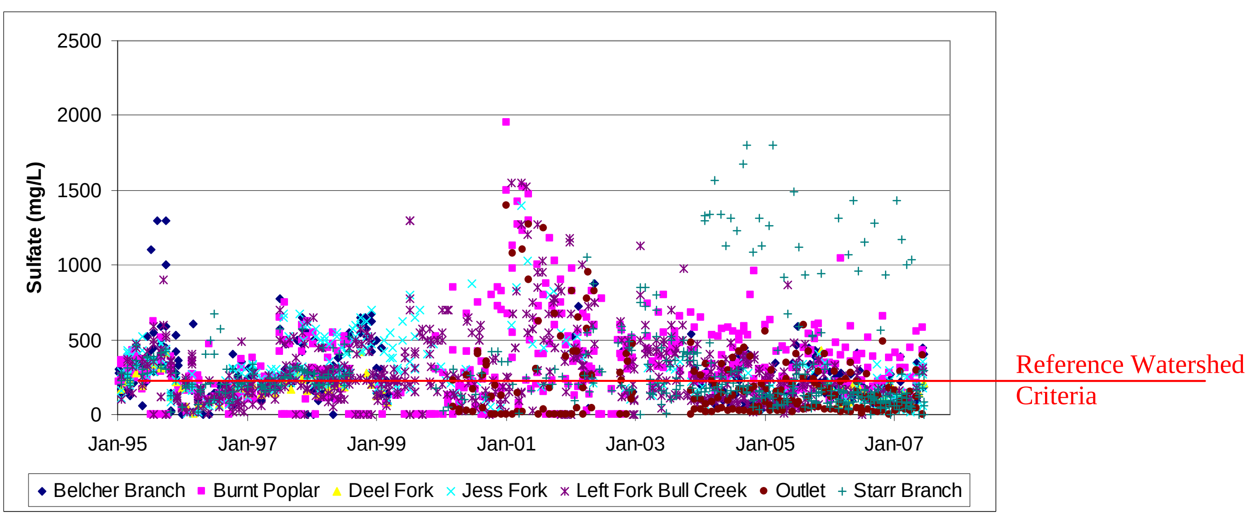


Figure 2.30. DMLR In-stream Sulfate Monitoring by Sub-watershed

Since many of the DMLR monitoring stations are below the biological monitoring point, average concentrations were calculated in Table 2.8 by year and sub-watershed, and summarized above and below the primary monitoring site – 6ABLC002.30 – to better evaluate potential TDS influences on the various biological samples.

Table 2.8. Average TDS Concentrations by Year, Above and Below 6ABLC002.30

	Above BLC002.30				Below BLC002.30				
	No. of Samples / year								
	Belcher Branch	Starr Branch	Deel Fork	Jess Fork	Left Fork Bull Creek	Burnt Poplar /Big Branch	Outlet	**Total above BLC002.30**	**Total below BLC002.30**
1995	94	36	12	48	55	44		**190**	**99**
1996	70	36	12	48	72	46		**166**	**118**
1997	71	36	12	48	70	40		**167**	**110**
1998	58	24	11	47	68	29		**140**	**97**
1999	12	2	3	31	59	6		**48**	**65**
2000		12		12	54	39	17	**24**	**110**
2001		12		11	56	43	17	**23**	**116**
2002	9	24		7	49	42	20	**40**	**111**
2003	2	44		9	64	29	5	**55**	**98**
2004	32	48		12	85	49	36	**92**	**170**
2005	36	62	3	12	74	48	36	**113**	**158**
2006	36	70	12	32	36	48	35	**150**	**119**
2007	18	34	6	36	18	24	16	**94**	**58**
1995-1999 Average	**61.0**	**26.8**	**10.0**	**44.4**	**64.8**	**33.0**	**--**	**165.8**	**106.0**
2000-2003 Average	**5.5**	**23.0**	**--**	**9.8**	**55.8**	**38.3**	**14.8**	**33.8**	**100.5**
2004-2007 Average	**30.5**	**53.5**	**7.0**	**23.0**	**53.3**	**42.3**	**30.8**	**100.8**	**120.6**
	Average TDS concentration (mg/L)								
	Belcher Branch	Starr Branch	Deel Fork	Jess Fork	Left Fork Bull Creek	Burnt Poplar /Big Branch	Outlet	**Average Above BLC002.30**	**Average Below BLC002.30**
1995	642.1	541.2	476.8	563.8	619.7	615.8		**592.8**	**618.0**
1996	433.9	506.1	271.7	339.9	371.5	409.5		**410.6**	**386.3**
1997	756.0	873.2	503.2	793.3	613.8	765.3		**773.8**	**668.9**
1998	659.1	577.0	427.5	640.0	542.7	611.3		**620.4**	**563.2**
1999	511.0	461.5	271.3	632.2	653.8	347.7		**572.2**	**625.5**
2000		342.6		523.5	512.1	689.1	246.4	**433.0**	**533.8**
2001		552.0		616.5	566.9	796.6	323.3	**582.9**	**616.3**
2002	539.2	457.9		488.7	439.9	640.1	375.1	**481.6**	**504.0**
2003	795.0	682.8		371.4	637.5	725.7	405.6	**635.9**	**651.8**
2004	404.0	852.9		350.8	413.9	665.9	287.4	**631.3**	**459.8**
2005	487.5	762.0	704.7	503.8	453.2	760.5	368.9	**645.6**	**527.4**
2006	406.9	631.0	350.5	358.4	440.3	762.2	276.5	**496.6**	**521.9**
2007	385.3	615.6	359.0	353.8	394.2	714.6	274.1	**454.9**	**493.7**
1995-1999 Average	**600.4**	**591.8**	**390.1**	**593.8**	**560.3**	**549.9**	**--**	**599.4**	**559.1**
2000-2003 Average	**667.1**	**508.8**	**--**	**500.1**	**539.1**	**712.9**	**337.6**	**517.4**	**569.9**
2004-2007 Average	**420.9**	**715.4**	**471.4**	**391.7**	**425.4**	**725.8**	**301.7**	**572.9**	**530.9**

Surface mining Start Date(s)	2001*, 2004	1999	none	none	2001*	2000, 2001*	2000
Remining* Start Date(s)	2001	none	none	none	2001	2001	none

It is difficult to determine exact periods of disturbance in each sub-watershed and to relate that with TDS concentrations and mining activity.

However, as in the combined time-series graph (Figure 2.29), TDS concentrations have varied within the same range fairly consistently over time, with the exception of the recent increases above the historic range exhibited in Starr Branch. Annual averages and multi-year averages in Table 2.8 show very slight trends that vary from slightly increasing to slightly decreasing from sub-watershed to sub-watershed. Overall, it appears that the TDS concentrations have remained fairly constant over time, with average concentrations during 2004-2007 increasing in Starr Branch and the Burnt Poplar/Big Branch. The 2004-2007 averages upstream and downstream of 6ABLC002.30 have decreased slightly from the 1995-1999 averages.

Extremely high concentrations of iron and TSS have been observed in both the NPDES and in-stream data sets and are reported in Table 2.9. Extreme values were defined as those values greater than approximately one order of magnitude above the mining permit effluent limits. Extreme concentration values were verified by evaluating relationships to recorded flow and rainfall on the day of, and on days preceding the date of, sampling, and by comparison with monitoring at nearby stations. DMLR provided the following explanations for these extreme values. On 04/10/03, the discharge resulted from 0.25 inches of rainfall with 2.28 inches of rainfall on previous days and a permit violation where a needed pond cleanout was not performed (noted in a DMLR inspection report). The elevated concentrations on 07/13/00 (rainfall = 0.04 inches), following 2.32 inches of rainfall on previous days, were monitored in the discharge of an upstream pond, whose discharge is contained by a newer downstream pond that was reported to be functioning properly by an inspector 2 weeks earlier. The event on 07/05/06 resulted from a daily rainfall of 0.11 inches, following 0.48 inches on previous days, in a portion of the watershed where active mining could not have caused the discharge. The concentration reported on 08/12/04 corresponded with a daily rainfall amount of 0.15 inches with 0.20 inches on preceding days, from a watershed with approved, but not constructed, NPDES outfalls, and no active mining. The concentration reported on 02/06/04 was due to a daily rainfall amounting to 0.69 inches with 0.26 inches on previous days and a permit violation that corresponded with a disturbance in the permit area prior to pond construction. On 03/16/07, where 0.46 inches of rainfall was received following 0.35 inches on previous days, the discharge was from a pond that had been noted by the inspector as nearing cleanout level. A follow-up report stated the pond had been cleaned out.

The extreme values from these 10 samples led to most of the elevated site-averages for metals and TSS in Tables 2.6 and 2.7. The three NPDES samples in this table were responsible for all of the flagged TSS site-averages, the largest iron site-average, and the one sub-watershed average TSS in Table 2.6. The extreme in-stream samples were responsible for all flagged site-averages and the one sub-watershed average of iron and TSS in Table 2.7.

Table 2.9. Summary of Extreme DMLR Iron, Manganese and TSS Concentrations

MPID	Monitoring Type	Date	Flow (gal/min)	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Sub-watershed
0003572	NPDES	04/10/03	95	3.0	3.0	**22,860**	Burnt Poplar/Big Branch
0003581	Instream		185	3.0	0.2	**10,430**	Burnt Poplar/Big Branch
5670249	NPDES	07/13/00	460	2.9	1.2	**10,640**	Burnt Poplar/Big Branch
5620257	Instream		400	3.0	1.3	**8,780**	Burnt Poplar/Big Branch
0004468	Instream	07/05/06	16,655	**164.0**	5.0	**8,704**	Outlet
5620131	Instream		1,805	**31.5**	1.3	**1,760**	Left Fork Bull Creek
5620130	Instream		1,750	14.0	0.7	**776**	Left Fork Bull Creek
0003584	Instream	02/06/04	80	1.4	1.3	**1,908**	Outlet
0006397	NPDES	03/16/07	50	**26.3**	0.3	**1,160**	Starr Branch
0005468	Instream	08/12/04	60	17.1	0.7	**882**	Belcher Branch
	Extreme values are in **Bold** type.						

DMLR groundwater monitoring locations in Bull Creek are shown in Figure 2.31. Site-average concentrations of monitored parameters are shown by monitoring point identification number (MPID) in Table 2.10. The DMLR monitored data represents 42 groundwater monitoring sites around the Bull Creek watershed with monitoring periods ranging between January 1995 and June 2007.

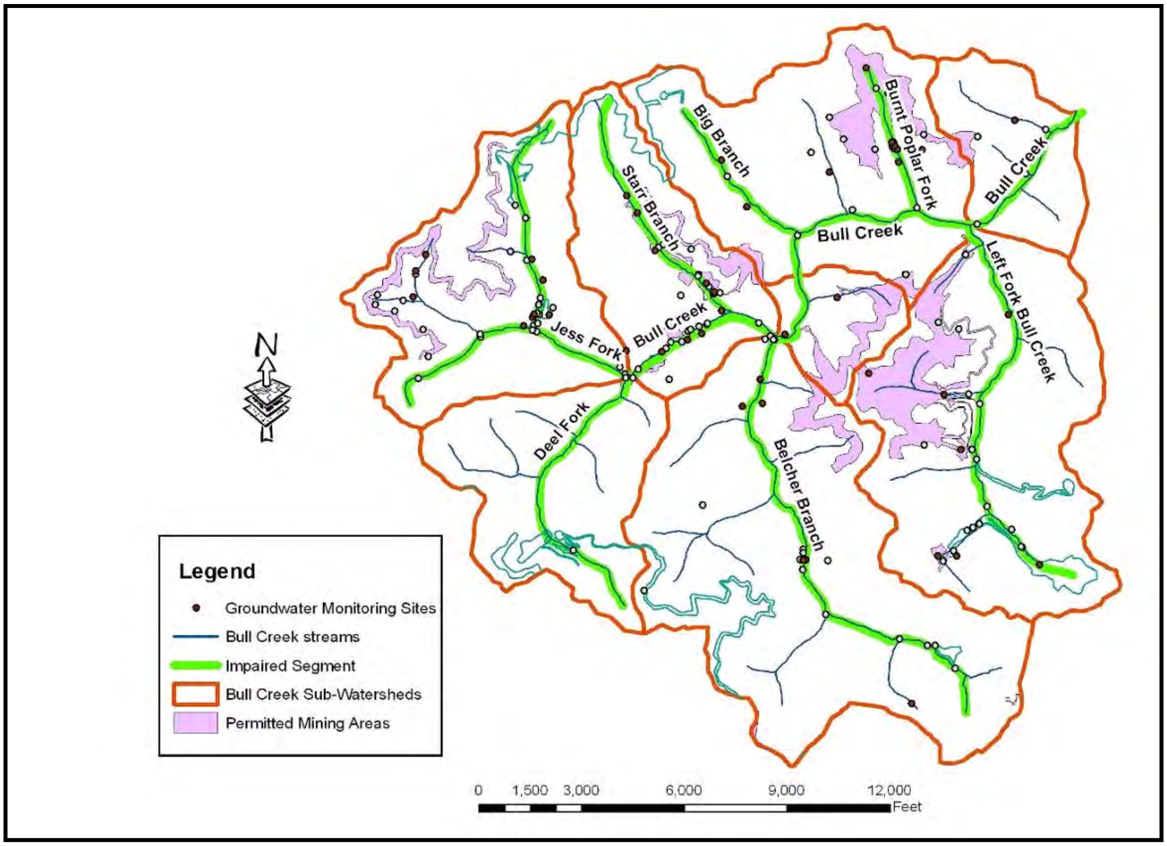


Figure 2.31. DMME-DMLR Groundwater Monitoring Sites, January 2005 – June 2007

Table 2.10. Bull Creek Groundwater Monitoring Data, Jan-95 through Jun-07

Average Concentrations over Period of Record

DMLR MPID	Flow (gpm)	pH	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Temperature (°C)	Acidity (mg/L)	Alkalinity (mg/L)	Conductivity (µmhos/cm)	TDS (mg/L)	Sulfate (mg/L)	Date of First Sample	Date of Last Sample	Permit Number	Sub-watershed
0001296	37.42	7.86	0.21	0.11	3.7	14.4	--	237.2	1,108.3	981.2	383.5	Jan-95	Aug-98	1201363	Belcher Branch
0004463	0.29	8.43	0.56	0.08	4.9	16.4	1.0	187.7	373.0	214.4	6.6	Jan-02	Jun-07	1601788	Belcher Branch
0005459	12.90	6.93	0.53	0.04	20.8	12.2	--	62.9	337.7	264.2	59.1	Apr-04	Jun-07	1101903	Belcher Branch
5600368	208.36	7.48	0.49	0.13	2.4	14.4	--	210.8	1,398.9	1,013.7	441.1	Jan-95	Aug-98	1201363	Belcher Branch
5645398	--	6.75	10.82	0.43	64.7	13.9	--	139.3	705.2	523.3	518.0	Jan-95	Mar-99	1300985	Belcher Branch
5650118	248.95	7.48	0.32	0.09	4.4	15.3	0.2	196.9	1,305.1	903.8	401.6	Jan-95	Sep-05	1201909	Belcher Branch
0001942	18.12	7.24	0.39	0.42	29.5	12.4	--	175.2	851.7	546.4	292.3	Dec-95	Dec-02	1401509	Burnt Poplar/Big Branch
0003444	18.70	7.63	0.69	0.81	13.2	13.8	0.5	178.7	1,552.7	939.5	643.9	Nov-99	Jun-07	1101701	Burnt Poplar/Big Branch
0003445	5.07	7.39	9.33	0.33	172.7	13.8	0.6	53.6	679.9	312.3	193.1	Nov-99	Jun-07	1101701	Burnt Poplar/Big Branch
0003576	29.02	7.69	0.16	0.03	6.7	15.2	0.4	223.9	1,449.4	814.4	432.5	Mar-00	Jun-07	1101736	Burnt Poplar/Big Branch
0003578	0.28	7.43	1.72	0.09	15.6	15.7	0.4	117.9	865.7	574.6	323.9	Mar-00	Jun-07	1101736	Burnt Poplar/Big Branch
0003579	185.12	7.41	0.13	0.03	5.3	15.2	0.4	179.8	1,260.4	727.8	363.0	Mar-00	Jun-07	1101736	Burnt Poplar/Big Branch
0003580	27.15	7.76	0.78	0.17	662.3	15.0	0.4	138.3	1,421.0	1,002.5	652.4	Jun-00	Jun-07	1101736	Burnt Poplar/Big Branch
5643333	--	7.13	0.63	0.60	36.3	14.0	--	231.0	654.0	497.3	176.7	Jan-95	Sep-95	1200272	Burnt Poplar/Big Branch
5644451	121.48	7.15	0.30	0.14	3.8	14.0	--	234.4	1,159.9	890.4	360.0	Jan-95	Aug-98	1201595	Burnt Poplar/Big Branch
5650252	3.32	7.55	1.76	0.15	64.1	14.0	--	93.3	581.3	373.8	242.4	Jan-95	Dec-02	1401509	Burnt Poplar/Big Branch
0000083	3.44	5.97	0.15	1.23	3.0	13.2	14.0	3.5	580.3	296.7	219.1	Jan-95	Jun-07	1401467	Jess Fork
0004539	--	7.35	0.01	--	0.1	20.8	--	7.6	514.5	48.4	35.1	Apr-03	Jul-04	1201574	Jess Fork
0004540	7.51	6.58	0.07	0.78	2.7	15.9	13.3	5.1	518.0	303.2	143.0	Apr-03	Jun-07	1201574	Jess Fork
0006430	1.00	7.18	2.00	0.18	5.0	13.3	1.0	120.5	278.9	163.0	5.3	Sep-06	Jun-07	1101979	Jess Fork
0006432	11.37	6.56	0.03	1.00	2.0	14.5	18.0	11.3	495.0	406.0	178.0	Sep-06	Jun-07	1101979	Jess Fork
5643399	1.26	6.73	0.80	1.00	100.0	15.3	--	355.0	521.4	226.0	120.0	Jan-95	Aug-99	1201615	Jess Fork
5643400	--	6.93	3.34	0.51	22.7	15.9	--	73.6	707.5	469.1	284.3	Jan-95	Aug-99	1201615	Jess Fork
5645399	0.16	6.71	9.24	0.28	76.1	13.8	--	101.6	660.3	571.3	309.1	Jan-95	Mar-99	1300985	Jess Fork
0004461		7.27	1.19	0.22	6.7	16.6	0.8	108.3	376.0	258.6	98.5	Jan-02	Jun-07	1601788	Left Fork Bull Creek
0004465	38.45	7.63	2.45	5.04	700.3	16.3	3.9	118.9	1,761.6	1,688.6	920.7	Dec-03	Jun-07	1601788	Left Fork Bull Creek
5640069	1.67	7.34	1.01	0.44	17.0	14.5	10.2	139.5	680.2	447.2	194.3	May-95	Nov-05	1200343	Left Fork Bull Creek
5650195	--	6.97	0.10	0.10	8.0	11.0	--	359.0	516.7	290.0	110.0	Jan-95	Sep-95	1201209	Left Fork Bull Creek
5653489	--	7.20	0.63	1.04	10.2	13.1	--	139.8	418.7	330.4	159.1	May-95	Nov-05	1200343	Left Fork Bull Creek
5655196	30.40	7.11	0.82	0.48	10.6	14.6	0.2	56.6	919.3	712.1	523.1	Jan-95	Aug-05	1301908	Left Fork Bull Creek
0003446	--	7.29	1.40	0.13	4.2	15.1	0.7	152.8	522.0	271.8	80.9	Nov-99	Jun-07	1101701	Middle Bull Creek
0004462	7.97	7.60	0.43	0.05	7.6	14.9	0.8	179.5	1,069.0	756.1	367.9	Jan-02	Jun-07	1601788	Middle Bull Creek
0003577	0.46	7.47	2.05	0.66	20.4	16.0	1.1	60.8	582.4	460.0	276.2	Mar-00	Jun-07	1101736	Outlet
0000942	29.67	7.16	0.10	0.10	48.0	18.9	--	124.0	753.8	1,441.0	717.5	Jan-95	May-97	1300985	Starr Branch
0000943	73.51	7.12	0.10	0.10	45.5	15.8	--	145.0	901.7	1,439.0	697.5	Jan-95	May-97	1300985	Starr Branch
0003443	2.05	7.18	23.34	0.71	808.5	17.1	17.9	37.9	689.5	428.8	193.0	Nov-99	Jun-07	1101701	Starr Branch
0004313	8.70	7.53	5.62	0.41	208.7	17.5	9.1	105.6	704.9	552.4	254.3	Apr-02	Jun-07	1201793	Starr Branch
5600375	241.35	7.89	1.20	0.20	9.9	13.7	--	257.6	801.0	676.9	275.3	Jan-95	Mar-99	1201364	Starr Branch
5640218	--	7.30	3.40	0.53	17.5	17.4	--	191.1	825.3	597.1	226.4	Jan-95	Aug-98	1300469	Starr Branch
5640219	22.34	7.46	0.91	1.26	25.3	16.0	--	81.1	2,115.4	1,837.4	562.9	Jan-95	Aug-98	1300469	Starr Branch
5650220	26.85	7.24	0.67	1.36	11.9	16.6	--	163.1	2,786.6	2,427.7	491.9	Jan-95	Aug-98	1300469	Starr Branch
5650221	--	5.28	5.57	3.77	66.7	18.0	20.3	20.9	2,425.9	2,592.7	804.2	Jan-95	Aug-98	1300469	Starr Branch

Average by Sub-watershed

Sub-watershed	Flow (gpm)	pH	Iron (mg/L)	Manganese (mg/L)	TSS (mg/L)	Temperature (°C)	Acidity (mg/L)	Alkalinity (mg/L)	Conductivity (µmhos/cm)	TDS (mg/L)	Sulfate (mg/L)
Outlet	0.5	7.5	2.0	0.7	20.4	16.0	1.1	60.8	582.4	460.0	276.2
Left Fork Bull Creek	12.1	7.3	1.0	1.0	72.0	14.5	3.1	116.0	736.5	574.5	326.6
Burnt Poplar/Big Branch	39.8	7.5	1.8	0.3	109.5	14.3	0.3	150.1	1,074.2	667.3	385.7
Middle Bull Creek	2.2	7.4	1.1	0.1	5.1	15.1	0.7	160.0	669.6	402.5	158.3
Belcher Branch	108.0	7.5	2.0	0.1	15.5	14.6	0.2	177.6	934.4	685.0	319.7
Starr Branch	41.6	7.2	6.6	1.0	208.4	16.7	6.9	116.8	1,294.8	1,211.3	415.5
Jess Fork	2.8	6.5	2.0	0.8	29.8	14.6	7.3	82.1	582.1	343.3	205.9
Deel Fork											

Thresholds used for evaluation: Iron (1.0 mg/L); Manganese (1.0 mg/L); TSS (100 mg/L); Conductivity (500 µmhos/cm); TDS (500 mg/L); Sulfate (250 mg/L).

2.1.4. DMME-DGO Permit Summary

Gas and oil permits are issued by the DMME Division of Gas and Oil (DGO) for construction of gas and oil well pumping facilities and are subject to stormwater erosion and sediment control (E&S) sediment permit limits. Contributions from gas and oil operations in the watershed are transient, and regulations require that any disturbed acreage during construction and drilling must be stabilized within 30 days. Sediment loads from both the pumping sites and the access roads are covered under the stormwater E&S permits, unless existing roads are used for access.

Currently there are 24 active gas wells in the watershed with an additional 5 wells permitted that have not yet been constructed. A summary of the current active well, plugged release, and pending well permits are shown in Table 2.11, with their locations shown in Figure 2.32.

Because of the recent flurry of activity surrounding the energy-producing industry, an increased number will likely be seen. Reclaimed areas not in other uses might be prime target areas for these applications.

Table 2.11. DMME Division of Gas and Oil (DGO) Well Permit Summary: June 2007

Permit No.	Operation ID	County	USGS Quad	Subwatershed	Operation Description	Permits Description
Active Wells						
BU-0566	EH-110	BUCHANAN	HARMAN	Belcher Branch	Gas	Constructed/Never Drilled
BU-3081	825903 (HY-137	BUCHANAN	HARMAN	Starr Branch	Gas/Pipeline	Construction
BU-2478	CBM N-76	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/
BU-2669	CBM N78	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/
BU-2688	CBM M77	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/
BU-2709	CBM L77	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/
BU-3000	CBM K76	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/
BU-3009	CBM L76	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/
BU-2477	CBM N-75	BUCHANAN	HARMAN	Belcher Branch	Coalbed/Pipeline	Drilled/Waiting Completion/
BU-3049	CNR 823540 (H	BUCHANAN	HARMAN	Jess Fork	Gas/Pipeline	Drilled/Waiting Completion/
BU-2335	CBM M76	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Not Connected
BU-2345	CBM K-75	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Not Connected
BU-2479	CBM N-77	BUCHANAN	HARMAN	Left Fork Bull Creek	Coal Bed	Not Connected
BU-0098	9591	BUCHANAN	HARMAN	Jess Fork	Gas	Producing
BU-0116	9692	BUCHANAN	HARMAN	Deel Fork	Gas	Producing
BU-0117	9678	BUCHANAN	HARMAN	Middle Bull Creek	Gas	Producing
BU-0118	9681	BUCHANAN	HARMAN	Deel Fork	Gas	Producing
BU-0126	9701	BUCHANAN	HARMAN	Jess Fork	Gas	Producing
BU-0131	9765	BUCHANAN	HARMAN	Burnt Poplar/Big Branch	Gas	Producing
BU-0147	20340	BUCHANAN	HARMAN	Jess Fork	Gas	Producing
BU-0167	20546	BUCHANAN	HARMAN	Deel Fork	Gas	Producing
BU-0564	EH-112	BUCHANAN	HARMAN	Belcher Branch	Gas	Producing
BU-0572	EH-114	BUCHANAN	HARMAN	Starr Branch	Gas	Producing
BU-0754	21732	BUCHANAN	HARMAN	Starr Branch	Gas	Producing
Plugged/Released Wells						
BU-0087	9582	BUCHANAN	HARMAN	Left Fork Bull Creek	Gas	Plugging/Plugged/Abandoned
BU-0135	9766	BUCHANAN	HARMAN	Burnt Poplar/Big Branch	Gas	Released
BU-0145	20342	BUCHANAN	HARMAN	Deel Fork	Gas	Released
BU-0606	EH-111	BUCHANAN	HARMAN	Deel Fork	Gas	Released
Pending Permits						
8869	4/26/2006	BUCHANAN	HARMAN	Belcher Branch		Pending
8870	4/26/2006	BUCHANAN	HARMAN	Belcher Branch		Pending
8871	4/26/2006	BUCHANAN	HARMAN	Belcher Branch		Pending
8872	4/26/2006	BUCHANAN	HARMAN	Belcher Branch		Pending
8880	4/27/2006	BUCHANAN	HARMAN	Belcher Branch		Pending

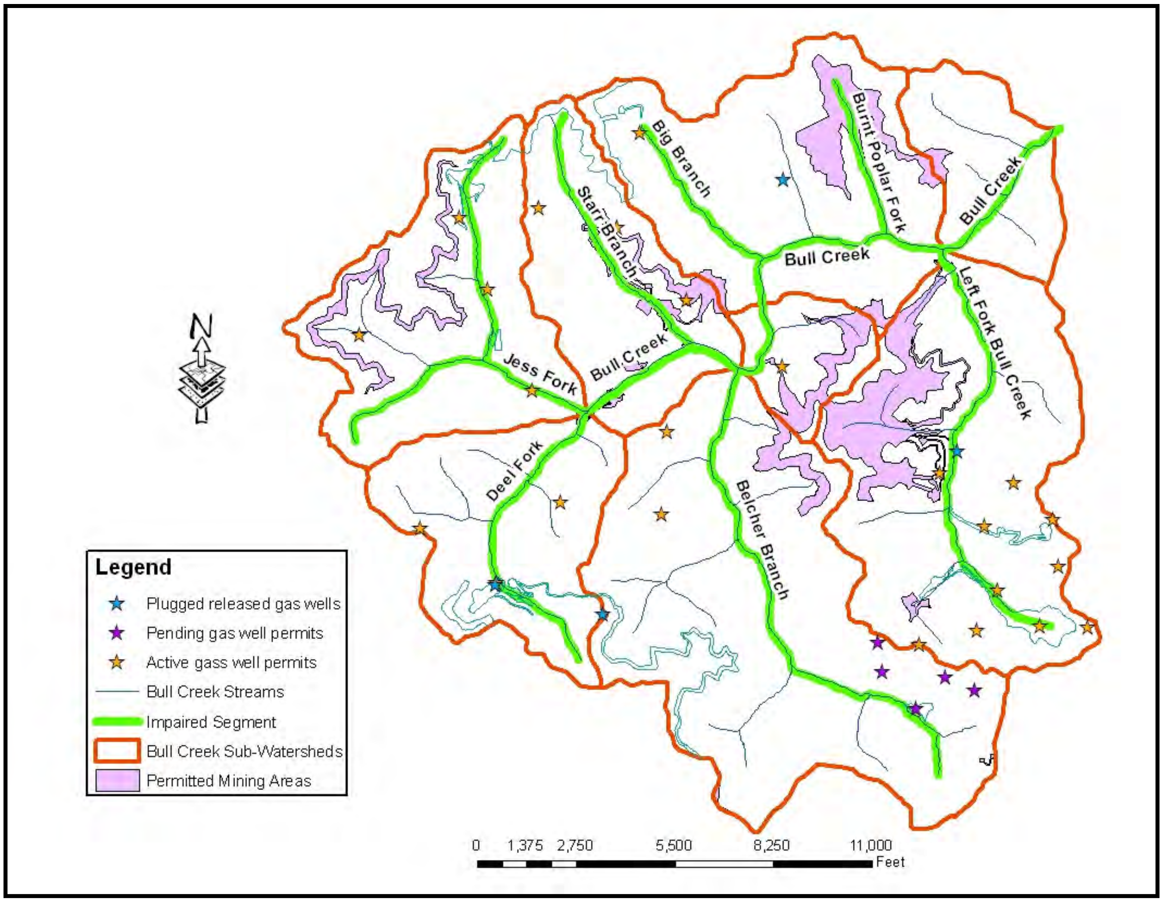


Figure 2.32. DMME DGO Gas Well Locations in Bull Creek

Point Source Permits

2.1.5. DEQ – VPDES Permits in Bull Creek

There are no Virginia Pollution Discharge Elimination System (VPDES) permits currently active in Bull Creek.

2.1.6. DMLR – NPDES Permit Summary

Within the Bull Creek watershed, the eleven mining permits, Table 2.12, are in various stages of activity, and are monitored at eighteen monitoring points. These permits require stormwater detention ponds to reduce the loading of sediment and other pollutants and downstream monitoring in order to check their compliance with permit requirements of a maximum daily effluent concentration of 70 mg/L for TSS. The locations, extent, and type of mining permits and DMLR in-stream monitoring points are shown in Figure 2.33 prior to 1997 (during the original listing of the impaired segments) and in Figure 2.34 at the present time.

Table 2.12. DMLR Mining Permit Summary: June 2007

Permit Number	Mining Operation Name	Outlet	Convict Hollow	Burnt Poplar / Big Branch	Middle Bull Creek	Starr Branch	Belcher Branch	Jess Fork	Deel Fork	PENO Total
		Area in hectares								
1101701	Starr Branch Strip			3.07	0.09	16.23				19.40
1101736	Burnt Poplar Surface Mine #1	3.51		45.67						49.18
1101903	Hawks Nest Surface Mine						1.10			1.10
1101979	Jess Fork Mine							25.90		25.90
1200129	Supreme Energy Corporation						0.34			0.34
1200281	Mine #1		2.47							2.47
1200343	K & H Coal Company		2.18							2.18
1201678	Apollo Mine #1					0.13		0.34	0.59	1.06
1201922	Mine #1					4.86				4.86
1201940	Clintwood Elkhorn H-1 Mine					2.22			0.08	2.29
1601788	Convict Hollow Remining Permit		72.04	3.53	23.80		14.72			114.09
Total by Sub-watershed		3.51	76.69	52.27	23.89	23.45	16.17	26.25	0.66	222.88

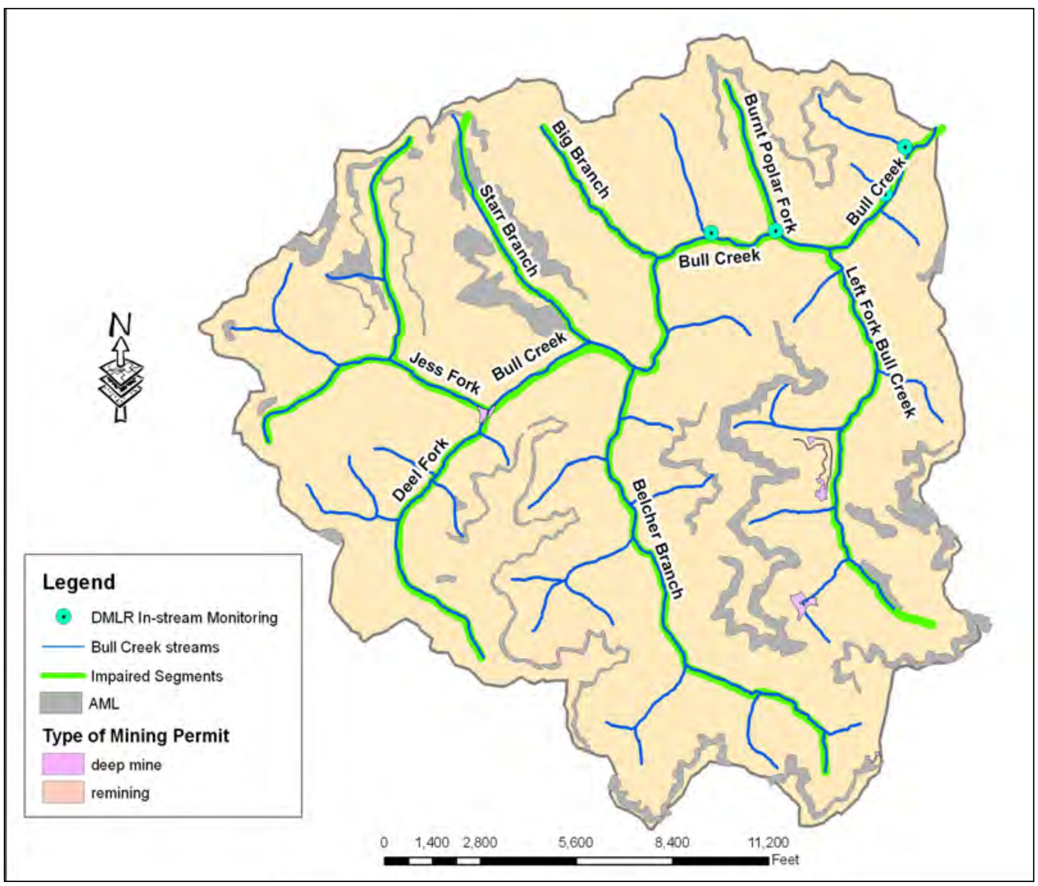


Figure 2.33. DMLR 1997 Permitted Mining Areas and In-stream Monitoring Points

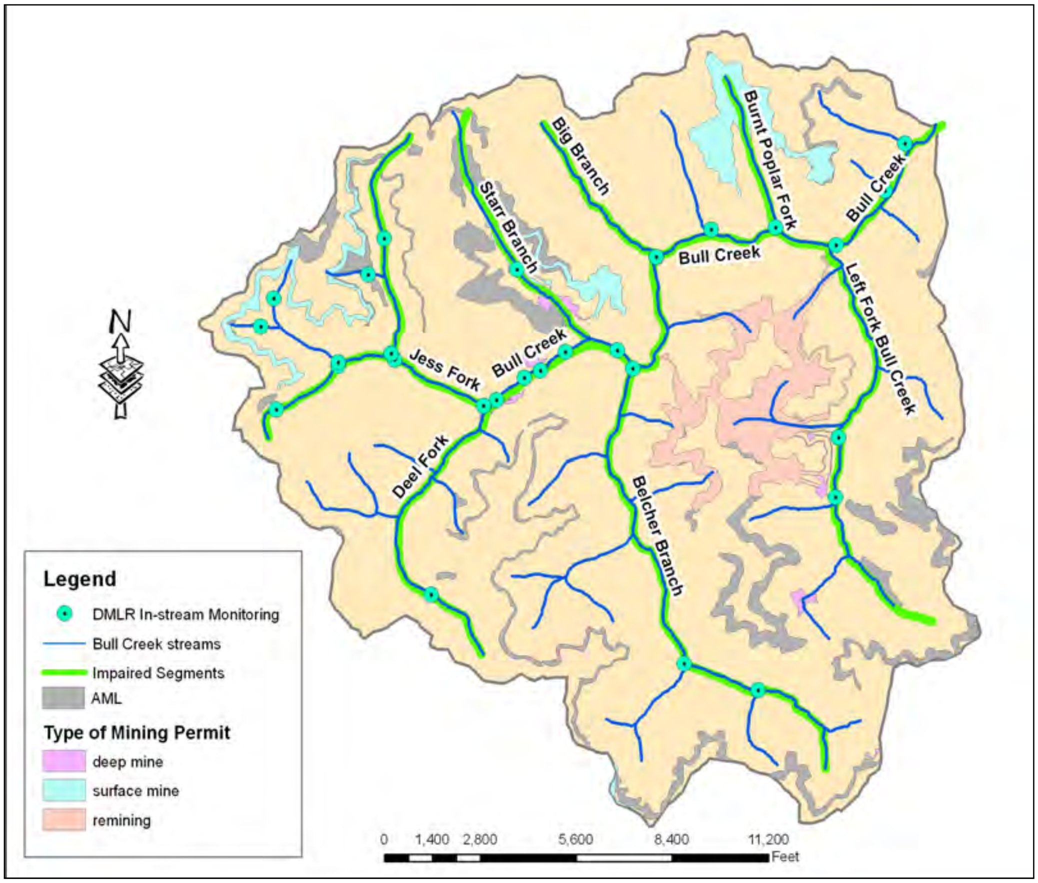


Figure 2.34. DMLR 2007 Permitted Mining Areas and In-stream Monitoring Points

2.1.7. DMME's Division of Gas & Oil (DGO) – Permit Summary

A summary of all DMME permits in the area encompassing the impaired segments and their related drainage are shown by major sub-watershed in Table 2.13. The sub-watershed location map was shown previously in Figure 1.1.

Table 2.13. Summary of DMME Permits and Monitoring Sites in Bull Creek, Jan-05 through Jun-07

Type of DMME Permits/Monitoring	Outlet	Left Fork Bull Creek	Burnt Poplar/ Big	Middle Bull Creek	Belcher Branch	Starr Branch	Jess Fork	Deel Fork	Total
DGO Active Wells		9	1	1	3	3	4	3	**24**
DGO Pending Wells					5				**5**
DGO Plugged Release Wells		1	1					2	**4**
DMLR NPDES Discharging Outfalls		7	3		7	11	6		**34**
DMLR NPDES Non-Discharging Outfalls	1	4	5		1	7	7		**25**
DMLR Instream Monitoring Sites	3	3	4		3	6	10	1	**30**

Ancillary Data

2.1.8. 305(b) Monitored Exceedances

In the three biennial reports between 1998 and 2002 (DEQ, 1998, 2000, 2002), station 6ABLC002.30 was listed with a biological impairment. Ambient water quality data was only available for the 2002 305(b) report, and included no standards exceedences of temperature, pH, or DO, as shown in Table 2.14 below.

No ambient or biological data were available during the time periods assessed for the 2004 and 2006 reports. Monitored data in 2006 and 2007 will appear in the 2008 report.

Table 2.14. 305(b) Monitored Exceedences in Bull Creek

				CONVENTIONAL WATER COLUMN MONITORING DATA			OTHER WATER COLUMN DATA				SEDIMENT		BENTHIC	
				#Violations/# Samples/Status			#Violations/# Samples/Status				#Violations/Status			
Year	**WBID**	**Monitoring Station**	**Type**	**Temperature**	**Dissolved Oxygen**	**pH**	**Fecal Coliform**	**Total Phosphorus**	**Chlorophyll A**	**Organics**	**Metals**	**Organics**	**Bio Mon**	**Station Type**
1998	**S-Q08R**	**6ABLC002.30**	B	/	0 /	0 /	/	/	/				**VI**	net
2000	**S-Q08R**	**6ABLC002.30**	B	/	0 /	0 /	/	/	/				**VI**	net
2002	**S-Q08R**	**6ABLC002.30**	B	0 / 1 W	0 / 1 W	0 / 1 W	/	/	/				**VI**	net
2004		**None Listed**												
2006		**None Listed**												

Bold/Shaded = Impaired Waters

2.1.9. DCR Watershed NPS Pollutant Load Ratings

DCR performs a biennial assessment of NPS pollutant loads for each of the state's 493 14-digit hydrologic units (DCR, 2004). Bull Creek and its tributary impaired segments are located within hydrologic unit Q08.

This NPS pollutant potential assessment in this hydrologic unit ranks forestry land uses as having a high potential, urban land uses as increasing from moderate to high potential, and agriculture with low potential for sediment loading, as shown in Table 2.15. In this classification, urban land uses include mining and barren. Riverine impairment potential was also rated as high in 2000, but since has been rated as low. Rating changes between 2000 and 2002 may be due to the changes in the rating categories and methodologies between those years.

Table 2.15. DCR Watershed NPS Pollutant Ratings – Q08

Watershed-ID	Year	AGR_N	AGR_P	AGR_S	URB_N	URB_P	URB_S	FOR_N	FOR_P	FOR_S	TOT_N	TOT_P	TOT_S	RIMP	EIMP	LIMP	SWP	IBI
Q08	2006	L	L	L	M	H	H	H	H	H	L	L	M	L	N	N	B	E
Q08	2004	L	L	L	M	M	M	H	M	H	L	L	L	L	N	L	E	C
Q08	2002	L	L	L	M	M	M	H	M	H	L	L	L	L	N	L	E	C
Q08	2000		L			L			L		L	--	--	H	N	--	--	--

Header Codes
AGR - agriculture
URB - urban
FOR - forestry
N - nitrogen
P - phosphorus
S - sediment
RIMP - Riverine Impairments
EIMP - Estuarine Impairments
LIMP - Lacustrine Impairments

Nutrient & Impairment Rank Codes
H - High
M - Medium
L - Low
N - Not Applicable

SWP - Source Water Protection Codes
A - Very High
B - High
C - Moderate
D - Low
E - None

IBI - miniMIBI Codes
A: 16-24/5
B: 16-24/1-3
C: 13-15
D: 1-12
E: Insufficient Data

CHAPTER 3: BENTHIC STRESSOR ANALYSIS

Introduction

TMDLs must be developed for a specific pollutant. Since a benthic impairment is based on a biological inventory, rather than on a physical or chemical water quality parameter, the pollutant is not explicitly identified in the assessment, as it is with physical and chemical parameters. The process outlined in USEPA's Stressor Identification Guidance Document (USEPA, 2000) was used to identify the critical stressor for Bull Creek and its impaired tributaries. A list of candidate causes was developed from the listing information, biological data, published literature, and stakeholder input. Chemical and physical monitoring data from DEQ monitoring provided additional evidence to support or eliminate the potential candidate causes. Biological metrics and habitat evaluations in aggregate provided the basis for the initial impairment listing, but individual metrics were also used to look for links with specific stressors, where possible. Volunteer monitoring data, land use distribution, Virginia Base Mapping Project (VBMP) aerial imagery, and visual assessment of conditions in and along the stream corridor provided additional information to investigate specific potential stressors. Logical pathways were explored between observed effects in the benthic community, potential stressors, and intermediate steps or interactions that would be consistent in establishing a cause and effect relationship with each candidate cause. The candidate benthic stressors considered in the following sections are ammonia, hydrologic modifications, nutrients, organic matter, pH, sediment, TDS/conductivity/sulfates, temperature, and toxics. The information in this section is adapted from the original Stressor Analysis Report for Bull Creek (Yagow et al., 2007).

The purpose of the stressor analysis is to look for a stressor that was present in the 1996 sample which caused Bull Creek's initial 1998 listing on the 303(d) impaired waters list and whose current response is consistent with current levels of the stressor. The stressor may be something that either directly affected the benthic community or indirectly affected its habitat. Virginia SCI ratings suggest that the benthic community has been severely to moderately stressed at different times during the period from 1996 to 2006. There was a slight improvement in the VaSCI biological assessment score from 1996 to 2001, and there is a slightly increasing trend of improvement from 1996 to 2006. There is no DEQ ambient monitoring data prior to 2005, so the only data that can be assessed for association with the 1996 biological sample are DMLR monitored data and land uses.

A list of candidate stressors was developed for Bull Creek and evaluated to determine the pollutant(s) responsible for the benthic impairment. A potential stressor checklist was used to evaluate known relationships or conditions that may show associations between potential stressors and changes in the benthic community. An outline of available evidence was then summarized as the basis for each potential stressor. Candidate stressors included ammonia, hydrologic modifications, metals, nutrients, organic matter, pH, sediment, the TDS/conductivity/sulfate suite of parameters, temperature, and toxics.

Depending on the weight of evidence available, each potential stressor was placed into one of the following three categories:

- Eliminated Stressors: Potential stressors with data indicating normal conditions, without violations of a governing standard, or without observable impacts usually associated with a specific stressor. These stressors were eliminated from the list of possible stressors.
- Possible Stressors: Stressors with data indicating possible links, but with inconclusive data, were considered to be possible stressors.
- Most Probable Stressor(s): Stressor(s) with the most consistent data linking it with the poorer benthic metrics, or the most plausible of the possible stressors were called the most probable stressor(s). This stressor(s) was then used for TMDL development.

Eliminated Stressors

Ammonia

High values of ammonia are toxic to many fish species and may impact the benthic community as well. All the values recorded at DEQ ambient monitoring stations were at or below the minimum detection limit (MDL) of 0.04 mg/L. No fish kills have been reported in this watershed and nothing in the ambient monitored data indicates ammonia as a stressor, therefore it was eliminated from further consideration as a stressor for Bull Creek.

Nutrients

Excessive nutrient inputs can lead to excessive algal growth, eutrophication, and low dissolved oxygen (DO) concentrations which may adversely affect the survival of benthic macroinvertebrates. In particular, DO levels may become low during overnight hours due to respiration. The majority of DEQ-monitored dissolved phosphorus concentrations have been at or below their minimum analytical detection limit at all stations and, therefore, the segment has never exceeded DEQ's "threatened waters" threshold for total phosphorus (TP). Total nitrogen (TN) concentrations are slightly elevated within the watershed but not at levels that would indicate problems since phosphorus concentrations are so low in the watershed. Sources of nitrogen include residential, atmospheric deposition, and mining activities (explosives and hydro-seeding fertilizers).

While the benthic community in Bull Creek has occasional high populations of Chironomidae or Hydropsychidae – organisms associated with excessive nutrients, it has also contained high numbers of low pollution tolerant organisms. Several low riparian vegetation habitat metric scores have been recorded, which could promote increased nutrient transport through surface runoff. There also appear to be some seasonal differences in VaSCI, but these do not appear to be related to nutrients, and since there is almost no phosphorus in the system, excessive production due to nutrients is limited. Therefore, nutrients have been eliminated as a possible stressor.

Organic Matter

Excessive organic matter can lead to low in-stream dissolved oxygen concentrations which may adversely affect the survival and growth of benthic macroinvertebrates. Potential sources of organic matter in Bull Creek include household wastewater discharges, malfunctioning septic systems, and runoff from impervious areas. Organic enrichment is also supported by the types of abundant benthic organisms found in many of the samples – Hydropsychidae and Simuliidae – typical of organic-enriched sites, and the low ratios of scrapers to filterer-collectors, indicative of abundant suspended organic matter, which is used as a food source for the filterer-collectors. The abundance of these organisms, however, could also be attributed to high TDS levels. Although modified family biotic index (MFBI) metric scores are elevated, excessive enrichment is not evident. Ambient dissolved oxygen concentrations are all within standards, and another measure of organic enrichment – chemical oxygen demand (COD) – was at minimal levels. Therefore, organic matter has been eliminated as a possible stressor.

pH

Benthic macroinvertebrates require a specific pH range of 6.0 to 9.0 to thirve. Changes in pH may adversely affect the survival of benthic macroinvertebrates. Treated wastewater, mining discharge and urban runoff can potentially alter in-stream levels of pH. No exceedances of the minimum or maximum pH standard were reported at either of the DEQ stations on the impaired segment. Exceedances were observed in the DMLR data upstream in Jess Fork specifically during the time of the 1998 assessment. Therefore, pH may have been a contributing source of stress but recent improvements in pH levels have not resulted in improved benthic metrics, so pH was eliminated from further consideration as a stressor.

Temperature

Elevated temperatures can stress benthic organisms and provide sub-optimal conditions for their survival. Bull Creek is classified as a Class IV mountain stream with a maximum temperature standard of 31°C. No exceedances of the temperature standard were recorded either by DMLR, or by DEQ ambient monitoring, or by monitoring during collection of the biological samples. Low riparian vegetation habitat metric scores were observed during several biological samplings, but did not correspond with elevated temperature levels. Therefore, no evidence supported temperature as a stressor, and it was eliminated.

Possible Stressors

Hydrologic Modifications

Hydrologic modifications can cause shifts in the supply of water, sediment, food supply, habitat, and pollutants from one part of the watershed to another, thereby causing changes in the types of biological communities that can be supported by the changed environment. Much of the headwaters of the Bull Creek and other tributaries in the watershed have been intensively mined. Residences throughout the watershed [particularly noted in Left Fork of Bull Creek (Convict Hollow) sub-watershed and in the Burnt Poplar sub-watershed around the town of Maxie] are crowded into the riparian corridor along the impaired segment with many of the stream channel walls armored with concrete and stone. Although these modifications are considered as "pollution" and not "pollutants" covered by the TMDL legislation, hydrologic modifications are considered a possible stressor as they are likely to increase channel erosion and sediment loads downstream.

Metals

Increased metals concentrations lead to low diversity and low total abundance of benthic organisms, with specific reduced abundance of metal-sensitive mayflies and increased abundance of metal-tolerant chironomids (Clements, 1994). Some monitoring site average concentrations of iron and manganese are above average daily permitted values (3.5 mg/L iron, 2,0 mg/L manganese; eCFR, 2007), but the majority of DMLR samples reported average iron and manganese concentrations within the average daily permitted levels. Total organism abundance was low with low diversity in the one sample that led to the initial 1996 listing, but it could possibly have been due to discharges from a historical coal processing plant that is no longer in operation, as the low diversity in the 1996 sample has not been seen in more recent samples. Therefore, while it is doubtful that they are the dominant stressor, elevated levels of iron and manganese are found throughout the watershed (Table 2.6, Table 2.7, and Table 2.10) and are considered possible stressors.

<u>Toxics</u>

Toxic substances by definition are not well tolerated by living organisms. The presence of toxics as a stressor in a watershed may be supported by very low numbers of any type of organisms, low organism diversity, exceedances of freshwater aquatic life criteria or consensus-based probable effect concentrations (PEC) for metals or inorganic compounds, by low percentages of the shredder population, reports of fish kills, or by the presence of available sources. Coal mining has occurred, or is occurring, in all parts of the Bull Creek watershed which led to the unusual listing not only of Bull Creek, but also to all of its tributary first-order stream segments as well. Prior to 1995, a coal processing plant sat on Bull Creek just above its confluence with Starr Branch. Local residents reported that weekly, and some times more frequently, discharges from the plant consisted of "black" coal water whose constituents were unknown. However, since the plant is no longer in operation and the biological impairment still exists, the plant is unlikely to be contributing to the current source of the impairment. Failing septic systems, straight pipes, and grey-water discharges still present in the watershed could also be possible sources of toxic substances to Bull Creek. Because of the possibility of contributions from these various sources, toxics are considered to be a possible stressor.

Most Probable Stressor

The two most probable stressors to the benthic community are considered to be sediment and TDS based on the following summary of available evidence.

Sediment

Excessive sedimentation can impair benthic communities through loss of habitat. Excess sediment can fill the pores in gravel and cobble substrate, eliminating macroinvertebrate habitat. Potential sources of sediment include residential runoff, forestry, mining operations, construction sites, and in-stream disturbances. Permitted point sources of sediment discharge, other than permitted mining discharges, are not present in this watershed and agricultural sources are sparse. Sediment problems appear to be primarily related to disturbed areas in the watershed that are subject to soil detachment and to runoff from impervious areas. The steep terrain of this watershed is also a contributing factor to sediment loads from disturbed areas. Disturbed or barren areas, often located close to streams, include recently cleared forested areas, new construction, surface mining operations, and poorly vegetated riparian areas along streams. Sediment is supported as a stressor for this impairment through the consistently low proportion of haptobenthos organisms, which require clean substrates for habitat, and through poor habitat metrics related to sediment including embeddedness and sediment deposition. Additionally, lower metric scores were reported in earlier samples for bank stability and riparian vegetation. DEQ ambient TSS concentrations are low, with one elevated concentration likely associated with a runoff event. Elevated TSS concentrations have been more widely and more frequently reported through DMLR's in-stream monitoring by the mining industry. Sediment is considered a most probable stressor in Bull Creek because of the poor habitat metrics related to sediment, the periodically-elevated TSS concentrations (Figure 2.26), and the availability of areas with poor vegetative cover or otherwise subject to erosion during runoff.

TDS

Total dissolved solids (TDS) are the inorganic salts, organic matter and other dissolved materials in water. Since sulfates are one of the constituent components of the TDS measurement, and conductivity measurements are a correlate of TDS, TDS will be used as the stressor that is evidenced by this suite of parameters. Elevated levels of TDS cause osmotic stress and alter the osmoregulatory functions of organisms (McCulloch et al., 1993). The average TDS and conductivity measurements reported in DMLR in-stream and groundwater monitoring data for Bull Creek watershed were greater than the screening values of 500 mg/L and 500 µmhos/cm, respectively. Sulfate values were greater than the screening value of 250 mg/L for Bull Creek for in-stream monitoring. The high levels of TDS and its related parameters are likely contributors to the stress evidenced by the benthic community.

Bull Creek (VAS-Q08R_BLC01A98) is severely to moderately impaired for its aquatic life use, with individual VaSCI scores varying between 26.1 and 43.2. A score of 60 or above represents a non-impaired condition (scale: 0 – 100). DEQ biological and ambient monitoring within this watershed is sparse with limited biological monitoring conducted in 1996, 2001, and 2006. Ambient water quality data has only been collected since May 2005. The longer term record of available DMLR in-stream monitoring data for TDS, conductivity, and sulfate concentrations are all frequently greater than the DEQ screening values used for selection of reference conditions. This watershed is impacted by mining activities.

Coal mining activities, including surface, auger, and deep mining, have been conducted in the Bull Creek watershed since the 1930's. Most of the mining was conducted prior to the current Surface Mining Control and Reclamation Regulations and resulted in over 1,000 acres of pre-law abandoned mined lands (AML) within the watershed. Five deep mines operated in the watershed prior to 1996. Although AML and surface mining activities are currently the major suspected sources of impairment in Bull Creek, immediately prior to the first benthic sample taken in 1996, no surface mines were active in the watershed, so that recent surface mining activities could not have been the cause of the original impairment. One of the deep mines ceased operation in 1994, and another was downstream from the biological monitoring station, 6ABLC002.30. Additionally, during the 1998 assessment period, a coal processing plant operated adjacent to Bull Creek, just above its confluence with Starr Branch, which may have contributed to the initial impairment. The coal processing plant ceased operations in the late 1990s and the rail spur has since been removed.

Prior to 1996, approximately 10 gas wells were producing above station 6ABLC002.30 and one abandoned mine contributed discharge on Belchers Branch. From DMLR monitoring, repeated low pH values were reported for Jess Fork in the mid-1990s, together with high values of conductivity, TDS, and sulfates from Jess Fork, Deel Fork, Starr Branch, and Belcher Branch. Therefore, the initial cause of the impairment appears to have been a combination of low pH, high TDS and sediment, associated primarily with the coal processing plant discharge, with additional impacts from AML runoff and deep mine discharges. Although the major suspected source of the 1996 impairment no longer exists and pH values all currently fall within an acceptable range, the TDS and sediment stressors continue to remain elevated and are most likely the cause of the present day impairment.

Biological monitoring metrics have shown a slight improvement over time. At the same time, TDS concentrations have shown a slight decrease. This further supports the association between the biological metrics and TDS and/or its constituents, even if it is not possible to discriminate between surface and deep mining sources causing the impairment. Sediment and TDS were selected as the most probable stressors based on the repeated poor scores for sediment metrics in the habitat assessment and elevated observed TSS and TDS concentrations.

CHAPTER 4: THE REFERENCE WATERSHED MODELING APPROACH

Introduction

Virginia has no numeric in-stream criteria for either sediment or TDS – the most probable stressors identified in this study. As a result, a "reference watershed" approach was used to set allowable loads for these constituents in the impaired watershed.

The reference watershed approach pairs two watersheds – one whose streams are supportive of their designated uses and one whose streams are impaired. This reference watershed may be, but does not have to be, the watershed corresponding to the reference monitoring site used for determining comparative biological metric scores. The reference watershed is selected on the basis of similarity of land use, topographical, ecological, and soils characteristics with those of the impaired watershed. This approach is based on the assumption that reduction of the stressor loads in the impaired watershed to the level of the loads in the reference watershed will result in elimination of the benthic impairment.

The reference watershed approach involves assessment of the impaired reach and its watershed, identification of potential causes of impairment through a benthic stressor analysis, selection of an appropriate reference watershed, model parameterization and pollutant simulation within the TMDL watershed, definition of the TMDL endpoint, and development of alternative TMDL reduction (allocation) scenarios. TMDL endpoints may be developed using either modeled loads or a statistical measure of monitored pollutant concentrations from the reference watershed. Where a simulated load is used as the TMDL endpoint, pollutant loads are also simulated from the reference watershed.

Selection of a Reference Watershed

4.1.1. Comparison of Potential Watersheds

Five watersheds were considered as references for Bull Creek – Upper Dismal Creek, Fryingpan Creek, Baileys Trace, Martin Creek, and Burns Creek. Upper Dismal Creek and Fryingpan Creek have been used as biological monitoring reference sites for Bull Creek. Baileys Trace, Martin Creek, and Burns Creek have been used as biological references for other southwest Virginia mined watersheds. Minimal differences exist among the eco-region classifications for all of the potential reference watersheds. Table 4.1 compares the various characteristics of the candidate reference watersheds to the characteristics of the impaired watershed. Representative characteristics that were compared include land use distribution, relative percentage of present and historic extractive land uses, average soil erodibility, average percent slope, average elevation, number of non-sewered homes, population density, and VaSCI scores. The Universal Soil Loss Equation (USLE) K-factor was used as an index of the erosivity of soils in the watersheds, and was calculated as a weighted average of all soil K-factors in each watershed.

Table 4.1. Reference Watershed Comparisons for Bull Creek

Station ID	Stream Name	Area (ha)	Landuse Distribution: Urban (%)	Forest (%)	Agr (%)	Extr (%)	Historic AML area (%)	DMLR Permit Area (%)	Watershed Average: STATSGO K-factor	Slope (%)	Elevation (meters)	Latest SCI: Score	Date	SubEco Region
			Impaired Watershed											
6ABLC002.30	Bull Creek	3,129	3%	81%	1%	15%	8.0%	7.4%	0.202	48.4	525.0	41.30	Nov-06	69d
			Potential TMDL Reference Watersheds											
6BBAI000.26	Baileys Trace	1,085	3%	81%	3%	13%	8.1%	17.0%	0.207	44.7	688.2	53.40	Sep-99	69d
6ADIS017.94	Upper Dismal Creek	7,228	3%	94%	2%	1%	5.1%	1.6%	0.206	41.1	748.4	68.62	Nov-97	69d
6ADIS003.52	Lower Dismal Creek	22,069	0%	97%	1%	2%	0.0%	1.8%	0.240	24.1	675.4	66.30	Nov-06	69d
6AFRY002.25	Fryingpan Creek	6,611	3%	94%	1%	2%	4.6%	2.1%	0.199	43.2	602.5	51.16	Jun-96	69d
6BMTN003.56	Martin Creek	4,731	2%	52%	46%	1%	0.0%	0.0%	0.288	22.2	492.6	61.58	Jun-98	67f
6BBUC000.24	Burns Creek	737	1%	84%	1%	15%	0.0%	0.0%	0.201	24.9	879.8	70.11	May-06	69d

- Impaired watershed
- Closest matches
- Selected Reference Watershed

EcoRegion	67	Central Appalachian Ridges and Valleys
	69	Central Appalachians
SubEcoRegion	67f	Southern Limestone/Dolomite Valleys and Low Rolling Hills
	69d	Cumberland Mountains

Footnote: AML = Abandoned Mine Land; DMLR = Division of Mined Land Reclamation; K-factor = Universal Soil Loss Equation index of soil erodibility; VaSCI = Virginia Stream Condition Index

4.1.2. The Selected Reference Watershed

The watershed characteristics in Table 4.1 were evaluated and considered during this comparison between Bull Creek and potential reference watersheds. During the analysis, Martin Creek was eliminated as it had a very large agricultural component, no historic AML, and was in a slightly different eco-region than the other watersheds. Burns Creek was considerably smaller in size, had no land currently permitted for mining, and a much lower average slope. Although Baileys Trace had a similar landuse distribution and percentage of historic AML area to Bull Creek, its disadvantages were its smaller size, larger percentage permitted area and a less than desirable VaSCI score.

Upper Dismal Creek and Fryingpan Creek watersheds are similar in size and somewhat larger than Bull Creek, but both had comparable landuse distributions and historic AML percentages. Upper Dismal Creek was selected over Fryingpan Creek as the reference watershed for Bull Creek based on its most recent VaSCI scores. These VaSCI scores were calculated as part of this study and were not used in the original assessment, as the VaSCI has only recently been developed. Since the VaSCI uses a fixed set of scales to score individual metrics, rather than relative measures from biological reference watersheds, VaSCI index scores are more directly comparable between watersheds than they were with the previous RBP II scoring and rating system. Using the VaSCI ratings, not only did Upper Dismal Creek score higher than Fryingpan Creek, but its score was indicative of a healthy biological community (was rated as “non-impaired” by the VaSCI), whereas Fryingpan Creek was rated as “impaired”, and therefore not appropriate for use as a reference watershed .

TMDL Modeling Endpoints

4.1.3. Sediment

Both the TMDL and reference watersheds were modeled to develop the sediment TMDL for Bull Creek. The size of the selected reference watershed, Upper Dismal Creek, was adjusted to match the area of the Bull Creek watershed. Land use distributions and other watershed characteristics were preserved throughout the adjustment. The sediment load TMDL target endpoint (t/yr) was established as the sediment load from the area-adjusted reference watershed, Upper Dismal Creek.

4.1.4. TDS

Concentration was determined to be the more meaningful endpoint in determining the TDS TMDL. Although there were no ambient DEQ monitoring stations in the Upper Dismal Creek watershed with which to assess an appropriate TDS endpoint, DEQ did have a downstream monitoring site with TDS data available at station 6ADIS001.24, referred to as Lower Dismal Creek. While the Lower Dismal Creek watershed is larger than the Upper Dismal Creek watershed, it has similar physical characteristics (landuse distribution, soils and slopes), has some mining activity, and has had several bioassessment samples taken which show a healthy aquatic community at stations 6ADIS003.52 and 6ADIS013.73. In addition, TDS data from station 6ADIS0001.24 in Lower Dismal Creek has been used previously to set the TDS TMDL endpoint for the Knox Creek TMDL (MapTech, 2006). The TDS TMDL concentration endpoint for Bull Creek was set at 369 mg/L, the 90th percentile of 34 DEQ-monitored TDS samples taken at station 6ADIS001.24 (369 mg/L).

Reductions in sediment to the TMDL target load and reductions in TDS loads to the TMDL target concentration are expected to allow benthic conditions to return to a non-impaired state.

CHAPTER 5: MODELING PROCESS FOR DEVELOPMENT OF THE SEDIMENT TMDL

A key component in developing a TMDL is establishing the relationship between pollutant loadings (both point and nonpoint) and in-stream 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 and cause the impairment of the waterbody of concern. Pollutant transport to water bodies is evaluated using a variety of tools, including monitoring, geographic information systems (GIS), and computer simulation models. In the development of the sediment TMDL for the Bull Creek watershed, the relationship between sediment sources and sediment loading to the stream was defined through computer modeling. In this chapter, the modeling process, input data requirements, and model calibration procedures for the sediment TMDL are discussed.

Model Selection

The reference watershed approach was used in this study to develop a sediment TMDL to partially address the benthic impairment in the Bull Creek watershed. The model selected for development of the sediment TMDL was the Generalized Watershed Loading Functions (GWLF) model, originally developed by Haith et al. (1992), with modifications by Evans et al. (2001), Yagow et al. (2002), and Yagow and Hession (2007).

The loading functions upon which the GWLF model is based are compromises between the empiricism of export coefficients and the complexity of process-based simulation models. GWLF is a continuous simulation spatially-lumped parameter model that operates on a daily time step. The model estimates runoff, sediment, and dissolved and attached nitrogen and phosphorus loads delivered to streams from complex watersheds with a combination of point and non-point sources of pollution. The model considers flow inputs from both surface runoff and groundwater. The hydrology in the model is simulated with a daily water balance procedure that considers different types of storages within the system. Runoff is generated based on the Soil Conservation Service's Curve Number method as presented in Technical Release 55 (SCS, 1986).

GWLF uses three input files for weather, transport, and nutrient data. The weather file contains daily temperature and precipitation for the period of simulation. The transport file contains input data primarily related to hydrology and sediment transport, while the nutrient file contains primarily nutrient values for the various land uses, point sources, and septic system types. The Penn State Visual Basic™ version of GWLF with modifications for use with ArcView was the starting point for additional modifications (Evans et al., 2001). The following modifications related to sediment were made to the Penn State version of the GWLF model, as incorporated in their ArcView interface for the model, AvGWLF v. 3.2:

- Urban sediment buildup was added as a variable input.
- Urban sediment washoff from impervious areas was added to total sediment load.
- Formulas for calculating monthly sediment yield by land use were corrected.
- Mean channel depth was added as a variable to the streambank erosion calculation.

The current Virginia Tech (VT) modified version of GWLF (Yagow and Hession, 2007) was used in this study. The VT version includes a correction to the flow accumulation calculation in the channel erosion routine that was implemented in December 2005 (DEQ, 2005). This version also includes modifications from Schneiderman et al. (2002) to remove the limitation that prevented carry-over of excess detached sediment from one simulated year (that runs from April through March of the following year) to the next, and to add in missing bounds for the calculation of erosivity using Richardson equations which were intended to have minimum and maximum bounds on daily calculations. These minimum and maximum bounds were not included in GWLF 2.0, and have been added to keep calculations within physically expected bounds.

Erosion is generated using a modification of the Universal Soil Loss Equation. Sediment supply uses a delivery ratio together with the erosion estimates, and sediment transport takes into consideration the transport capacity of the runoff. Stream bank and channel erosion was calculated using an algorithm by Evans et al. (2003) as incorporated in the AVGWLF version (Evans et al., 2001) of the GWLF model and corrected for a flow accumulation coding error (DEQ, 2005).

GWLF Model Development

As described in the previous chapter, Upper Dismal Creek in Buchanan County was selected as the reference watershed. Using a reference watershed with a history of coal mining and benthic impairment ensures that the sediment TMDL developed for Bull Creek is achievable. The average annual sediment load from the area-adjusted Upper Dismal Creek was used to define the sediment TMDL for the Bull Creek watershed. Model development for Bull Creek and its reference watershed were performed by assessing the sources of sediment in the watershed, applying procedures to represent some of the sources supplemental to the model, evaluating the necessary parameters for modeling loads, calibrating to observed flow and sediment data, and finally applying the model and procedures for calculating loads.

Eighteen sub-watersheds were delineated within the Bull Creek watershed in order to represent the spatial distribution of land uses and pollutant sources in the watershed for modeling purposes, as shown in Figure 5.1.

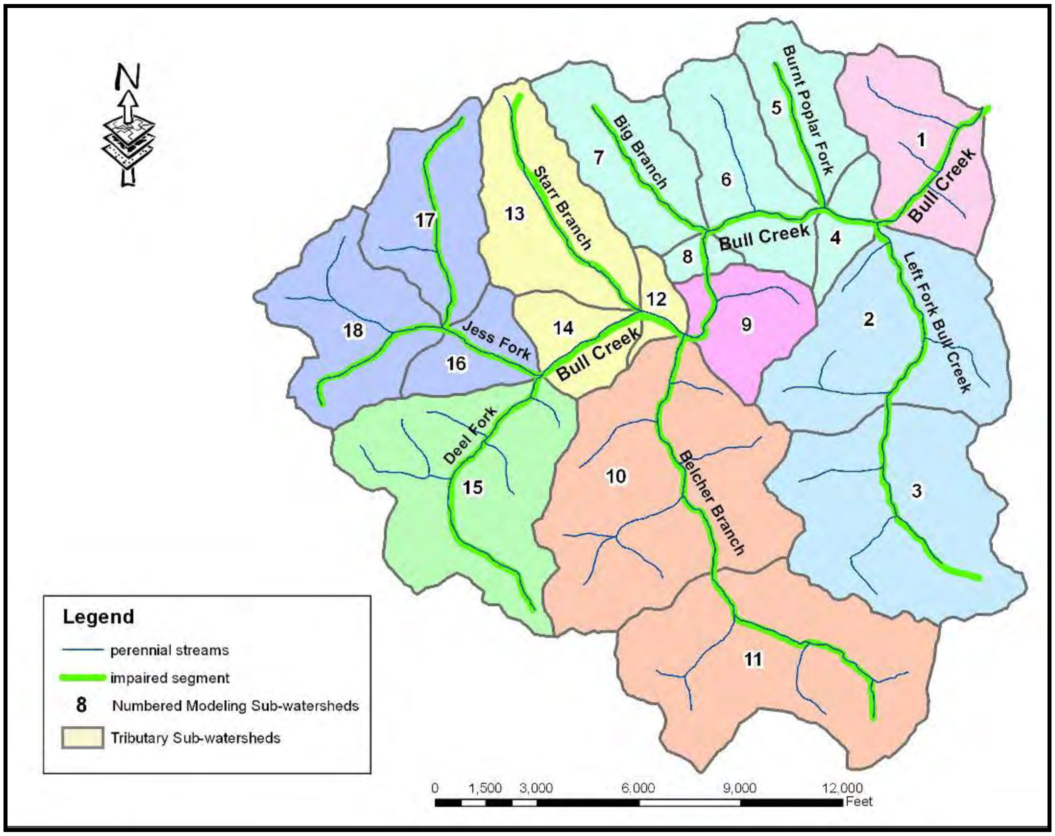


Figure 5.1. GWLF Modeling Sub-watersheds in Bull Creek

Sediment is generated in the Bull Creek watershed through the processes of surface runoff, in-channel disturbances, and streambank and channel erosion, as well as from background geologic forces. Sediment generation is accelerated through human-induced land-disturbing activities related to a variety of agricultural, forestry, mining, transportation, and residential land uses.

During runoff events, sediment loading occurs from both pervious and impervious surfaces around the watershed. For pervious areas, soil is detached by rainfall impact or shear stresses created by overland flow and transported by overland flow to nearby streams. This process is influenced by vegetative cover, soil erodibility, slope, slope length, rainfall intensity and duration, and land management practices. During periods without rainfall, dirt, dust and fine sediment build up on impervious areas through dry deposition, which is then subject to washoff during rainfall events. Sediment generated from impervious areas can be reduced through the use of management practices that reduce the surface load subject to washoff.

Vegetative cover and stream buffers in the riparian zone are essential to maintaining stable stream banks. The topography of Bull Creek is such that roads, railroads, residences, and businesses are all located in the riparian zones of the narrow valleys throughout this watershed, leaving minimal buffers, if any, and spotty vegetative cover. Additionally, impervious areas, especially in the riparian zone, increase the percentage of rainfall that runs off the land surface leading to larger volumes of runoff with higher peak flows and greater channel erosion potential. The majority of the Bull Creek impaired stream segments have their streambanks armored, which could also contribute to increased velocities and channel erosion below those sections.

Permitted stormwater dischargers in Bull Creek include both short-term and long-term activities. Short-term activities include VPDES construction permits regulated through Virginia's Erosion and Sediment Control Program, and permits for construction of gas and oil wells and facilities under the administration of DMME-DGO. Currently, there are no VPDES permitted facilities within the Bull Creek watershed. Long-term permitted activities contributing sediment include industrial stormwater dischargers and runoff from areas permitted for mining. All permitted stormwater dischargers have requirements for installation of best management practices (BMPs) to minimize the impact of their activities on water quality. Permitted mining activities are required to have sediment detention pond BMPs installed to detain stormwater runoff from all disturbed areas.

Input Data Requirements

5.1.1. Climate Data

The climate in Bull Creek watershed was characterized by meteorological observations from the National Weather Service Cooperative Station 443640 at Grundy, Virginia, while Upper Dismal Creek was modeled using data from station 447174 in nearby Richlands, Virginia in Tazewell County. The Grundy station is located in Buchanan County approximately 4 miles east of the Bull Creek DEQ monitoring station 6ABLC002.30. The period of record used for modeling was a thirteen-year period from January 1995 through December 2007, with the preceding 9 months of data used to initialize storage parameters. The beginning of this period was chosen to correspond with the beginning of DMLR monitoring data being stored in an electronic format. The locations of Bull Creek and the Grundy station are shown in Figure 5.2.

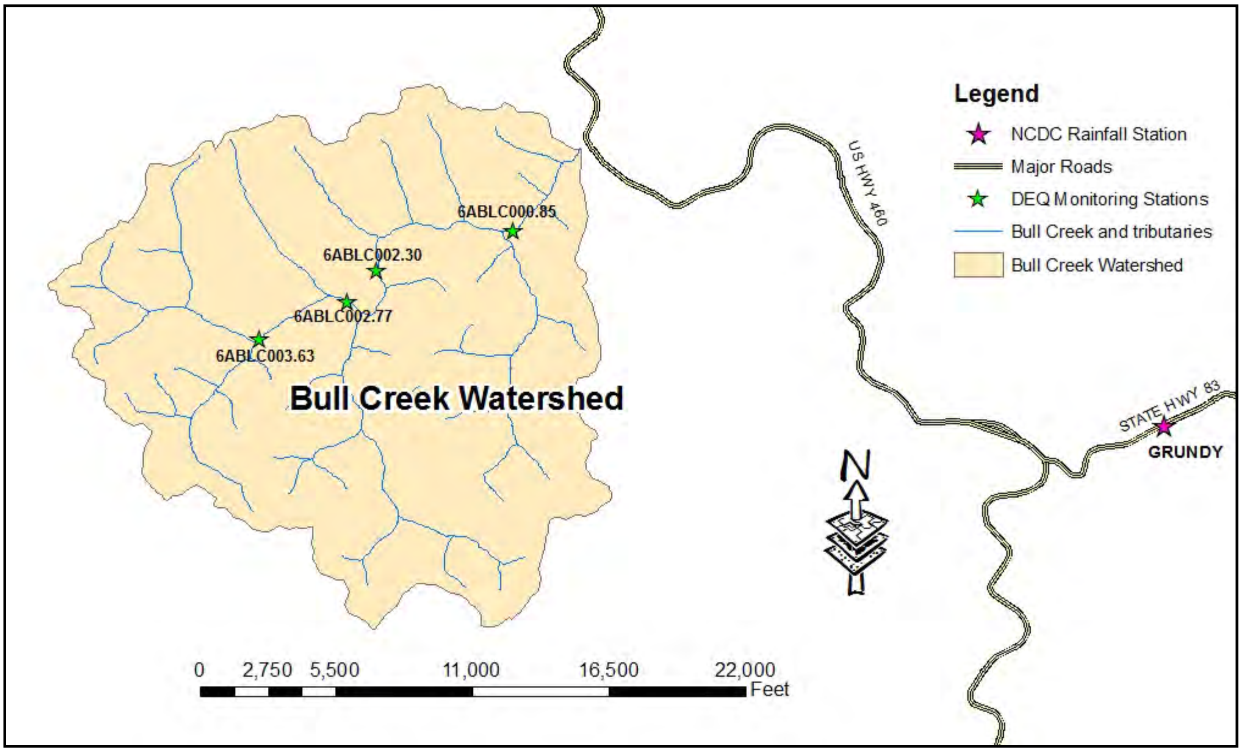


Figure 5.2. Location of Bull Creek and the Grundy Weather Station

5.1.2. Land Use

Land use for the Bull Creek watershed was derived from the Mid-Atlantic RESAC land use-land cover digital data, as discussed in Section 2.5. The RESAC categories were consolidated into a smaller number of categories based on the similarities in associated sediment sources, Table 5.1. The pasture/hay category was subdivided into "Pasture" and "Hay" categories based on percentages assessed during the 2002 Statewide NPS Pollution Assessment study (Yagow et al., 2002). Some additional editing was done to reclassify portions of the "barren" and "extractive" classifications which were inconsistent with residential features observed in VBMP aerial imagery. Barren land uses result from construction of access roads and drilling sites for gas and oil wells, logging, and from residential activities; whereas extractive land uses refer to actively disturbed surface mining areas. The 38 land uses in the RESAC data were re-categorized and three mined land use categories added for spatial analysis: AML, AML within a permit (to be reclaimed), and other permit areas (new mining). Permitted mining areas were further divided into 4 land use categories: "disturbed", "reclaimed", "released", and "to be disturbed".

Table 5.1. Consolidation of RESAC Land Use Categories for Bull Creek

TMDL Land Use Categories	Pervious/Impervious (percentage)	RESAC or Mined Land Use Categories
Cropland	Pervious (100%)	Cropland (26)
Pasture	Pervious (100%)	Pasture/hay (25), Natural grass (30)
Hay	Pervious (100%)	
Forest	Pervious (100%)	Open water (1), Urban deciduous (10), Urban evergreen (11), Urban mixed (12), Deciduous forest (20), Evergreen forest (21), Mixed forest (22), Deciduous woody wetland (35), Evergreen woody wetland (36), Emergent herbaceous (37), Mixed wetlands (38), also includes fractional portions of mining permits listed as "to be disturbed"
Extractive	Pervious (100%)	Extractive (17), includes fractional portions of existing mining permits listed as "disturbed"
Barren	Pervious (100%)	Barren (18)
Abandoned mine land (AML)	Pervious (100%)	Digitized from USGS 7½-min topographic maps, excluding existing permit areas
Reclaimed	Pervious (100%)	Fractional portions of existing mining permits listed as "reclaimed"
Released	Pervious (100%)	Fractional portions of existing mining permits listed as "released" from bond
Low Density Residential (LDR)	Pervious (88%) Impervious (12%)	Low intensity developed (3)
Medium Density Residential (MDR)	Pervious (70%) Impervious (30%)	Medium intensity developed (4)
High Density Residential	Pervious (35%) Impervious (65%)	High intensity developed (5)

The pervious and impervious portions of the residential categories were modeled separately and cropland was broken down into hi-till and lo-till fractions based on county statistics from the statewide modeling (Yagow et al., 2002). Based on this categorization, the main land uses in Bull Creek are forest, mining, residential, and agricultural, comprising approximately 86%, 8%, 5%, and 1%, respectively, of the total watershed area. This re-distribution of mining permitted areas resulted in a shift of forested area into the mining and barren categories of

1.5% and 0.5%, respectively. The existing land use distribution within the Bull Creek watershed is not expected to change significantly in the near future. Consolidation of the land use data resulted in the 15 land use categories and distributions within Bull Creek and its reference watershed (Upper Dismal Creek), shown in Table 5.2. The areas shown for the area-adjusted Upper Dismal Creek were used for simulation purposes.

Table 5.2. Land Use Distribution in Bull Creek and its Reference Watershed

Modeled Land Use Categories	Bull Creek (ha)	Area-Adjusted Upper Dismal Creek (ha)	Upper Dismal Creek (ha)
Cropland	2.8	0.3	0.8
Pasture	25.7	49.2	113.6
Hay	0.7	0.0	0.0
Forest	2,686.9	2,806.5	6,484.0
Barren	62.8	24.9	57.6
Mining*			
Extractive	15.0	3.9	9.1
Reclaimed	9.7	2.7	6.3
Released	19.7	2.9	6.7
AML	212.4	149.2	344.6
LDR - pervious	52.4	53.6	123.7
MDR - pervious	1.9	0.1	0.3
HDR - pervious	10.7	9.8	22.5
LDR - impervious	7.2	7.3	16.9
MDR - impervious	0.8	0.1	0.1
HDR - impervious	19.9	18.1	41.8
Total Area	**3,128.5**	**3,128.5**	**7,228.1**
% Forest	85.9%	89.7%	89.7%
% Agriculture	0.9%	1.6%	1.6%
% Urban/residential	3.0%	2.8%	2.8%
% Mining	8.2%	5.1%	5.1%
% Barren	2.0%	0.8%	0.8%

* The portion of permitted mining areas "To Be Disturbed" are included in the Forest category.

Each land use within a sub-watershed formed a hydrologic response unit (HRU). Model parameters were then calculated for each HRU using GIS analysis to reflect the variability in topographic and soil characteristics across the watershed. A description of model parameters follows in section 5.4.

GWLF Parameter Evaluation

All parameters were initially evaluated in a consistent manner between the reference and impaired watersheds, in order to ensure their comparability for the reference watershed approach. All GWLF parameter values were evaluated from a combination of GWLF user manual guidance (Haith et al., 1992), AVGWLF procedures (Evans et al., 2001), procedures developed during the 2002 statewide NPS pollution assessment (Yagow et al., 2002), and best professional judgment. Initial parameter values for active mining and AML land uses were evaluated from available literature sources, as shown in Table 5.3.

Table 5.3. Initially Assigned Curve Numbers and C-Factors Prior to Calibration

Mining Land Use	Curve Number (CN)[1]	C-factor (vegetative cover)	C-factor Definition and Source
Extractive	88	0.664	MPWS[2]: 60% bare soil (0.45); 30% active mining (1.00); 10% regrading (0.94); Barfield et al., p.339
AML	88	0.288	MPWS[2]: 30% residue cover, poor soil, 50% weed cover; Barfield et al., p.391
Reclaimed	81.5	0.071	Pasture: no appreciable canopy, 60% cover (40% grass-60% weed); Wischmeier and Smith, p.32
Released	72.6	0.028	Pasture: no appreciable canopy, 80% cover (half grass-half weed); Wischmeier and Smith, p.32

[1] CN source: Technical Release 55 (TR-55), USDA-SCS, 1986; reclaimed and released values are weighted averages by hydrologic soil type.
[2] MPWS - mechanically prepared woodland sites.

Soil erodibility (K-factors) and %slope for barren, extractive, and AML were evaluated using GIS. K-factors for reclaimed and released land uses were calculated as 1.2 and 1.1 times the extractive land use values, respectively, to simulate the higher bulk density, lower porosity, and lower hydraulic conductivity in post-mined soils (Galbraith, 2004; Ritter and Gardner, 1991), which are expected to decrease over time in the released areas. Percent slope for reclaimed and released land uses were calculated as 0.9 times the extractive land use values. Select initial parameter values were then calibrated as discussed in section 5.8.

Hydrologic and sediment parameters are all included in GWLF's transport input file, with the exception of urban sediment buildup rates, which are in the nutrient input file. Descriptions of each of the hydrologic and sediment parameters are listed below according to whether the parameters were related to the overall watershed, to the month of the year, or to individual land uses.

5.1.3. Hydrology Parameters

Watershed-Related Parameter Descriptions

- Unsaturated Soil Moisture Capacity (SMC, cm): The amount of moisture in the root zone, evaluated as a function of the area-weighted soil type attribute - available water capacity.
- Recession coefficient (day^{-1}): The recession coefficient is a measure of the rate at which streamflow recedes following the cessation of a storm, and is approximated by averaging the ratios of streamflow on any given day to that on the following day during a wide range of weather conditions, all during the recession limb of each storm's hydrograph. This parameter was evaluated using the following relationship from Lee et al. (2000): RecCoeff = 0.045+1.13/(0.306+Area in square kilometers)
- Seepage coefficient (day^{-1}): The seepage coefficient represents the amount of flow lost as seepage to deep storage and initially set to zero.

The following parameters were initialized by running the model for a 9-month period prior to the period used for load calculation:

- Initial unsaturated storage (cm): Initial depth of water stored in the unsaturated (surface) zone.
- Initial saturated storage (cm): Initial depth of water stored in the saturated zone.
- Initial snow (cm): Initial amount of snow on the ground at the beginning of the simulation.
- Antecedent Rainfall for each of 5 previous days (cm): The amount of rainfall on each of the five days preceding the first day in the weather file

Month-Related Parameter Descriptions

- Month: Months were ordered, starting with April and ending with March – in keeping with the design of the GWLF model.
- ET_CV: Composite evapotranspiration cover coefficient, calculated as an area-weighted average from land uses within each watershed.
- Hours per Day: Mean number of daylight hours.
- Erosion Coefficient: This is a regional coefficient used in Richardson's equation for calculating daily rainfall erosivity. Each region is assigned separate coefficients for the months October-March, and for April-September.

Land Use-Related Parameter Descriptions

- Curve Number: The SCS curve number (CN) is used in calculating runoff associated with a daily rainfall event, evaluated using SCS TR-55 guidance.

5.1.4. Sediment Parameters

Watershed-Related Parameter Descriptions

- Sediment delivery ratio: The fraction of erosion – detached sediment – that is transported or delivered to the edge of the stream, calculated as an inverse function of watershed size (Evans et al., 2001).

Land Use-Related Parameter Descriptions

- USLE K-factor: The soil erodibility factor was calculated as an area-weighted average of all component soil types.
- USLE LS-factor: This factor is calculated from slope and slope length measurements by land use. Slope is evaluated by GIS analysis, and slope length is calculated as an inverse function of slope.
- USLE C-factor: The vegetative cover factor for each land use was evaluated following GWLF manual guidance, Wischmeier and Smith (1978), and Hession et al. (1997); and then adjusted after consultation with local NRCS personnel.
- Daily sediment buildup rate on impervious surfaces: The daily amount of dry deposition deposited from the air on impervious surfaces on days without rainfall, assigned using GWLF manual guidance.

Streambank Erosion Parameter Descriptions (Evans et al., 2003)

- % Developed land: percentage of the watershed with urban-related land uses – defined as all land in MDR, HDR, and COM land uses, as well as the impervious portions of LDR.
- Animal density: calculated as the number of beef and dairy 1000-lb equivalent animal units (AU) divided by the watershed area in acres.
- Curve Number: area-weighted average value for the watershed.
- K Factor: area-weighted USLE soil erodibility factor for the watershed.
- Slope: mean percent slope for the watershed.
- Stream length: calculated as the total stream length of natural perennial stream channels, in meters. Excludes any non-erosive hardened and piped sections of the stream.
- Mean channel depth (m): calculated from relationships developed either by the Chesapeake Bay Program or by USDA-NRCS by physiographic region, of the general form – $y = a * A^b$, where y = mean channel depth in ft, and A = drainage area in square miles (USDA-NRCS, 2005).

Supplemental Post-Model Processing

After modeling was performed on individual and cumulative sub-watersheds, model output was post-processed in a Microsoft Excel™ spreadsheet to summarize the modeling results and to account for existing levels of BMPs already implemented within the Bull Creek watershed.

The extent and effect of existing agricultural BMPs was based on the DCR State Cost-Share Database. The DCR database tracks the implementation of BMPs within each state 1995 Hydrologic Unit Program (HUP) watershed. These data are then used by USEPA's Chesapeake Bay Program to calculate sediment reduction and pass-through fractions of the sediment load from each land use in each HUP for use with the Chesapeake Bay model and with the Virginia 2002 Statewide NPS Pollution Assessment (Yagow et al., 2002). Since Bull Creek lies within the Q08 watershed, the modeled land use categories used for this TMDL study were assigned sediment pass-through fractions for related land use categories from the Q08 watershed. In addition to the agricultural BMPs, mining sediment detention ponds were simulated as reducing existing extractive and reclaimed loads by 85% from all sub-watersheds containing sediment ponds. The chosen efficiency was based on an approximate average of literature values on sediment pond efficiency estimates, which vary widely based on pond design, rainfall intensities, and sediment particle sizes, including values of 60% for urban wet ponds (Simpson and Weammert, 2009), 91.8-96.7% for simulated detention of 17 ponds (USEPA, 1979), and 81-98% for small reservoirs (Dendy, 1974). Modeled sediment loads within each land use category were then multiplied by their respective pass-through fractions to simulate the reduced loads resulting from existing BMPs.

Representation of Sediment Sources

5.1.5. Surface Runoff

Pervious unit-area sediment loads (kg/ha) were modeled with the GWLF model using sediment detachment based on a modified USLE erosion algorithm, and a sediment delivery ratio to calculate loads at the watershed outlet, and were reported on a monthly basis by land use. Impervious area sediment loads were modeled in the GWLF model using an exponential buildup-washoff algorithm.

5.1.6. Channel and Streambank Erosion

Streambank erosion was modeled within the GWLF model using a modification of the routine included in the AVGWLF version of the GWLF model (Evans et al., 2001). This routine calculates average annual streambank erosion as a function of percentage developed land, average area-weighted curve number (CN) and K-factors, watershed animal density, average slope, streamflow volume, mean channel depth, and total stream length in the watershed. Livestock population, which figures into animal density, was estimated based on the available pasture, hay and reclaimed areas in each sub-watershed times a stocking density of 0.378 animal units per acre (AU/acre).

5.1.7. Stormwater Sources

Construction Permits: No construction or industrial stormwater runoff discharges are currently permitted in Bull Creek.

Gas & Oil Permits: Contributions from gas and oil operations in the watershed are transient, and stormwater E&S regulations require that any disturbed acreage during construction and drilling must be stabilized within 30 days. Currently there are 11 producing wells, 13 wells that are in some stage of construction or drilling, 4 older wells that have been plugged and released, and 5 wells that are pending, as listed in Table 5.4. The DMME-DGO estimates footprints of the pumping sites to average 50’-100’ by 100’-200’, or an average of approximately 0.26 acres each. Access road lengths vary widely but average around 0.5 miles in length and 20 feet wide for another 1.21 acres each. Sediment loads from both the pumping sites and the access roads are covered under the stormwater E&S permits, unless existing roads are used for access. For purposes of allowing for future growth in this industry, two additional wells were estimated as being built each year, each at the average disturbed acreage (7 ac.) from the existing wells in the Bull Creek, multiplied by the average monthly runoff from the “barren” land use category (19.11/12 = 1.59 cm), times the maximum permitted daily sediment concentration of 60 mg/L.

Table 5.4. Gas and Oil Permits in Bull Creek

Permit No.	Operation ID	Company Name	Sub-watershed	Operation Description	Permit Status	Construction Area (ac)
			Active Wells			
BU-0566	EH-110	Appalachian Energy	Belcher Branch	Gas	Constructed/Never Drilled	
BU-3081	825903 (HY-137) W/PL	Chesapeake Appalachia, LLC	Starr Branch	Gas/Pipeline	Construction	24
BU-2478	CBM N-76	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/	4
BU-2669	CBM N78	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/	7
BU-2688	CBM M77	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/	4
BU-2709	CBM L77	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/	4
BU-3000	CBM K76	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/	4
BU-3009	CBM L76	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Drilled/Waiting Completion/	8
BU-2477	CBM N-75	CNX Gas Company LLC	Belcher Branch	Coalbed/Pipeline	Drilled/Waiting Completion/	5
BU-3049	CNR 823540 (HY-19) W/PL	Chesapeake Appalachia, LLC	Jess Fork	Gas/Pipeline	Drilled/Waiting Completion/	16
BU-2335	CBM M76	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Not Connected	3
BU-2345	CBM K-75	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Not Connected	2
BU-2479	CBM N-77	CNX Gas Company LLC	Left Fork Bull Creek	Coal Bed	Not Connected	3
BU-0098	9591	Chesapeake Appalachia, LLC	Jess Fork	Gas	Producing	
BU-0116	9692	Chesapeake Appalachia, LLC	Deel Fork	Gas	Producing	
BU-0117	9678	Chesapeake Appalachia, LLC	Middle Bull Creek	Gas	Producing	
BU-0118	9681	Chesapeake Appalachia, LLC	Deel Fork	Gas	Producing	
BU-0126	9701	Chesapeake Appalachia, LLC	Jess Fork	Gas	Producing	
BU-0131	9765	Chesapeake Appalachia, LLC	Burnt Poplar/Big Branch	Gas	Producing	
BU-0147	20340	Chesapeake Appalachia, LLC	Jess Fork	Gas	Producing	
BU-0167	20546	Chesapeake Appalachia, LLC	Deel Fork	Gas	Producing	
BU-0564	EH-112	Appalachian Energy	Belcher Branch	Gas	Producing	
BU-0572	EH-114	Appalachian Energy	Starr Branch	Gas	Producing	
BU-0754	21732	Chesapeake Appalachia, LLC	Starr Branch	Gas	Producing	
			Plugged/Released Wells			
BU-0087	9582	United Fuel (Columbia)	Left Fork Bull Creek	Gas	Plugging/Plugged/Abandoned	
BU-0135	9766	Columbia Natural Resources LLC	Burnt Poplar/Big Branch	Gas	Released	
BU-0145	20342	Columbia Natural Resources LLC	Deel Fork	Gas	Released	
BU-0606	EH-111	Virginia Gas Company	Deel Fork	Gas	Released	
			Pending Permits			
8869		CNX Gas Company LLC	Belcher Branch		Pending	
8870		CNX Gas Company LLC	Belcher Branch		Pending	
8871		CNX Gas Company LLC	Belcher Branch		Pending	
8872		CNX Gas Company LLC	Belcher Branch		Pending	
8880		CNX Gas Company LLC	Belcher Branch		Pending	

Coal Mining: Stormwater from an individual coal mining permit may be controlled by one or more NPDES-permitted sediment detention ponds, and individual sediment ponds may control runoff from parts of areas under more than a single mining permit. During the 1995-2007 period, monitored flow and pollutants were recorded from 34 permitted sediment ponds in Bull Creek that control runoff from parts of eleven different mining permits, while 25 permitted outfalls recorded no discharge. Individual sediment detention ponds are designed to capture 0.125 ac-ft of runoff per acre of disturbed land (barren and extractive land uses) for each storm event, and assuming that the entire permitted acreage is disturbed. In the modeling, existing loads from these areas were represented by combinations of loads from a number of land use categories explained previously, and the sediment ponds were simulated with an 85% sediment reduction. In the phased TMDL calculation, the waste load allocation for permitted mining areas is based upon their permitted acreage, a daily maximum sediment concentration of 70 mg/L, and the average annual simulated runoff from the "extractive" land use – 18.81 cm/yr in Bull Creek. A summary of existing and future stormwater WLAs for sediment within Bull Creek are given in Table 5.5.

Table 5.5. Summary of Stormwater WLAs of TSS in Bull Creek

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

5.1.8. Point Source

There are no DEQ permitted point source dischargers in the Bull Creek watershed.

Accounting for Critical Conditions and Seasonal Variations

5.1.9. Selection of Representative Modeling Period

Selection of the modeling period was based on the availability of daily weather data and the need to represent variability in weather patterns over time in the watershed, with the beginning of the simulation period chosen to correspond with the beginning of electronic record-keeping by DMLR (January 1995). A long period of weather inputs was selected to represent long-term variability in the watershed. The model was run using a weather time series from April 1994 through December 2007, with the first 9 months used as an initialization period for internal storages within the model. The remaining 13-year period was used to calculate average annual sediment loads in both the Bull Creek and Upper Dismal Creek watersheds.

5.1.10. Critical Conditions

The GWLF model is a continuous simulation model that uses daily time steps for weather data and water balance calculations. The period of rainfall selected for modeling was chosen as a multi-year period that was representative of typical weather conditions for the area, and included "dry", "normal" and "wet" years. The model, therefore, incorporated the variable inputs needed to represent critical conditions during low flow – generally associated with point source loads – and critical conditions during high flow – generally associated with nonpoint source loads.

5.1.11. Seasonal Variability

The GWLF model used for this analysis considers seasonal variation through a number of mechanisms. Daily time steps are used for weather data and water balance calculations. The model also allows for monthly-variable parameter inputs for evapo-transpiration cover coefficients, daylight hours/day, and rainfall erosivity coefficients for user-specified growing season months.

Model Calibration

Model calibration is the process of adjusting model parameter values so that simulated loads from a watershed match loads calculated from corresponding monitored ("observed") flow and concentrations at a given point in a stream. Although GWLF was originally developed for use in non-gaged watersheds and, therefore, does not require calibration, hydrologic calibration has been recommended where observed flow data is available (Dai et al., 2000). Historically in Virginia, the GWLF model has been used to develop TMDLs to address sediment as a stressor in streams with benthic impairments. In these previous TMDLs, sediment has only been subject to accounting and reductions from non-permitted sources, and the successful restoration of the impaired stream was to be judged solely by the recovery of the benthic macro-invertebrate population and associated metrics, not by measured in-stream sediment. This is clearly not the case in Bull Creek, where permitted waste load allocations for sediment are closely monitored and tracked, and will serve as the basis for determining existing waste load allocations for new mining permits. Therefore, calibration was performed for flow and sediment in both Bull Creek and its reference watershed, in order to obtain a greater correlation with available observed data, and to achieve a greater degree of consistency with DMLR's tracking software for Waste Load Allocations.

Within Bull Creek watershed, the closest in-stream monitoring point – MPID #4468 – is a monthly DMLR station located just below the confluence of

Left Fork Bull Creek (Convict Hollow) and Bull Creek, 0.89 miles upstream from the outlet and representing 94.6% of the Bull Creek watershed area. Monitoring at this station began in January 2002 and continues through the present. However, the DMLR flow data during the 2003-2005 period looked inconsistent with other monitored flow at that station and was considered inappropriate for use in calibration. DMLR is checking for a possible units inconsistency or other explanation in order to allow for an expanded calibration period during the second phase. Because of this limitation, therefore, Apr-05 through Mar-07 was used as the period for calibrating DMLR monitored data with GWLF simulated TSS loads. Data from one large monitored event (Jul-06) that did not correspond with a significant monitored rainfall event was not used for calibration. Within Upper Dismal Creek, the closest in-stream monitoring point – MPID #4569 – is a monthly DMLR station located just below the confluence of Laurel Fork and Dismal Creek, 3.8 miles upstream from the outlet and representing 13.9% of the Upper Dismal Creek watershed area. The same Apr-05 through Mar-07 period was used for calibration of flow and sediment at this station.

The GWLF model was calibrated for both hydrology and sediment, using sub-watersheds above each of the selected calibration DMLR stations in Bull Creek and Upper Dismal Creek. The hydrology parameters adjusted during calibration included: monthly evapotranspiration (ET) coefficients, the seepage coefficient, and the curve number by landuse. The sediment parameters adjusted during calibration included: sediment pond efficiency, and the curve number by landuse. The adjustments made to the calibration parameters are given in Table 5.6.

Table 5.6. Calibrated parameters and value adjustments, Apr-05 through Mar-07

Calibration Adjustments	Bull Creek at MPID 4468	Upper Dismal Creek at MPID 4569
ET Dormant period MF*	1.05	1.05
ET Growing period MF*	0.756	0.97
Seepage coefficient	0.020	0.074
Curve number MF*	0.890	0.765
Sediment pond efficiency	0.85	0.85

* MF = multiplication factor.

Calibration endpoints were set as unit-area TSS measures developed using the observed data at available DMLR monitoring stations in both the reference and TMDL watershed. Unit-area measures allow for comparison between watersheds of different sizes. The average unit-area flow and unit-area TSS loads from the observed data used as calibration targets and the results of simulated output from the calibrated model in each calibration sub-watershed are shown in Table 5.7.

Table 5.7. Calibration targets and results for calibration sub-watersheds, Apr-05 to Mar-07 (excluding Jul-06)

Unit-area Measures	Bull Creek at DMLR MPID 4468		Upper Dismal Creek at DMLR MPID 4569	
	Calibration Target	Result	Calibration Target	Result
Flow (cfs/sq.mi.)	1.027	1.026	0.787	0.787
TSS Load (kg/ha-yr)	59.68	59.83	18.52	19.18

The simulated unit-area output for both flow and sediment (TSS) from both the calibrated reference and TMDL watershed models were each within 4% of their respective calibration targets. The calibration adjustments (shown in Table 5.6) were then applied to models of the full Bull Creek and Upper Dismal Creek watersheds and model simulations run for the 1995-2007 period. A comparison of simulated flow and loads for the full watersheds for both the calibration and simulation periods, shown in Table 5.8, further support the reasonableness of these calibrations.

Table 5.8. Calibrated simulation results for Bull Creek and the area-adjusted Upper Dismal Creek for both the calibration and TMDL simulation periods

	Bull Creek calibrated		Upper Dismal Creek calibrated	
Parameter	Apr-05 to Mar-07	1995 - 2007	Apr-05 to Mar-07	1995 - 2007
Unit-area Flow (cfs/sq.mi.)	1.02	1.38	0.60	0.72
Unit-area TSS Load (kg/ha-yr)	6.65	158.2	1.83	77.0
Average [TSS] (mg/L)	40.6	245.7	36.4	290.4

Median [TSS] (mg/L)	4.1	9.2	0.3	0.3
Flow-weighted [TSS] (mg/L)	22.6	387.4	10.6	380.4

For each watershed, the unit-area flows are similar, with small increases, between the calibration period (Apr-05 to Mar-07) and the full simulation period (1995-2007). The unit-area TSS loads for the full watersheds (Table 5.8) are smaller than those from the smaller calibration sub-watersheds (Table 5.7), as they should be, since sediment delivery tends to decrease the larger the watershed. The unit-area flows and loads increase during the longer 13-yr simulation period, because the calibration period was limited to a set of drier years, while the longer simulation period included a broader range of rainfall conditions, including some wetter years. The *median* TSS concentrations reflect the typically low levels observed during baseflow conditions. The model simulated larger *average* TSS concentrations during the longer period with greater rainfall, as would be expected. The higher *average* TSS concentrations reflect larger loads associated with stormwater runoff, which was fairly minimal during the drier calibration period. Overall, the calibrated Bull Creek and Upper Dismal Creek models simulated flow and TSS loads that match the observed data and performed as expected under wetter conditions of the full simulation period.

GWLF Model Parameters

The GWLF parameter values used for the Bull Creek and Upper Dismal Creek watershed simulations are shown in Table 5.9 through Table 5.11. Table 5.9 lists the various watershed-wide parameters and their values, Table 5.10 displays the monthly variable evapo-transpiration cover coefficients, and Table 5.11 shows the land use-related parameters – runoff curve numbers (CN) and the Universal Soil Loss Equation's KLSCP product - used for erosion modeling. Calibrated parameters and their calibrated values are indicated in each of the tables.

Table 5.9. GWLF Watershed Parameters for Bull Creek

GWLF Watershed Parameters	units	TMDL	Reference
		Bull Creek	Area-adjusted Dismal Creek
recession coefficient	(day^{-1})	0.0808	0.0808
seepage coefficient*	(day^{-1})	0.0200	0.0740
sediment delivery ratio		0.1591	0.1591
unsaturated water capacity	(cm)	11.87	12.00
erosivity coefficient (Nov - Apr)		0.126	0.143
erosivity coefficient (growing season)		0.244	0.241
% developed land	(%)	3.0	2.8
no. of livestock	(AU)	10	19
area-weighted runoff curve number		67.43	70.07
area-weighted soil erodibility		0.200	0.208
area-weighted slope	(%)	47.90	41.63
aFactor		0.0000842	0.0000821
total stream length	(m)	48,139.2	43,250.1
Mean Channel Depth	(m)	0.625	0.625
* Calibrated value			

Table 5.10. GWLF Monthly Evapotranspiration Cover Coefficients

Watershed	Apr	May	Jun	Jul*	Aug	Sep	Oct	Nov	Dec	Jan**	Feb	Mar
Bull Creek	0.740	0.735	0.734	**0.734**	0.734	0.739	0.774	0.809	0.824	**0.834**	0.784	0.750
Area-adjusted Dismal Creek	0.949	0.954	0.955	**0.955**	0.955	0.950	0.911	0.873	0.856	**0.845**	0.900	0.938

* July values represent the maximum composite ET coefficients during the growing season, calibrated.

** Jan values represent the minimum composite ET coefficients during the dormant season, calibrated.

Table 5.11. GWLF Land Use Parameters – Existing Conditions

Landuse	Bull Creek		Area-adjusted Dismal Creek	
	KLSCP	CN*	KLSCP	CN*
HIGH_TILL	0.9110	69.7	1.2852	61.8
LOW_TILL	0.3848	69.0	0.5429	61.2
pasture2	0.1364	64.6	0.1145	57.8
hay	0.0633	64.3	0.0532	57.3
forest	0.0283	57.5	0.0292	52.4
barren	1.3747	78.2	1.3830	68.3
extractive	2.7805	78.3	4.5791	67.3
AML	1.2728	78.3	1.6715	67.3
reclaimed	0.3257	72.5	0.5100	63.9
released	0.1170	64.6	0.2194	57.8
pur_LDR	0.0169	64.6	0.0186	57.8
pur_MDR	0.0107	64.6	0.0174	57.8
pur_HDR	0.0176	64.6	0.0183	57.8
imp_LDR	0.0000	80.1	0.0000	69.6
imp_MDR	0.0000	87.2	0.0000	75.0
imp_HDR	0.0000	87.2	0.0000	75.0

* Calibrated value

pur = pervious urban areas
imp = impervious urban areas
LDR = low density residential
MDR = medium density residential
HDR = high density residential

CHAPTER 6: MODELING PROCESS FOR TDS TMDL DEVELOPMENT

In the development of the total dissolved solids (TDS) TMDL for the Bull Creek watershed, the relationship between pollutant sources and in-stream water quality was defined through computer modeling. In this chapter, the modeling process, input data requirements, and model calibration procedures for TDS are discussed.

Model Selection

The model selected for development of the TDS TMDL was Hydrological Simulation Program – FORTRAN (HSPF), version 12 (Bicknell et al., 2001; Duda et al., 2001).

The TMDL development process requires the use of a watershed-based model that integrates both point and nonpoint sources and simulates in-stream water quality processes. HSPF was used to model TDS transport and fate throughout the Bull Creek watershed. The ArcGIS™ 9.1 Geographic Information System (GIS) software was used to display and analyze landscape information for the development of inputs to HSPF.

The HSPF model simulates nonpoint source runoff and pollutant loadings, performs flow routing through streams, and simulates in-stream 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 within the module PERLND simulates runoff, and hence, estimates the water budget, on pervious areas (e.g., agricultural land). Runoff from impervious areas is modeled using the IWATER sub-module within the IMPLND module. The simulation of flow and routing through the stream network is performed using the sub-module HYDR within the module RCHRES. Transport of TDS on pervious and impervious land segments is simulated using the PQUAL (PERLND module) and IQUAL (IMPLND module) sub-modules, respectively. TDS was simulated in-stream as a conservative pollutant with load contributed from the various sources through surface runoff, interflow, groundwater, and direct discharge to the stream.

HSPF Model Development

As described previously, Lower Dismal Creek in Buchanan County was selected as the reference watershed for Bull Creek and the 90th percentile of DEQ-monitored surface water TDS samples was used to set the TMDL modeling concentration endpoint of 369 mg/L. In the absence of TDS water quality criteria, an assumption was made that the 90th percentile TDS concentration from a reference watershed with a healthy benthic community and a history of coal mining, will set an achievable, effective TDS endpoint for Bull Creek. Model development for Bull Creek was performed by assessing the sources of TDS in the watershed, evaluating the necessary parameters for modeling, calibrating the model to observed data, and applying the model to simulate TDS loads.

Eighteen sub-watersheds were delineated within the Bull Creek watershed to represent the spatial distribution of land uses and pollutant sources (see Figure 5.1).

The majority of TDS loads are associated with current and historical mining activities within the watershed. TDS are generated from active and abandoned mining areas within the watershed, both surface and underground, and are delivered to the stream through surface runoff, interflow, groundwater, and direct mine discharges. Residential sources of TDS within the watershed include failing septic systems and straight pipes. Road salt applications are another source of TDS within the watershed that will be accounted for in the modeling process. In addition, TDS is also present from natural geologic sources in both the impaired and reference watersheds.

While all groundwater contains some background TDS, elevated levels are usually indicative of human activities. Background levels of TDS in groundwater for the Appalachian Plateau region of Virginia average 230 mg/L (USGS, 1997). Mining-related current and historical groundwater monitoring show elevated levels of TDS in groundwater near mining activities. Groundwater TDS concentrations may also be greater in shallower groundwater, which eventually returns to streams as interflow. Areas with valley fill may provide larger TDS loads from interflow because the flow of water percolating below the upper surface of the valley fill may cause an increase in the volume of interflow, and as a result, an increase in exposure time and soluble ion surface area interaction with the water. Although under natural conditions, interflow may contribute a substantial fraction of 'total groundwater' flow, in fractured valley fills, interflow may be considerably greater than 'natural condition' volumes, and contribute even more to the TDS load on a percentage basis.

Sources of TDS that contribute during surface runoff events include disturbed land, abandoned mine land, active surface mining areas, and road salt. Contributions of TDS to surface waters between storms may arise from interflow, groundwater, direct mine discharges, failing septic systems, and straight pipes.

There are no VPDES permitted facilities within the Bull Creek Watershed. Eleven NPDES permits issued by DMME are currently active in Bull Creek for mining activities. There are 8 pre-law mine discharges in the watershed. Limits for TDS are not part of current mining permits.

Input Data Requirements

The HSPF model requires a wide variety of input data to describe hydrology, water quality, and land use characteristics of any given watershed. The different types and sources of input data used to develop the TDS TMDL for the Bull Creek watershed are discussed below.

6.1.1. Climatological Data

Daily precipitation data for Bull Creek were obtained from the National Climatic Data Center weather station at Grundy (443640) in Buchanan County, located 4 miles (6.4 km) east of the Bull Creek DEQ monitoring station 6ABLC002.30 (Figure 5.2). Missing precipitation data was patched with data from Breaks Interstate Park and John Flannagan Lake located in Dickenson County. Because HSPF requires some climatic parameters that are not available at Grundy, data from Richlands, Lonesome Pine Airport, Bristol Tri City Airport, Abingdon, and Lynchburg Airport were also used to complete the meteorological data set required for running HSPF. Detailed descriptions of the weather data and the procedure for converting the raw data into the required data set are presented in Appendix B.

6.1.2. Land Use

Land use categories were defined in a similar manner as for the GWLF modeling described in Section 5.1.2, with the exception that an impervious roads layer was added for simulation of road salt application.

HSPF Parameter Evaluation

The hydrology parameters required by HSPF were defined for each land use category. Required hydrology parameters are listed in the HSPF Version 12 User's Manual (Bicknell et al., 2001). Spatial analysis was performed using the ArcGIS™ geographical information system (GIS) to evaluate many of the HSPF input parameter values. Sub-watersheds were first delineated using GIS routines. Areas of individual land use categories were calculated using GIS within each sub-watershed and used to define the various PERLND (pervious land segments) and IMPLND (impervious land segments) model components. The spatially-defined sub-watershed/land use category areas were then used to evaluate other corresponding topographic and soils characteristics required by the model. Simplified representative stream reaches were then manually defined within each sub-watershed, and hydraulic stage-discharge relationships defined.

Since no daily flow gauging stations were available in the Bull Creek watershed, hydrologic calibration was performed on a surrogate watershed and the values of the selected calibrated parameters were applied to the Bull Creek model. The Cranes Nest River in Wise and Dickenson Counties was selected as the surrogate watershed, as it was one of the closest gauged stations and had previously been used as a surrogate for the Lick Creek TMDL modeling. Initial estimates for required hydrology parameters, outside of those evaluated from available digital spatial data, were evaluated for the surrogate watershed based on guidance in BASINS Technical Note 6 (USEPA, 2000a). Sub-watersheds were also created in Cranes Nest River at major confluences in order to represent the hydrology in the watershed. The stream reach in each sub-watershed requires a function table (FTABLE) to describe the relationship between water depth, surface area, volume, and discharge (Bicknell et al., 2001). The procedures described in Staley et al. (2006) were used to develop FTABLEs using NRCS bankfull equations and digital elevation models and to characterize the reaches in the Cranes Nest River watershed, while FTABLEs for Bull Creek were generated from digital data and NRCS regional curves (http://wmc.ar.nrcs.usda.gov/technical/HHSWR/Geomorphic/index.html). The calibrated hydrologic model was fine-tuned by comparing with periodic measurements of flow available at various DMLR in-stream monitoring stations.

Representation of TDS Sources

The HSPF model was then configured for representation of TDS as a conservative generalized water quality constituent. Required water quality parameters are given in the HSPF User's Manual (Bicknell et al., 2001). TDS was simulated as contributing to stream loads from surface runoff, direct discharges to the stream, and through interflow and groundwater. TDS parameter values for the model were initially estimated, and calibration was then performed using periodic DMLR in-stream observed concentrations at several points throughout the watershed.

6.1.3. Surface Runoff

Since TDS is associated with mining activities, TDS was simulated using buildup/washoff functions from extractive, abandoned mine land (AML), and reclaimed land uses. Since monitored surface runoff data were not available, initial loading rates were estimated and then adjusted during the water quality calibration.

An impervious land use was created for paved roads. Application of TDS from road salts was modeled as atmospheric deposition subject to surface runoff. Road salt was simulated as being applied on days with recorded snow events greater than 0.50 inches. Runoff TDS loads were calculated as a daily time series and summarized as annual loads by sub-watershed. The length of named paved roads in each sub-watershed was calculated using TIGER™ data and an assumed impervious width of 20 feet (2.424 ac/linear-mile). The Wise County office of the Virginia Department of Transportation (VDOT) estimated that 350 pounds of road salt was applied per linear mile of paved road on days with recorded snow events. A monthly time series of TDS loads was generated within the watershed from the Grundy NCDC daily surface data (Station 443640) for days with snow greater than 0.50 inches and then disaggregated to hourly loads. Hourly TDS loads were then calculated from this time-series as 350 lb/mi divided by 2.424 ac/linear-mile and 24 hrs/day (6.0156 lbs/ac-hr) and multiplied by the area of paved roads in each sub-watershed.

6.1.4. Interflow and Groundwater

The spatial variability of interflow TDS concentrations were simulated by land use and were determined through calibration.

Groundwater TDS concentrations were represented by time-series of DMLR groundwater monitoring data in each sub-watershed. The time-series were created from the existing network of DMLR sampling sites and adjusted with calibration multiplication factors. In Bull Creek, groundwater TDS concentrations were initially estimated as monthly average concentrations within each sub-watershed for the period of January 1995 through April 2007. Where possible, interpolation was performed to estimate TDS concentrations in months with missing data. Sub-watersheds without monitored data, or with missing monthly data at the beginning or ending of the period were assigned concentrations, either from a neighboring watershed, or as an average from several neighboring watersheds for that month. The monthly time-series for each sub-watershed was then minimally adjusted during calibration. The time-series multiplication factors ranged from 1.0 to 1.1, and the adjusted monthly concentrations ranged from 24 to 2,990 mg/L, with an overall average groundwater TDS concentration of 712 mg/L.

6.1.5. Direct Discharge Sources

There were eight pre-law direct mine discharges from underground mines located within the Bull Creek watershed. The eight discharges (MPID nos. 00011296, 0003444, 0003576, 0003577, 0003579, 5600368, 5600375 and 5650118) occurred in 6 of the 18 sub-watersheds. Flow and concentration data for these discharges were accounted for in HSPF as time-series input from MUTSIN files.

Septic system effluent TDS loads were simulated from areas in Bull Creek without sewer access. Sewer lines follow the main stem of Bull Creek from U.S. Route 460 to Cove Hollow and part way down Convict Hollow. Therefore, no septic systems were included in the model for the corresponding sub-watersheds (1, 2, 4, 5, and 6; Figure 5.1). The number of houses per sub-watershed was estimated from USGS 7.5-min topographic maps, with older homes defined as those structures that did not show up as photo-revised additions (approximately after 1967). Each household was classified into three age categories (pre-1969, 1970-1989, and post-1990) based on population categories available in the 2000 census data. The population of the Bull Creek watershed is approximately 1,210, with 445 of those currently served by the sewer system operated by Buchanan County Public Service Authority. The TDS concentration in residential straight pipe discharges was simulated as 500 mg/L (EPA, 2007). The TDS concentration from failing septic systems was simulated as 425 mg/L, estimated as half the difference between straight pipes and effluent concentrations from normally functioning septic systems (350 mg/L; EPA, 2007). The numbers of houses with straight pipes were estimated from census data. The numbers of failing septic systems were based on estimates of failure rates in the three age categories as 20, 5, and 1%, respectively (based on personal communication with R.B. Reneau, 3 December 1999, Blacksburg, Virginia). The model, therefore, represents TDS in the effluent from older systems with potential maintenance problems (31), and from systems estimated to be discharging directly to streams via a straight pipe (205). TDS loads in effluent from normally functioning septic systems were assumed to be negligible.

Accounting for Critical Conditions and Seasonal Variations

6.1.6. Selection of Representative Modeling Period

Selection of the modeling period was based on the availability of daily weather data and the need to represent variability in weather patterns over time in the watershed. All available DMLR monitoring data was used for the hydrology calibration which ran from January 1995 through October 2006. However, a shorter time period, January 2000 through December 2005, was selected for the TDS calibration and TMDL modeling. The shorter period was selected because it represented the most recent period of mining activity with little change in land use. Therefore, during this period, monitoring results will most closely relate to the current mining activities and other land uses in the Bull Creek watershed.

6.1.7. Critical Conditions

The HSPF model is a continuous simulation model that uses hourly inputs of rainfall and climate to simulate runoff and pollutant loading, also on an hourly basis. The period of rainfall selected for modeling (January 2000 through December 2005) was chosen as a multi-year period that was representative of typical weather conditions for the area, and included “dry”, “normal” and “wet” years. The model, therefore, incorporated the variable inputs needed to represent critical conditions during low flow – generally associated with point source loads – and critical conditions during high flow – generally associated with nonpoint source loads.

6.1.8. Seasonal Variability

The HSPF model used to develop this TMDL considers seasonal variation through a number of mechanisms. Some parameters varied monthly and additional parameters were entered as estimated or monitored time-series. TDS inputs in surface runoff were a direct response of seasonal weather variations. Groundwater concentrations were simulated as monthly averages by sub-watershed from DMLR-monitored data. Direct mine discharges were simulated as a time-series of approximately monthly DMLR flow and discharge measurements. Road salt applications were simulated as a time-series related to days with snow events. All of the model inputs that are simulated as direct measurement time-series capture as much seasonal variability as possible and minimize the uncertainty inherent in estimation by annual or overall averages.

Model Calibration and Validation

Model calibration is the process of evaluating model parameter values so that the model is an accurate representation of the watershed. In this section, the procedures followed for calibrating the hydrologic and water quality components of the HSPF model are discussed.

6.1.9. Hydrology

Because no continuous daily monitoring data were available for Bull Creek, detailed hydrology calibration and validation were performed for nearby Cranes Nest River, and calibrated parameter values transferred to the Bull Creek model. Observed daily flow data for Cranes Nest River were available from the USGS monitoring station 03208950 on Cranes Nest River near Clintwood, VA. The HSPEXP decision support system developed by USGS (Lumb et al., 1994) was used to calibrate the hydrologic portion of HSPF for Cranes Nest River. The default HSPEXP criteria for evaluating the accuracy of the flow simulation were used in the calibration for Cranes Nest River. These criteria are listed in Table 6.1.

Table 6.1. Default hydrology calibration criteria for HSPEXP.

Variable	Percent Error Criteria
Total Volume	10%
50% Lowest Flows	10%
10% Highest Flows	15%
Storm Peaks	15%
Seasonal Volume Error	10%
Summer Storm Volume Error	15%

The hydrologic calibration period was August 1, 1989 to July 31, 1997. The hydrologic validation period was from May 1, 2001 to July 31, 2005. The output from the HSPF model for both calibration and validation was daily average flow in cubic feet per second (cfs). Calibration parameters were adjusted within the recommended range (USEPA, 2000a).

The simulated flow for both the calibration and validation matched the observed flow well, as shown in Figure 6.1 and Figure 6.2. The agreement with observed flows is further illustrated in Figure 6.3 and Figure 6.4 for a representative year and Figure 6.5 and Figure 6.6 for a representative storm. The agreement between the simulated and observed time series can be further seen through the comparison of their cumulative frequency curves (Figure 6.7 and Figure 6.8).

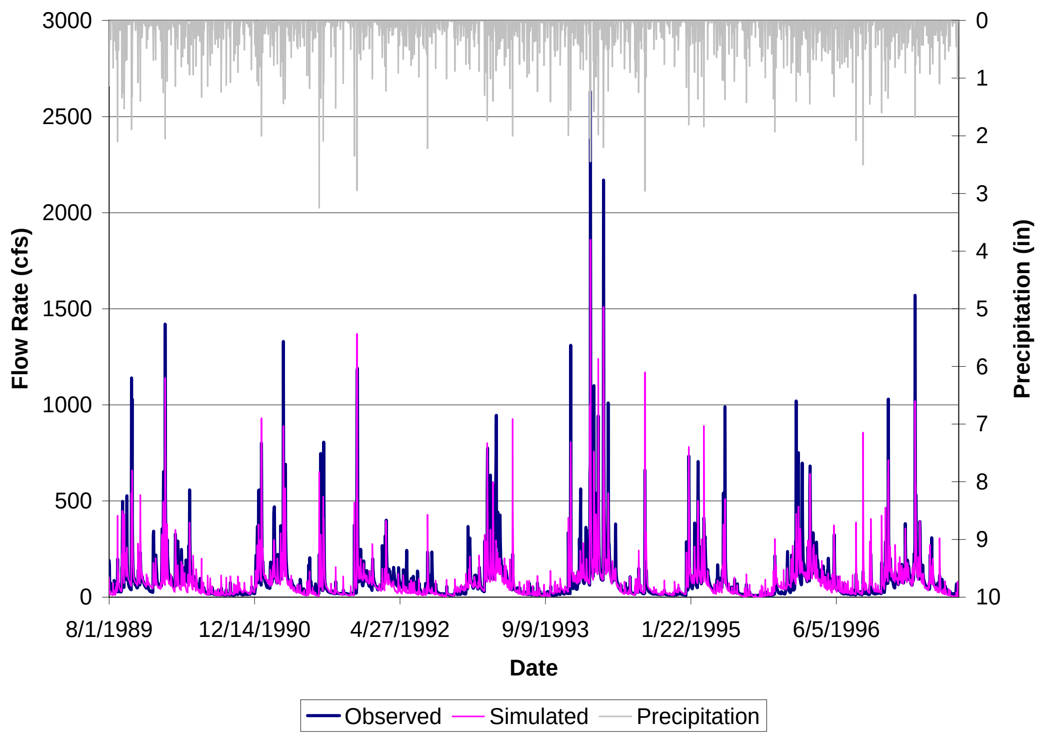


Figure 6.1. Observed and simulated flows and precipitation for Cranes Nest River for the calibration period.

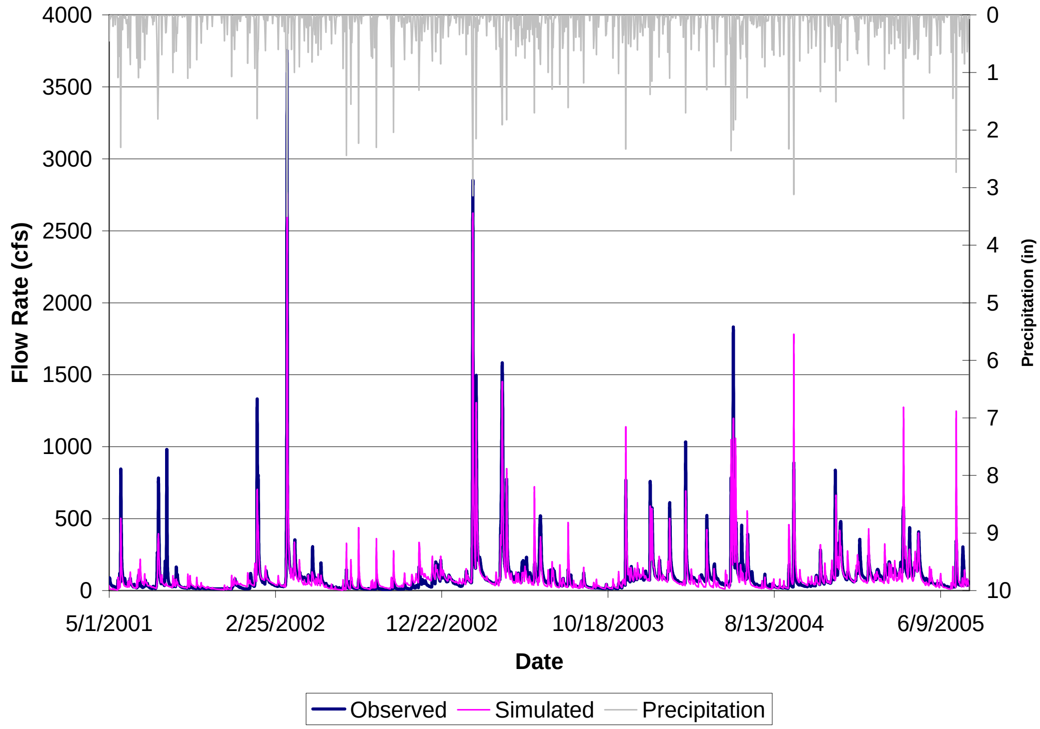


Figure 6.2. Observed and simulated flows and precipitation for Cranes Nest River during the validation period.

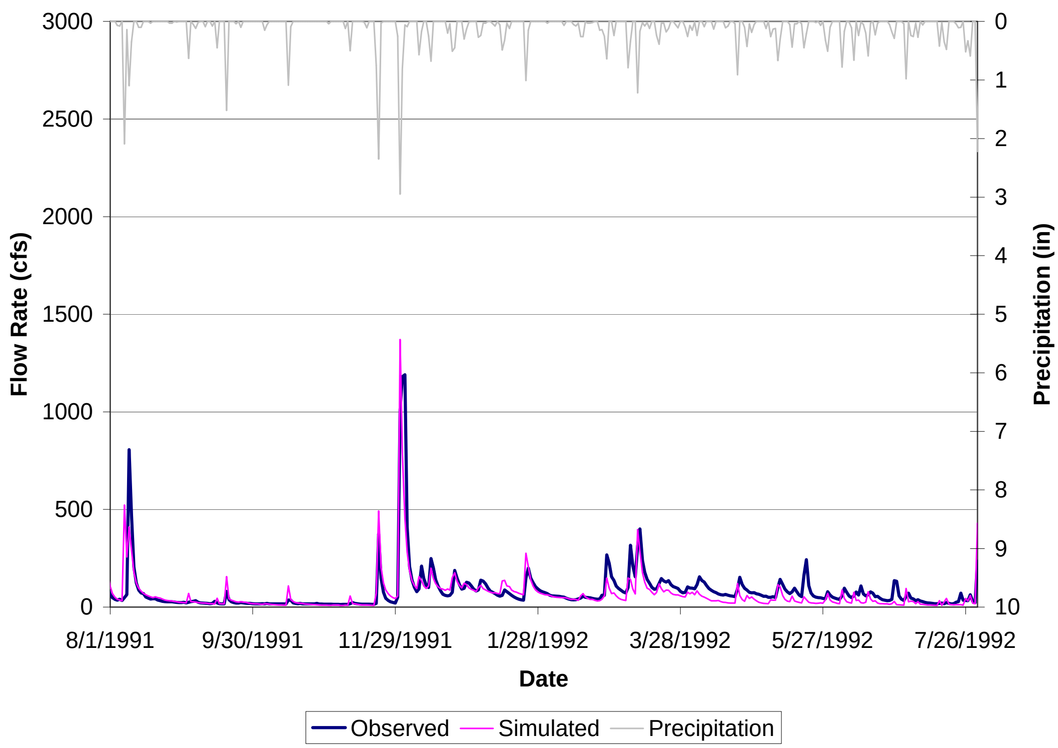


Figure 6.3. Observed and simulated flows and precipitation for a representative year in the calibration period for Cranes Nest River.

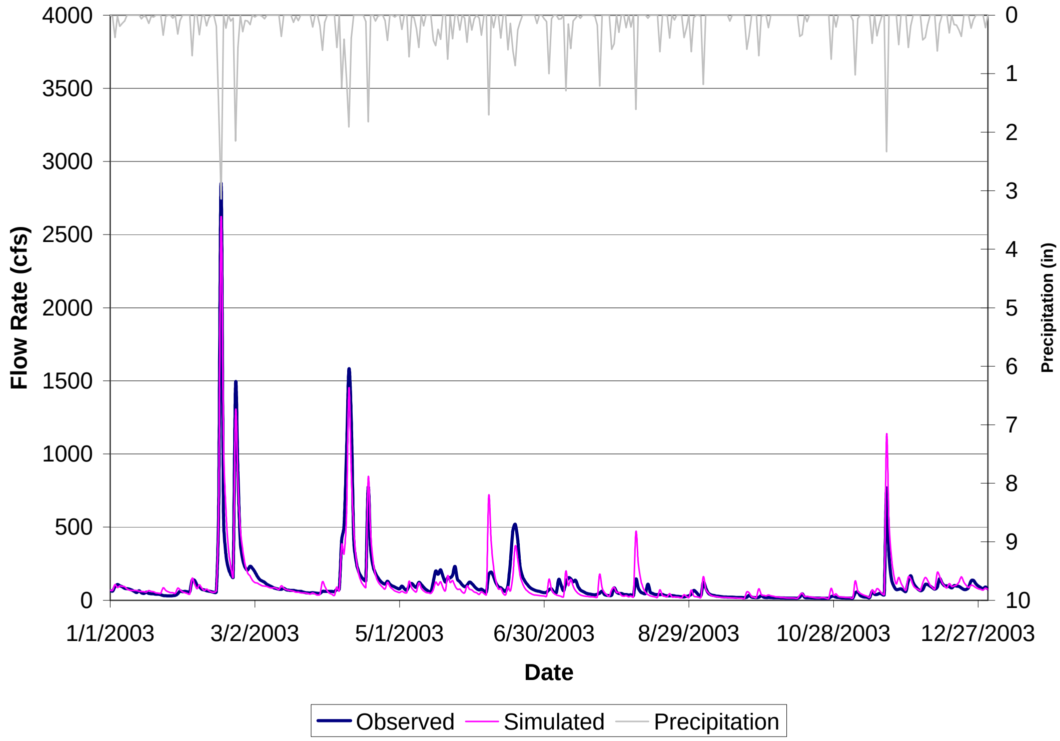


Figure 6.4. Observed and simulated flows and precipitation for Cranes Nest River during a representative year in the validation period.

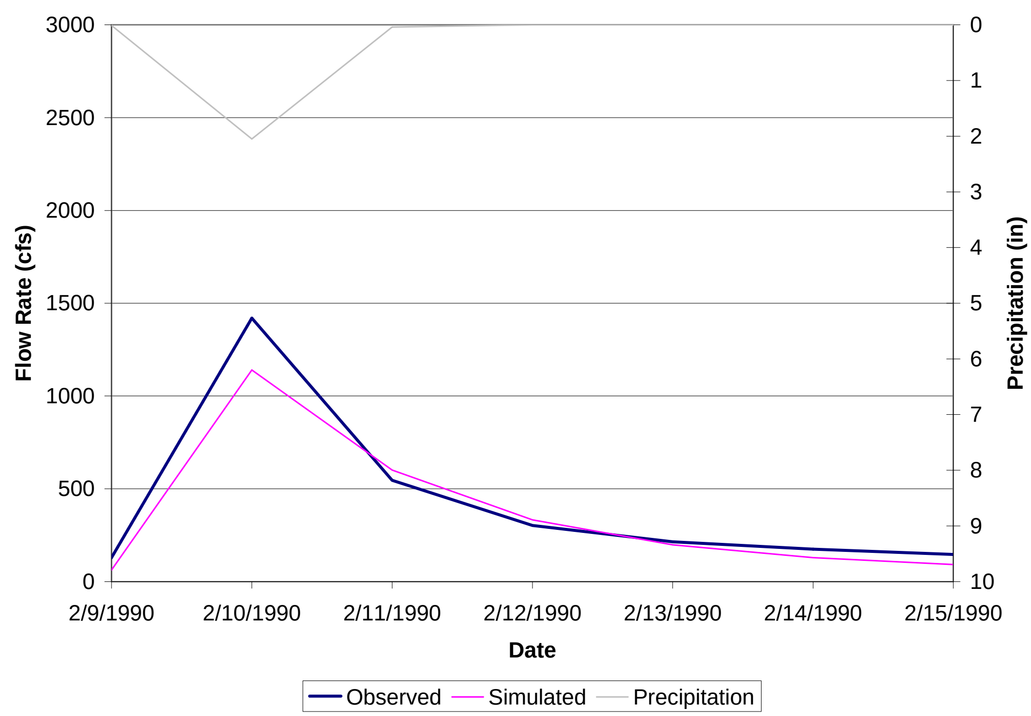


Figure 6.5. Observed and simulated flows and precipitation for Cranes Nest River for a representative storm in the calibration period.

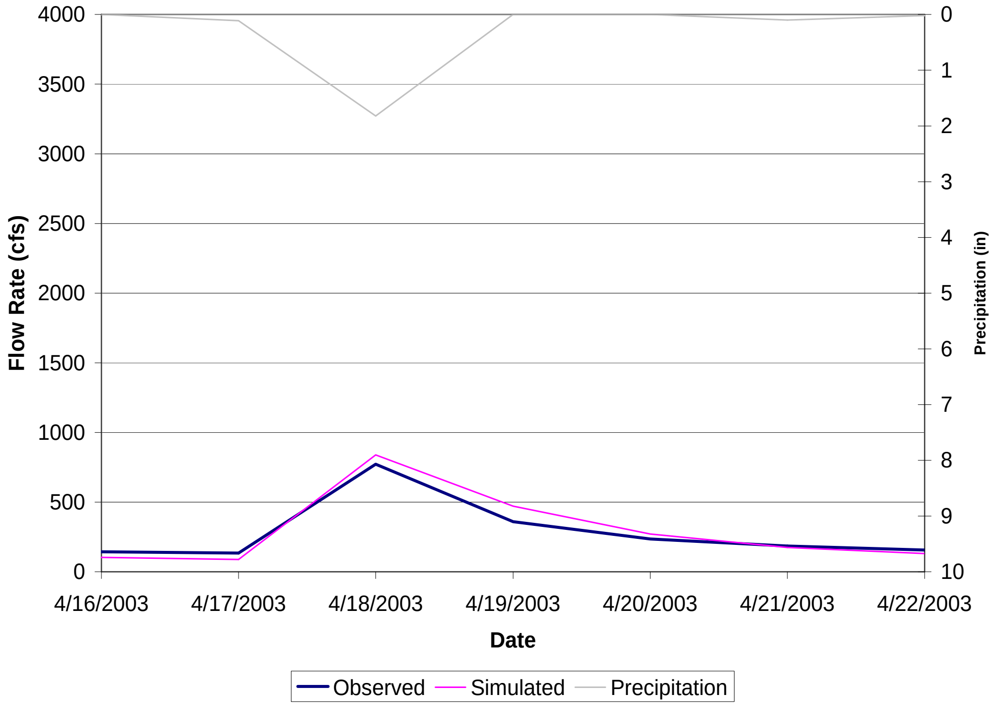


Figure 6.6. Observed and simulated flows, and precipitation for Cranes Nest River for a representative storm in the validation period.

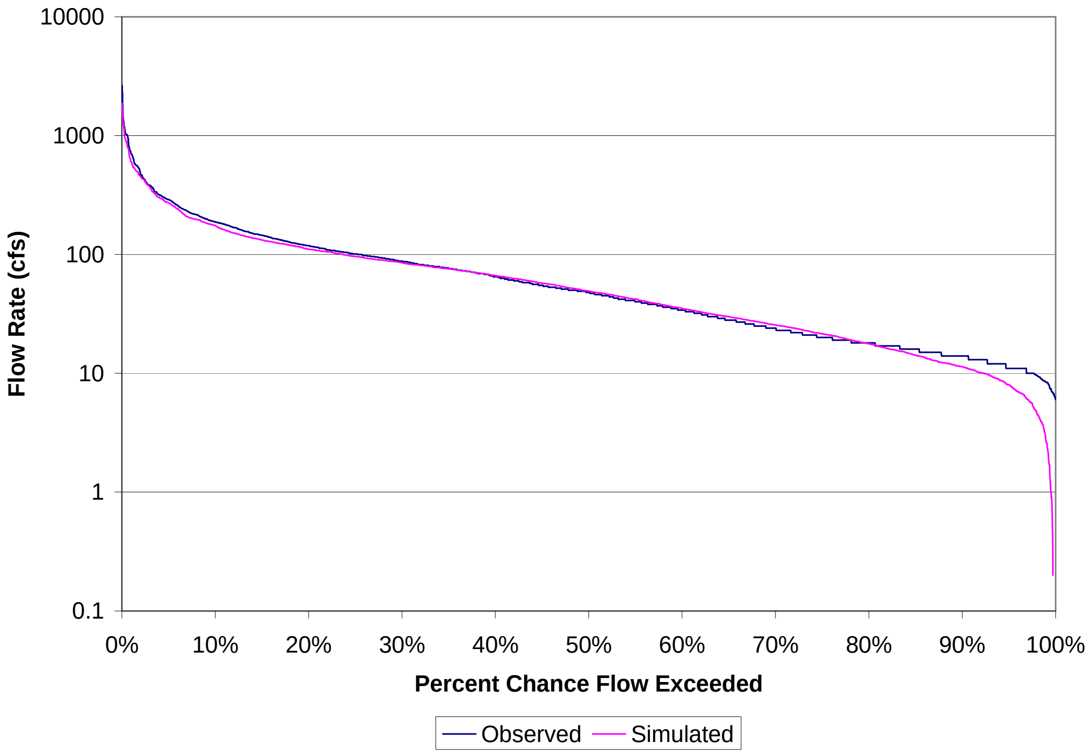


Figure 6.7. Cumulative frequency curves for the calibration period for Cranes Nest River.

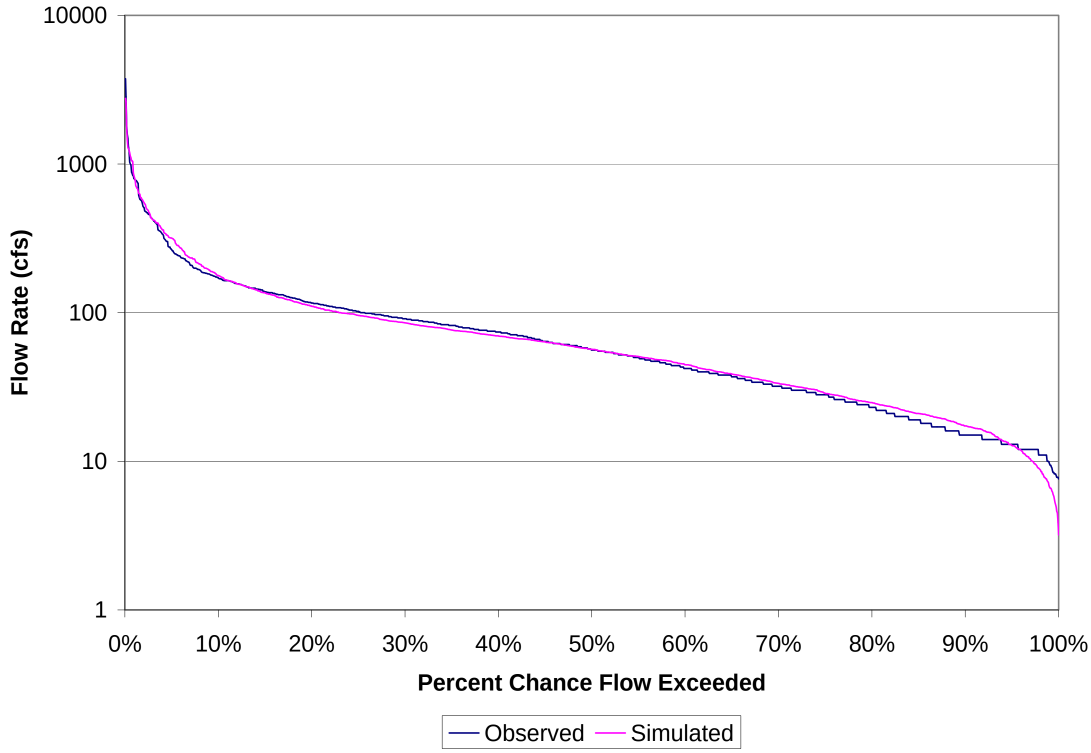


Figure 6.8. Cumulative frequency curves for the validation period for Cranes Nest River.

Selected diagnostic output from the HSPEXP program is listed in Table 6.2 and Table 6.3. All of the criteria were met for both the calibration and validation periods. The total winter runoff and total summer runoff errors are considered in the HSPEXP term 'seasonal volume error' (see Table 6.1). The errors for seasonal volume error were 1.9% for the calibration period and 3.0% for the validation period; both are within the required range of ±10%.

Table 6.2. Summary statistics for the calibration period for Cranes Nest River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)†	136.3	144.6	-5.8	10%
Average Annual Total Runoff (in)	17.04	18.08	-5.8	10%
Total of Highest 10% of flows (in) †	57.3	63.4	-9.6	15%
Total of Lowest 50% of flows (in) †	18.9	19.0	-0.3	10%
Total Winter Runoff (in) †	51.6	54.3	-5.0	na
Total Summer Runoff (in) †	15.5	16.0	-3.1	na
Coefficient of Determination, r^2	0.73			

† total for the 8-year calibration period
na = not applicable; these are not criteria directly considered by HSPEXP

Table 6.3. Summary statistics for the validation period for Cranes Nest River.

	Simulated	Observed	Error (%)	Criterion
Total Runoff (in)†	83.7	83.0	+0.8	10%
Average Annual Total Runoff (in)	19.69	19.53	+0.8	10%
Total of Highest 10% of flows (in) †	37.8	36.5	+3.6	15%
Total of Lowest 50% of flows (in) †	13.2	12.6	+4.7	10%
Total Winter Runoff (in) †	25.9	26.0	-0.3	na
Total Summer Runoff (in) †	16.6	16.2	+2.7	na
Coefficient of Determination, r^2	0.76			

† total for the 4.25-year validation period
na = not applicable; these were not criteria directly considered by HSPEXP

Flow partitioning for the Cranes Nest River hydrologic model calibration and validation is shown in Table 6.4. When the observed flow data were evaluated using HYSEP (Sloto and Crouse, 1996), the average baseflow indices for the calibration and validation periods were 0.55 and 0.53, respectively. The annual baseflow indices ranged from 0.42 to 0.62 for the calibration period and from 0.42 to 0.60 for the validation period. The baseflow indices for the simulated data are also presented in Table 6.4. The simulated baseflow index is close to the observed index for both periods, and both simulated baseflow indices fall within the observed range of baseflow indices.

Table 6.4. Flow partitioning for the calibration and validation periods for Cranes Nest River.

Average Annual Flow	Calibration	Validation
Total Annual Runoff (in)	17.04	19.69
Surface Runoff (in)	3.17 (19%)	4.17 (21%)
Interflow (in)	4.92 (29%)	6.45 (33%)
Baseflow (in)	8.95 (53%)	9.07 (46%)
Baseflow Index	0.53	0.46

All of the criteria were met for both the calibration and the validation periods. This indicates that the developed hydrologic model provides an acceptable prediction of Cranes Nest River flows. The final list of calibrated hydrologic parameters and their calibrated values for Cranes Nest River are listed in Table 6.5.

Table 6.5. Final calibrated hydrology parameters for Cranes Nest River.

Parameter	Definition	Units	FINAL CALIBRATION	FUNCTION OF…	Appendix C Table (if applicable)
PERLND					
LZSN	Lower zone nominal soil moisture storage	inches	4.0	Soil properties	
INFILT	Index to infiltration capacity	in/hr	0.186-0.286[a]	Soil and cover conditions	1
AGWRC	Base groundwater recession	none	0.965	Calibrate	
DEEPFR	Fraction of GW inflow to deep recharge	none	0.40	Geology	
CEPSC	Interception storage capacity	inches	monthly[b]	Vegetation	2
UZSN	Upper zone nominal soil moisture storage	inches	0.8	Soil properties	
INTFW	Interflow/surface runoff partition parameter	none	1.5	Soils, topography, land use	
IRC	Interflow recession parameter	none	0.5	Soils, topography, land use	
LZETP	Lower zone ET parameter	none	monthly[b]	Vegetation	3
RCHRES					
KS	Weighting factor for hydraulic routing		0.5		

[a]Varies with land use
[b]Varies by month and with land use

These parameters were then transferred to the Bull Creek watershed model. Since DMLR requires periodic in-stream flow and TDS monitoring above and below various permitted mining sites around the Bull Creek watershed, these data were available for fine-tuning the hydrologic calibration. The DMLR data were available at multiple points throughout the watershed which made it possible to account for differences in headwater and main channel contributions to flow during the fine-tuning.

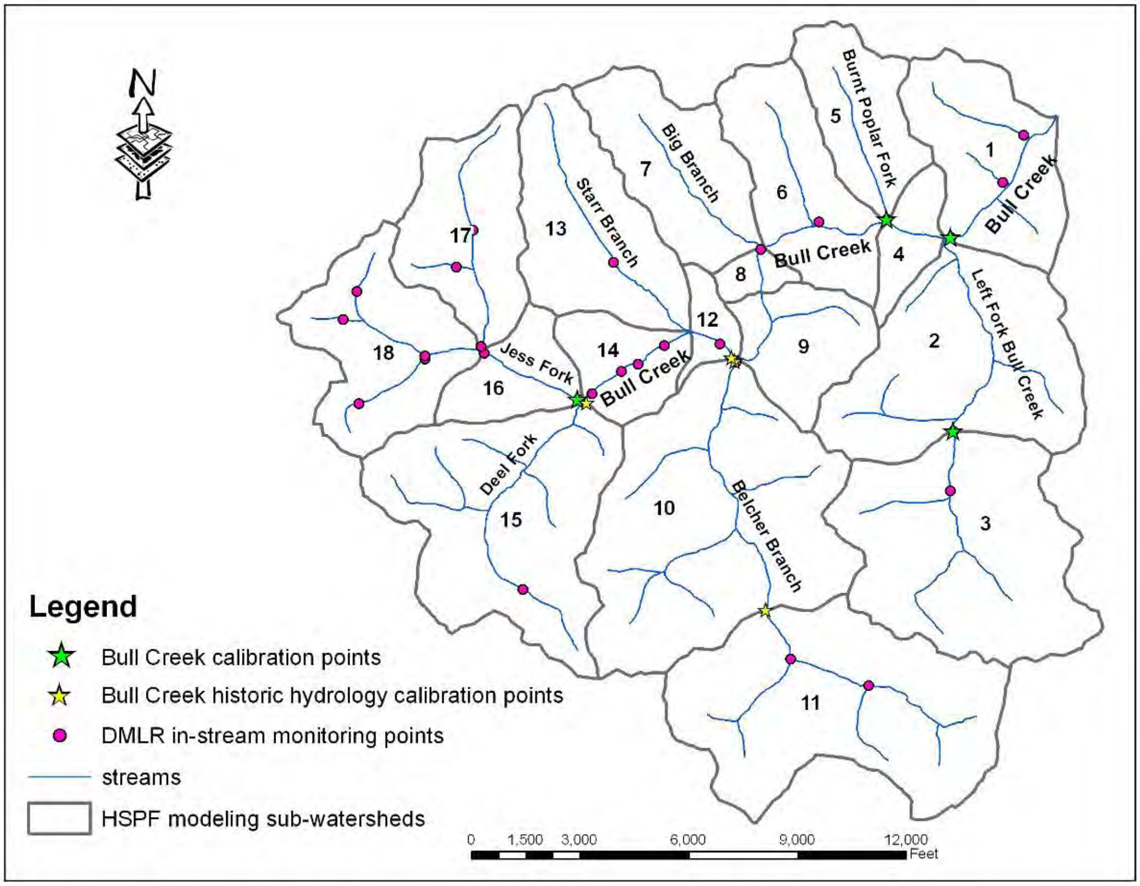


Figure 6.9. DMLR In-stream Monitoring Points in Bull Creek and Selected Calibration Points

Flows were then simulated with the Bull Creek model that incorporated the calibrated Cranes Nest River hydrologic parameter values. These simulated flows were then compared with DMLR observed flow data at the select monitoring points around the Bull Creek watershed. The locations of these DMLR in-stream monitoring points are shown in Figure 6.9. Although all of the hydrology calibration points were used for hydrology comparisons, the historic hydrology calibration points were not used for the TDS calibration.

Two minor changes were made during the hydrologic fine-tuning. One of these changes was made to eliminate the occurrence of non-typical no-flow days, by changing the value of the AGWRC parameter for forest land uses from 0.965 to 0.990, in conformance with guidance in BASINS Technical Note 6 (USEPA, 2000a). The second change made to Bull Creek was to adjust the DEEPFR parameter from a constant of 0.40 to a value varying from 0.20 to 0.50 by sub-watershed to better match the observed DMLR-monitored flows. The results are shown in Figure 6.10 through Figure 6.16. As can be seen from the figures, the simulated flows reasonably match the patterns and ranges of the observed data. Thus, the calibrated parameters were deemed acceptable for use in the Bull Creek watershed. The hydrology fine-tuning resulted in a flow distribution with 12% arising from surface runoff, 29% from interflow, and 59% from groundwater during the simulated period.

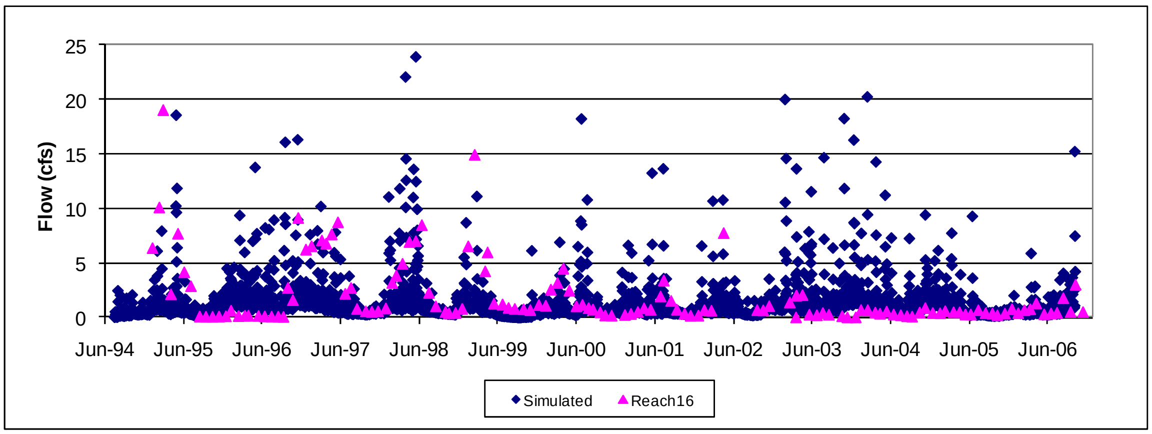


Figure 6.10. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watershed 16 (Jess Fork).

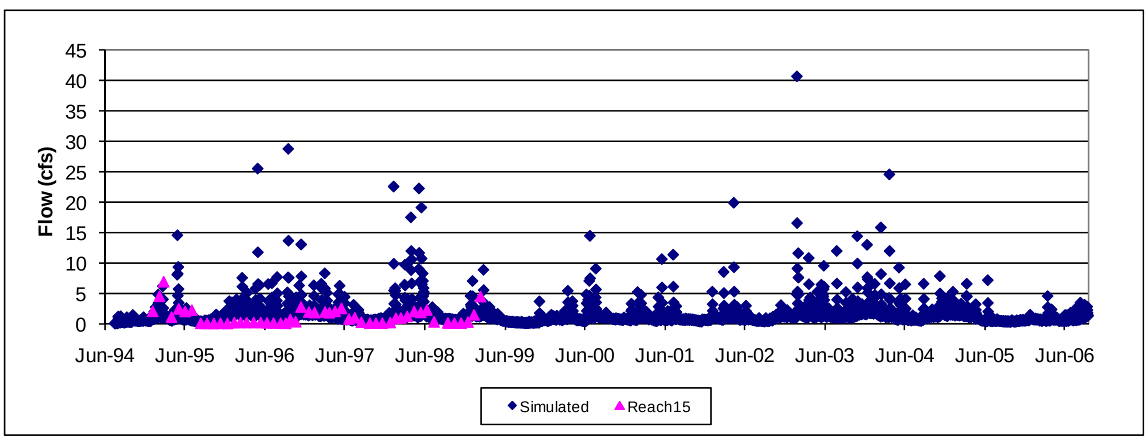


Figure 6.11. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watershed 15 (Deel Fork).

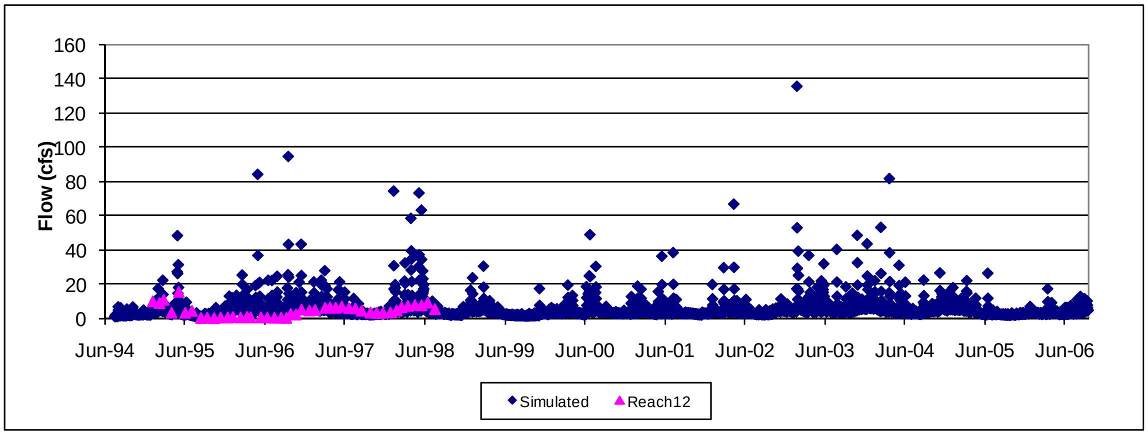


Figure 6.12. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watershed 12 (Bull Creek below Starr Branch).

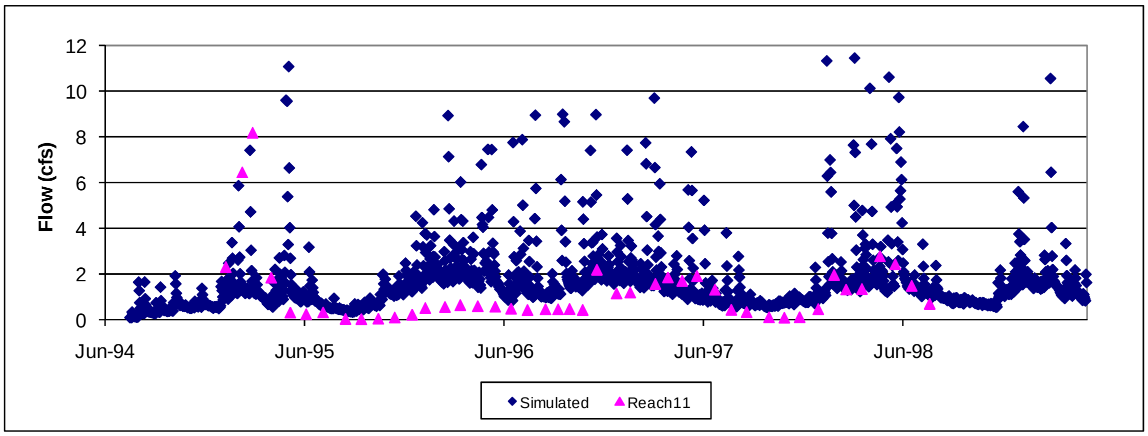


Figure 6.13. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watershed 11 (Upper Belcher Branch).

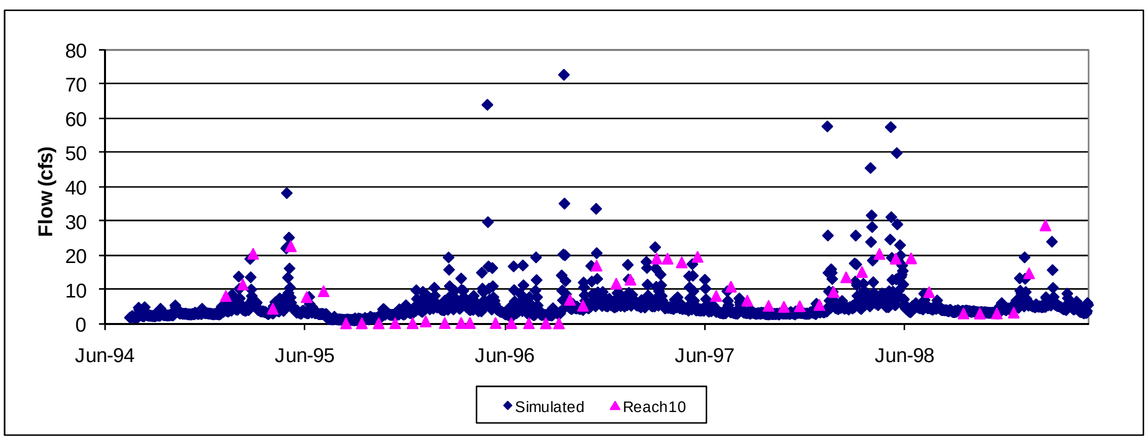


Figure 6.14. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watershed 10 (Lower Belcher Branch).

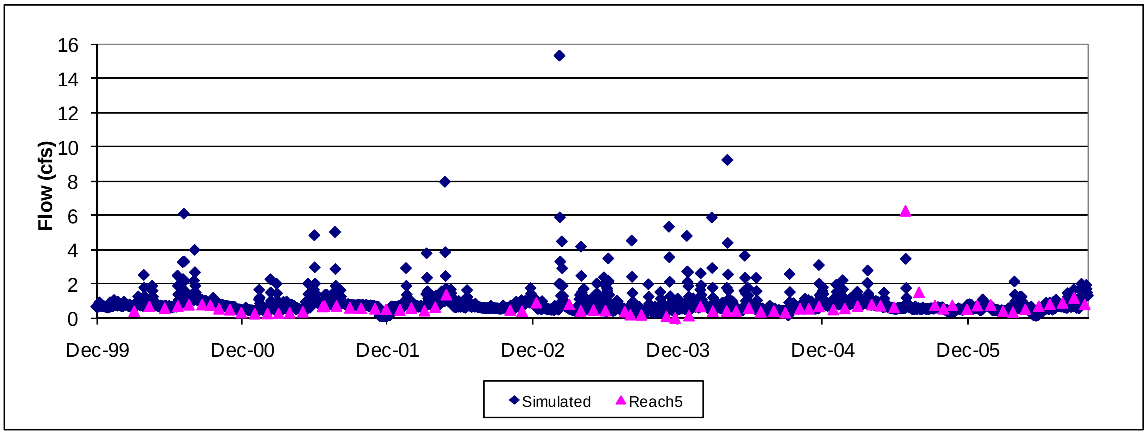


Figure 6.15. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watershed 5 (Burnt Poplar Fork).

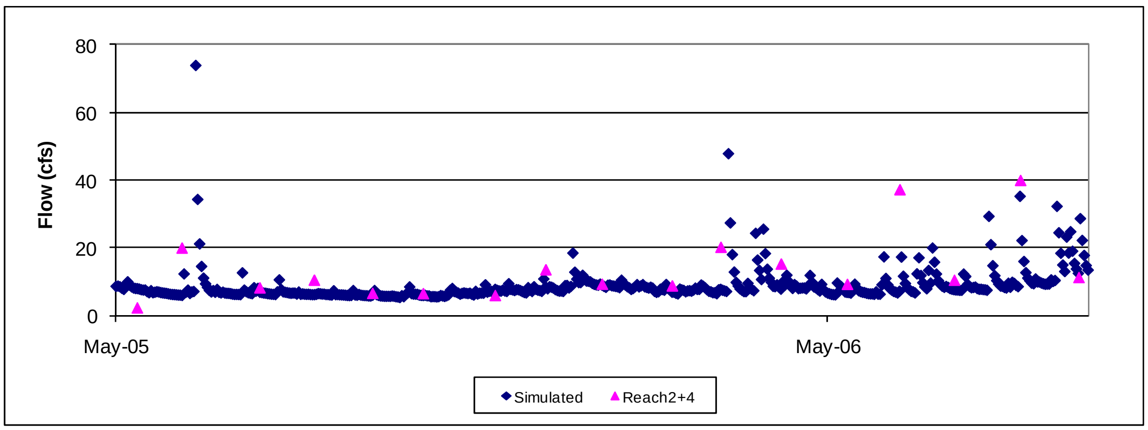


Figure 6.16. Calibrated simulated flow and DMLR observed flow in Bull Creek sub-watersheds 2+4 (Bull Creek near the outlet).

6.1.10. Water Quality (TDS)

Observed in-stream TDS concentrations from DMLR monitoring were also available at various points within the Bull Creek watershed. Four calibration points were selected in Bull Creek corresponding with the subset of points used for the hydrologic calibration assessment that also monitored for TDS.

During TDS calibration, parameter values were adjusted to match the available DMLR TDS data collected in Bull Creek for the period January 2000 - December 2005. Inputs for TDS loads from road salt applications, failing septic systems, straight pipes and pre-law mine discharges were quantified as described in Section 6.5 and were not subjected to calibration. TDS load calibration focused on parameters affecting the remaining TDS load components – surface runoff, interflow, and groundwater. Three parameters control surface runoff loads – ACQOP, SQOLIM, and WSQOP. ACQOP is the rate of daily TDS buildup or availability on the land surface; SQOLIM is the maximum level of TDS load on the land surface at any given time; and WSQOP is the rate of surface runoff that will remove 90% of the surface buildup in any given time step. Surface runoff loads were only simulated for the extractive and reclaimed land uses. Impervious area buildup and washoff of TDS was only simulated for the road surfaces. Additional calibration parameters included interflow TDS concentrations (IOQC) and groundwater concentrations (AOQC). The calibrated values and/or ranges for these parameters in the Bull Creek watershed are given in Table 6.6.

Table 6.6. TDS calibration parameters and values for Bull Creek

Parameter	Value/Range	Units	Spatially Variable	Temporally Variable
Pervious Land Segments				
ACQOP	200	lb/ac-day	constant	constant
SQOLIM	400	lb/ac-day	constant	constant
WSQOP	2.00	in/hr	constant	constant
AOQC	24 - 2,990	mg/L	by sub-watershed	monthly
IOQC	0.01436 - 0.04683 (230 - 750)	lb/ft3 (mg/L)	by land use and sub-watershed	constant
Impervious Land Segments				
CONS	144.4	lb/ac-day	roads	constant
SQOLIM	350	lb/ac-day	constant	constant
WSQOP	2.30	in/hr	constant	constant

The graphs comparing mean daily simulated and instantaneous observed TDS concentrations at the four calibration points along Bull Creek are shown in Figure 6.17 to Figure 6.20.

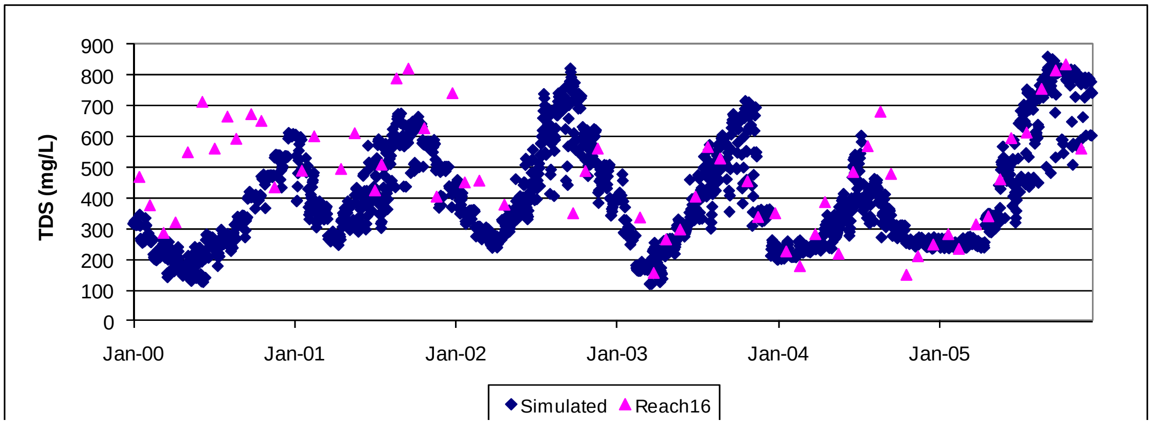


Figure 6.17. Simulated TDS concentrations and DMLR observed TDS concentrations in Bull Creek sub-watershed 16 (Jess Fork) after calibration.

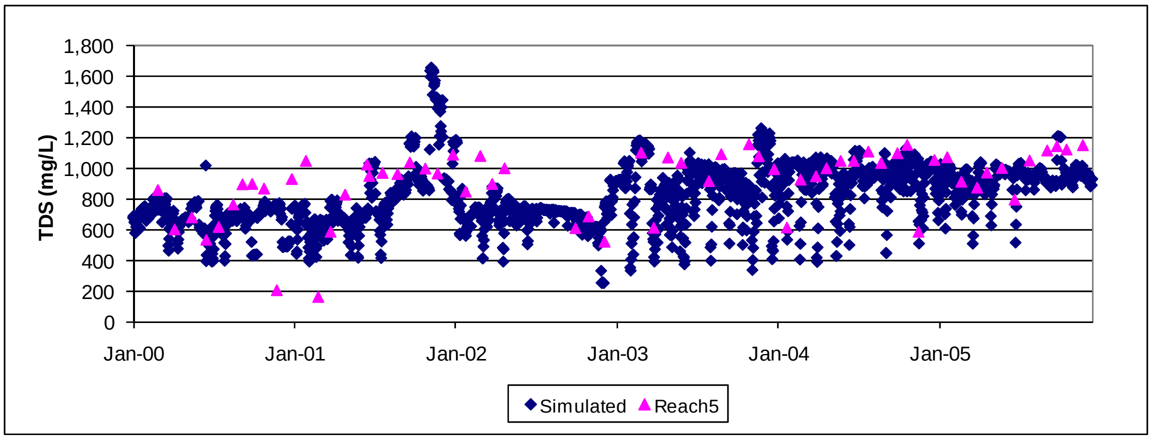


Figure 6.18. Simulated TDS concentrations and DMLR observed TDS concentrations in Bull Creek sub-watershed 5 (Burnt Poplar Fork) after calibration.

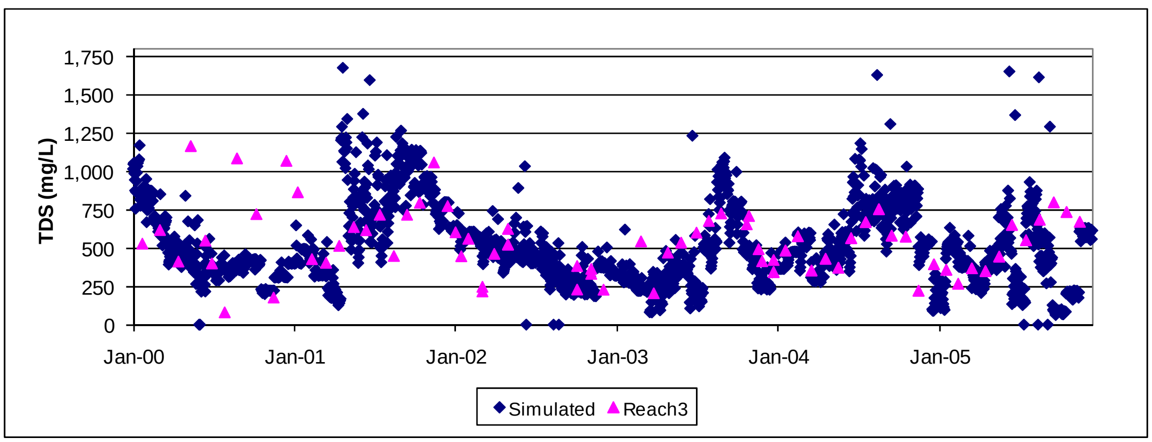


Figure 6.19. Simulated TDS concentrations and DMLR observed TDS concentrations in Bull Creek sub-watershed 3 (Upper Left Fork Bull Creek [Convict Hollow]).

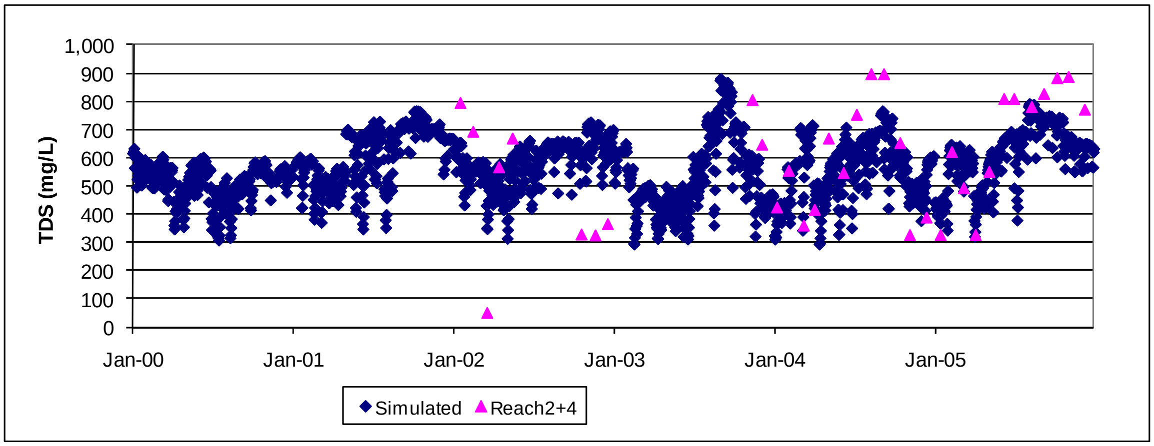


Figure 6.20. Simulated TDS concentrations and DMLR observed TDS concentrations in Bull Creek sub-watersheds 2+4 (Bull Creek near outlet) after calibration.

A visual comparison of simulated and observed in-stream TDS concentrations and best professional judgment were used to assess when a reasonable model calibration had been achieved. Additionally, the range and average of TDS concentrations were considered during calibration. Table 6.7 shows the comparison of these statistics and the percentage match between simulated and observed average TDS concentrations at each calibration point. Taken together, the visual data comparison and the descriptive statistics indicate a reasonable calibration of this highly variable parameter.

Table 6.7. TDS calibration statistics in 4 sub-watersheds of Bull Creek, January 2000 – December 2005

Sub-watershed Reach	Simulated		Observed		Sim Ave / Obs Ave
	Range (mg/L)	Average (mg/L)	Range (mg/L)	Average (mg/L)	(%)
Reach 16	120 - 859	399	150 - 1020	452	88.4%
Reach 5	250 - 1648	817	160 - 1248	960	85.1%
Reach 3	62 - 3235	508	78 - 1158	499	101.7%
Reach 2+4	290 - 882	568	50 - 896	578	98.2%

Although the total TDS loads from the watershed appear reasonable in relation to observed in-stream concentrations, the distributions among the various pathways of surface transport, interflow, and groundwater contributions to stream loads and between permitted mining and AML sources are somewhat uncertain. Loads from the other sources of TDS – residential, road salt, and pre-law mining – have been estimated with a degree of confidence. The parameters from the remaining sources of TDS in the watershed – active mining and AML land uses – were initially evaluated from available literature sources; however, only limited information was available to differentiate between these sources. Because of the uncertainties in the exact distribution of these loads, a phased TMDL was determined to be appropriate for the TDS stressor in Bull Creek. To calculate TDS loads generated for each mining permit, the model was first run with loads calculated from individual sub-watersheds with TDS sources from AML, road salt, pre-law mine discharges, residential septic source, and background interflow contributions turned off. The resulting sub-watershed TDS loads attributable to permitted mining sources were then apportioned to permits within each sub-watershed on an area-basis. The load for each permit was then summed from its area-weighted portions in each sub-watershed.

HSPF Model Parameters

A summary of the hydrologic parameter values used for Bull Creek are listed in Table 6.8. Complete listings of HSPF parameters that vary by month or by land use are included in Appendix C.

Table 6.8. Summary of HSPF hydrologic parameters and values for Bull Creek

Parameter	Definition	Units	Values	FUNCTION OF…	Appendix C Table (if applicable)
PERLND					
PWAT-PARM2					
FOREST	Fraction forest cover	none	1.0 forest, 0.0 other	Forest cover	
LZSN	Lower zone nominal soil moisture storage	inches	4.0	Soil properties	
INFILT	Index to infiltration capacity	in/hr	0.186-0.286[a]	Soil and cover conditions	1
LSUR	Length of overland flow	feet	30-200[a]	Topography	1
SLSUR	Slope of overland flowplane	none	0.16-0.54[a]	Topography	1
KVARY	Groundwater recession variable	1/in	0.0	Calibrate	
AGWRC	Base groundwater recession	none	0.99 forest, 0.965 other	Calibrate	
PWAT-PARM3					
PETMAX	Temp below which ET is reduced	deg. F	40	Climate, vegetation	
PETMIN	Temp below which ET is set to zero	deg. F	35	Climate, vegetation	
INFEXP	Exponent in infiltration equation	none	2	Soil properties	
INFILD	Ratio of max/mean infiltration capacities	none	2	Soil properties	
DEEPFR	Fraction of GW inflow to deep recharge	none	0.20 – 0.50	Sub-watershed	
BASETP	Fraction of remaining ET from baseflow	none	0.12	Riparian vegetation	
AGWETP	Fraction of remaining ET from active GW	none	0.10	Marsh/wetlands ET	
PWAT-PARM4					
CEPSC	Interception storage capacity	inches	monthly[b]	Vegetation	2
UZSN	Upper zone nominal soil moisture storage	inches	0.8	Soil properties	
NSUR	Mannings' n (roughness)	none	0.011-0.6[a]	Land use, surface condition	4
INTFW	Interflow/surface runoff partition parameter	none	1.5	Soils, topography, land use	
IRC	Interflow recession parameter	none	0.5	Soils, topography, land use	
LZETP	Lower zone ET parameter	none	monthly[b]	Vegetation	5
IMPLND					
IWAT-PARM2					
LSUR	Length of overland flow	feet	116	Topography	
SLSUR	Slope of overland flowplane	none	0.28	Topography	
NSUR	Mannings' n (roughness)	none	0.08	Land use, surface condition	
RETSC	Retention/interception storage capacity	inches	0.100	Land use, surface condition	

[a]Varies with land use
[b]Varies by month and with land use

CHAPTER 7: TMDL ALLOCATIONS

The objective of a TMDL is to allocate allowable loads among different pollutant sources so that appropriate actions can be taken to achieve water quality standards (USEPA, 1991). The stressor analysis indicated that sediment and TDS were the “most probable stressors” in the watershed (Yagow et al., 2007), and therefore, a TMDL was developed for each constituent.

Bull Creek Phased Sediment TMDL

7.1.1. TMDLs and Existing Conditions

Table 7.1 shows annual sediment loads (t/yr) and unit area sediment loads (t/ha) averaged over the 13-yr simulation period by source category for both the impaired watershed (Bull Creek) and the reference watershed (Upper Dismal Creek).

Table 7.1. Existing sediment loads (t/yr) and unit-area sediment loads (t/ha) in Bull Creek and Upper Dismal Creek

Sediment Sources	Bull Creek		Area-adjusted Upper Dismal Creek	
	(t/yr)	(t/ha)	(t/yr)	(t/ha)
Cropland	11.7	4.2	1.1	3.4
Pasture	8.2	0.3	34.5	0.7
Hay	0.1	0.1	0.0	
Forest	398.9	0.1	374.3	0.1
Barren	1,226.4	19.5	280.3	11.2
Mining				
Extractive	428.3	28.5	21.8	5.6
Reclaimed	8.4	0.9	1.4	0.5
Released	23.9	1.2	4.1	1.4
AML	3,890.3	18.3	2,017.6	13.5
Pervious Urban	9.9	0.2	7.5	0.1
Impervious Urban	6.1	0.2	2.7	0.1
Channel Erosion	26.0		14.4	
Watershed Totals	**6,038.3**		**2,759.7**	

The phased sediment TMDL for Bull Creek was calculated using the following equation:

$$\text{TMDL} = \sum\text{WLA} + \sum\text{LA} + \text{MOS}$$

where ∑WLA = sum of the wasteload (permitted) allocations;

∑LA = sum of load (nonpoint source) allocations; and

MOS = margin of safety.

The phased sediment TMDL for Bull Creek watershed was calculated as the average annual sediment load from the area-adjusted Upper Dismal Creek watershed for existing conditions (2,759.7 t/yr, Table 7.2).

Annual waste load allocations were calculated for individual stormwater permits in the Bull Creek watershed based on their area in the watershed, the permitted maximum daily concentration of TSS, and the average annual simulated runoff from the corresponding land use, as detailed in Table 5.5. A future growth allowance is also included for a 10% increase in permitted mining area and a corresponding 10% increase in allocated load. This increase in sediment allocation was allocated to the tributary sub-watersheds as a fraction of their current permitted loads. A future growth allocation was also included for stormwater E&S sediment loads from anticipated new gas & oil well construction based on 2 new wells per year and an average disturbed area of 7 acres per well site (based on current permits).

An explicit MOS of 10% was used in the sediment TMDL to reflect the uncertainty involved in developing a TMDL. The LA was calculated as the TMDL minus the MOS minus the WLA. The TMDL load and its components are shown in Table 7.2.

Table 7.2. Bull Creek Phased Sediment TMDL (t/yr)

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

7.1.2. Allocation Scenarios

For development of the allocation scenarios: pasture and hay were grouped into the “pasture/hay” category; and all residential sources were grouped together as “residential/urban”. The modeling target sediment load is the TMDL minus the MOS (2,759.7 – 276.0 = 2,483.7 t/yr), so that the overall reduction required for sediment is 58.9%, from 6,038.3 to 2,483.7 t/yr. Several TMDL allocation scenarios were developed based on reductions from different combinations of sediment sources under existing conditions (Table 7.3). The first scenario calls for equal percent reductions from all permitted and non-permitted mining and disturbed land use categories. The last two scenarios use reductions from only non-permitted sources. TMDL Alternative 2 calls for equal percent reductions from the two largest sources – barren and AML, while TMDL Alternative 3 calls for reductions only from AML. TMDL Alternative 2 is recommended as a starting point for consideration by a local watershed steering committee during the implementation phase.

Table 7.3. Phased Sediment TMDL Load Allocation Scenarios for Bull Creek

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

AML and barren areas were assessed as the primary sources of sediment in the Bull Creek watershed. AML reclamation and improved erosion control management and minimization of disturbed area footprints are recommended as the primary targets of implementation efforts. Barren land uses result from construction of access roads and drilling sites for gas and oil wells, logging, and from residential activities. The sediment TMDL for Bull Creek is being developed as a phased TMDL because of uncertainties in contributions of simulated loads from various land uses, including permitted sources. Additional monitoring will be conducted during the 2-year phased TMDL period, including TSS monitoring during storms currently allowed to meet an alternate standard for settleable solids. TMDL modeling will be revised based on the additional monitoring data.

7.1.3. Maximum Daily Load for Sediment

The USEPA has mandated that TMDL studies submitted since 2007 include a maximum "daily" load (MDL), in addition to the average annual load shown in Section 7.1.1 (USEPA, 2006a). The approach used to develop the MDL was provided in Appendix B of a related USEPA guidance document (USEPA, 2006b). The appendix entitled "Approaches for developing a Daily Load Expression for TMDLs computed for Longer Term Averages" is dated December 15, 2006. This guidance provides a procedure for calculating an MDL (t/day) for each watershed from the long-term average annual TMDL load (t/yr) and a coefficient of variation (CV) based on annual loads over a period of time. Annual simulated loads for the entire Bull Creek watershed were analyzed over the 13-year simulation period where annual sediment loads ranged from 135 to 23,021 t/yr to produce a CV = 1.24. A "long-term average to maximum daily load" multiplier was then interpolated from the USEPA guidance and calculated as 8.135 for the Bull Creek watershed. The MDL was calculated as the TMDL, divided by 365 days/yr, and multiplied by 8.135. Since the WLA represents permitted loads, no multiplier was applied to these loads. Therefore the daily WLA was converted to a daily load by dividing by 365 days/yr. The daily MOS was calculated in the same manner as the long-term average TMDL (10% of the MDL), and the daily LA was calculated as the MDL minus the daily WLA minus the daily MOS. The resulting MDL and associated components for the Bull Creek watershed are shown in Table 7.4. Expressing the TMDL as a daily load does not interfere with a permit writer's authority under the regulations to translate that daily load into the appropriate permit limitation, which in turn could be expressed as an hourly, weekly, monthly or other measure (USEPA, 2006a).

Table 7.4. Maximum "Daily" Loads (t/day) for Bull Creek

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

Bull Creek Phased TDS TMDL

7.1.4. Existing Conditions

Table 7.5 shows the annual TDS loads (kg/yr) averaged over the 6-yr simulation period by source category for existing conditions in Bull Creek.

Table 7.5. Sources of Existing TDS Loads in Bull Creek

TDS Sources	**Bull Creek Existing TDS Load** (kg/yr)
Permitted Mining	2,976,342
Mine Discharge	1,834,292
AML	600,924
Background	563,863
Road Salt	18,565
Residential	28,063
Total	**6,022,048**

7.1.5. TMDL Endpoint

The TMDL endpoint for Bull Creek is 369 mg/L, the 90th percentile of DEQ-monitored TDS concentrations from Lower Dismal Creek at DEQ monitoring station 6ADIS001.24.

7.1.6. Allocation Scenarios

The TDS concentration endpoint for Bull Creek was achieved by making incremental reductions from various anthropogenic sources of TDS and then simulating the corresponding TDS concentrations and loads. Residential sources of TDS were reduced first, followed by elimination of AML TDS sources. After that, one successful scenario (Scenario 3) was achieved by applying various percent reductions equally to all active mining source categories and mine discharges until the maximum daily average TDS concentration goal of 369 mg/L was achieved. A second successful scenario (Scenario 9) was achieved by also reducing mine discharges by 100% and then applying equal percent reductions to the active mining categories until all daily average TDS concentrations were below the concentration goal. Scenario 9 is recommended as a starting point during implementation, since it requires reductions from all controllable sources before requiring reductions from permitted sources. However, since the Scenario 9 requires a larger overall reduction, a comparison of costs and benefits may lead back to the Scenario 3 as a more cost-effective means of achieving the TMDL goal. A summary of the reduction percentages, the resulting maximum daily average concentration, the corresponding annual TDS load, and the overall percent load reduction for a number of scenarios are shown in Table 7.6. The time-series of TDS concentrations before and after allocation are shown in Figure 7.1, based on Allocation Scenario 9.

Table 7.6. Allocation Reduction Scenarios for Bull Creek

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

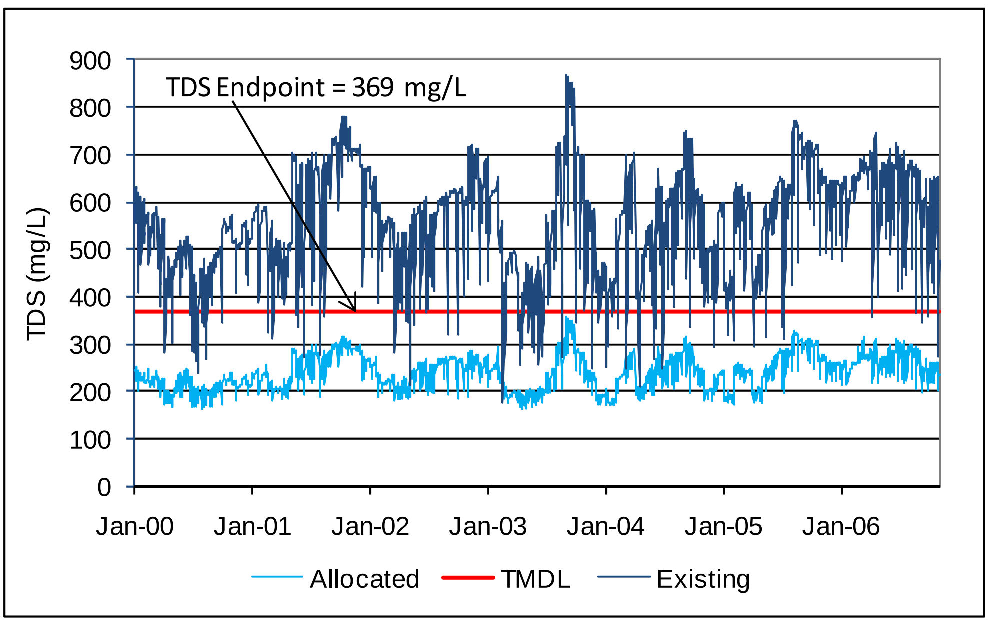


Figure 7.1. Existing and Allocated TDS time-series concentrations in Bull Creek

7.1.7. Bull Creek Phased TDS TMDL

The phased TDS TMDL is the load corresponding to Scenario 9 (Table 7.6). The TDS TMDL for Bull Creek was calculated using the following equation:

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

where $\sum$WLA = sum of the waste load (permitted) allocations;

$\sum$LA = sum of load (nonpoint source) allocations; and

MOS = margin of safety.

The LA component load was calculated as the TDS load from road salts, from pre-law direct mine discharges, and from background sources in interflow. The MOS used in this TMDL was implicit, based on the use of the conservative 90th percentile of observed TDS concentrations in the reference watershed for setting the TMDL TDS concentration endpoint. In Lower Dismal Creek, the 90th percentile values were actually 15.5% lower than the maximum observed values. The WLA was calculated as the combined allocations for mining sources from a combination of surface runoff, interflow, and groundwater loads, based on reductions in TMDL allocation Scenario 9 (Table 7.6). Individual WLAs for each mining permit were based on the proportionate area of each permit within each of the 18 modeling sub-watersheds multiplied times the TDS load from permitted mining sources in each sub-watershed. The distribution of permit areas by sub-watershed is given in Appendix Table D.1. The TMDL and its component loads are shown in Table 7.7, based on Allocation Scenario 9.

Table 7.7. Bull Creek Phased TDS TMDL (kg/yr)

Allocations can be found in the amendment attached to the end of this document: Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

In this watershed, after source characterization and modeling were completed, AML areas, pre-law mine discharges, and active mining sources were assessed as the primary contributors of TDS. AML reclamation and improved source reduction and site management of active mining areas are recommended as the primary targets of implementation efforts.

CHAPTER 8: PHASED TMDLS

Guidance on Phased TMDLs

Current EPA guidance recommends that the phased TMDL approach be used in situations “where limited existing data are used to develop a TMDL and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL” (USEPA, 2006c). All phased TMDLs must include all elements of a regular TMDL, including load allocations, wasteload allocations and a margin of safety. Each phase must be established to attain and maintain the applicable water quality standard. In addition, EPA recommends that a phased TMDL document include a monitoring plan and a scheduled timeframe for revision of the TMDL in a second phase (EPA, 2006). Because of the uncertainties in representing mining sources in preliminary modeling and the subsequent load allocations, phased TMDLs are being developed for both sediment and TDS in Bull Creek.

State TMDL Regulatory Agencies

The Virginia Department of Mines, Minerals and Energy (DMME) is the delegated agency to administer the VPDES permit program for regulating stormwater runoff from mining sites.

The Virginia Department of Conservation and Recreation (DCR) is the delegated agency to administer the VPDES permit program for regulating stormwater runoff from urban areas.

The Virginia Department of Environmental Quality (DEQ) is authorized by the Code of Virginia to develop TMDLs and plans to implement TMDLs in accordance with the provisions of the Clean Water Act and EPA’s enabling regulation 40 CFR § 130.7.

Also, EPA’s 40 CFR § 122.44 (d)(1)(vii)(B) states that VPDES permits must be consistent with new or revised TMDL WLAs.

Rationale for the Use of a Phased Sediment TMDL for Bull Creek

Modeling of the Bull Creek watershed produced monthly flow volumes and total suspended sediment (TSS) loads, with major contributions from abandoned mine land (AML) and barren land uses. This modeling relied on land use-based parameters that governed surface runoff and erodibility, with limited data available in the literature to evaluate and differentiate between AML and extractive (active mining) areas, two of the major sediment sources. Furthermore, the trapping efficiencies of sediment ponds are highly variable, and sufficient data were not available in Bull Creek to evaluate site specific values, leading to the use of debatable values obtained through calibration. In addition, the limited TSS data available at the calibration station in Bull Creek, with a limited range of rainfall-runoff response, made it difficult to judge the reasonableness of modeled load estimates and of relative loads from various mining sources.

EPA's 40 CFR § 434 contains TSS criteria for storms with provisions for alternate measurements during certain conditions. In a DMLR 1994 Memorandum to Operators, the "settleable solids" parameter was allowed as an alternative to TSS on days with a rainfall total of greater that 0.2 inches/day.

Between the 0.2 in/day storm and the 10-yr 24-hr design storm, settleable solids may be analyzed instead of TSS for mining permit compliance purposes. Since sediment is more likely to be contributed from nonpoint sources during larger rainfall events, this has resulted in fewer TSS measurements from permitted sources against which to evaluate the reasonableness of modeled TSS loads due to surface runoff.

Large TSS loads from AML areas were modeled in the TMDL and represent the largest single source of TSS in the Bull Creek watershed. There is a general consensus by the state agencies that an effective way to reduce the majority of excessive TSS loads is through incentives for re-mining and reclaiming these AML areas. As the first phase of the Bull Creek TMDL is proposed to last two years, this phased TMDL provides a 2-year window to encourage mine operators to re-mine or reclaim AML and to demonstrate the potential of re-mining, by itself, to make the sediment reductions called for in this TMDL and to restore the aquatic health of Bull Creek.

Bull Creek is also under the Consent Decree schedule for the Commonwealth of Virginia and its TMDLs must be completed by May 2010.

Rationale for the Use of a Phased TDS TMDL for Bull Creek

Although calibration to in-stream observed TDS concentrations instills confidence in the overall TDS loading in the watershed, the load distribution between permitted mining sources and AML, and between surface, interflow, and groundwater flow paths from each of these sources is highly uncertain. Additional monitoring is needed to determine the most equitable distribution of the required TDS load reductions between pre-existing and currently permitted mining sources.

Components of the Bull Creek Phased Sediment TMDL

The Bull Creek Phased TMDL for sediment will be developed in accordance with EPA's 2006 Guidance on Phased TMDL and will include the following components:

1. The TSS load from permitted mining areas will be calculated from the maximum daily TSS permit criterion of 70 mg/L and the simulated average annual surface runoff volume from extractive land uses for all storms, and will comprise the permitted mining component of the WLA.
2. Consistent with current permit conditions, no additional reductions will be required from permitted mining sites below a maximum daily TSS concentration of 70 mg/L, pending further data collection and analysis during the next phase.
3. To address the TSS data deficiency for storm events, monitoring during the 2-yr phased TMDL period will include the full range of storm events occurring below the 10-yr, 24-hr design storm. This will improve the assessment of sediment loads from active mining areas.

DMME's March 30, 2009 Memorandum will assist the phased TMDL monitoring effort, by requiring additional TSS sampling for all National Pollutant Discharge Elimination System (NPDES) discharges in TMDL watersheds where TSS is a stressor and in impaired watersheds where resource extraction is listed as causing the impairment. It is important that TSS monitoring be performed during all storm events, because TSS loads are currently not tracked when alternate effluent limits are utilized.

Components of the Bull Creek Phased TDS TMDL

The Bull Creek Phased TMDL for TDS will be developed in accordance with EPA's 2006 Guidance on Phased TMDL and will include the following components:

1. For the phased TDS TMDL, TDS loads will be calculated for each mining permit based on simulated loads with all TDS sources turned off except those related to permitted mining. The TDS loads from each sub-watershed will then be apportioned on an area-basis to all permits within each sub-watershed. TDS loads attributed to each permit will be summed from all sub-watersheds that included part of each permit's area.

2. Expanded DMLR requirements, as noted in a March 30, 2009 Memorandum to coal mining permittees, will include TDS monitoring at all outfalls in watersheds where an Aquatic Life Use impairment has been identified, in addition to those where TDS has already been identified as a stressor.

3. Although difficult to quantify, additional monitoring is needed to more accurately distinguish between levels of TDS attributable to permitted mining and AML from surface runoff, interflow and groundwater, as well as relative contributions between surface and deep mining.

4. DMLR's joint SMCRA/NPDES permits are made consistent with approved coalfield TMDLs. Since 2005, DMLR has utilized electronic permitting processes and specially designed TMDL software to insure consistency.

TMDL IMPLEMENTATION

The goal of the TMDL program is to establish a three-step path that will lead to attainment of water quality standards. The first step in the process is to develop TMDLs that will result in meeting water quality standards. This report represents the culmination of that effort for the benthic impairment on Bull Creek. The second step is to develop a TMDL implementation plan. The final step is to implement the TMDL implementation plan and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by USEPA and then the State Water Control Board (SWCB), measures must be taken to reduce pollutant levels in the stream. These measures, which can include the use of better treatment technology and the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. The process for developing an implementation plan has been described in the recent "TMDL Implementation Plan Guidance Manual", published in July 2003 and available upon request from the DEQ and DCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia begins the process of restoring impaired waters and enhancing the value of this important resource. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation.

DCR and DEQ will work closely with watershed stakeholders, interested state agencies, and support groups to develop an acceptable implementation plan that will result in meeting the water quality target. Stream delisting of Bull Creek will be based on biological health and not on numerical pollution loads. Since this TMDL consists of NPS load allocations originating from abandoned mine lands and wasteloads originating from permitted active mines, DMME will share responsibilities with DCR during implementation.

Staged Implementation

Implementation of BMPs in these watersheds will occur in stages. The benefit of staged implementation is that it provides a mechanism for developing public support and for evaluating the efficacy of the TMDL in achieving the water quality standard.

In general, Virginia intends for the required reductions to be implemented in an iterative process that first addresses those sources with the largest impact on water quality. Among the sediment and TDS sources identified in the Bull Creek watershed, the following BMPs should be useful in effecting the necessary reductions. AML areas could be addressed through remining, offsets, and through stabilization of critical areas; barren areas through establishment of vegetative cover; residential/urban areas and channel erosion through a combination of streambank stabilization measures and establishment of riparian buffers.

The iterative implementation of BMPs in the watershed has several benefits:

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

Watershed stakeholders will have opportunity to participate in the development of the TMDL implementation plan. Specific goals for BMP implementation will be established as part of the implementation plan development.

It is recommended that reclamation of AML be one of the initial targets for both sediment and TDS reductions during implementation. Additionally, it is recommended that straight pipes and failing septic systems also be addressed during the initial stages of implementation. It is anticipated that waste load allocations and pollutant load reductions of sediment and TDS to address benthic impairments will be achieved in watersheds with active mining through properly installed and maintained sediment control measures and BMPs (the BMP Approach) instead of altered effluent limitations.

Link to ongoing Restoration Efforts

Implementation of this TMDL will contribute to on-going water quality improvement efforts in Bull Creek.

One such effort in the Bull Creek watershed is a project under the Southern River Wastewater Enhancement Program (SRWEP), funded through a state Water Quality Improvement Grant. Under the SRWEP program, Buchanan County will receive $550,000 for a sewer line extension in the Convict Hollow sub-watershed in Bull Creek. The county will provide public wastewater service to 25 households that are currently using individual septic systems, many of which are failing to meet local permit requirements. Recent testing indicates that 57% of the local water supplies in the area are contaminated with coliform and are also positive for fecal coliform. As a result of this project, 6,500 linear feet of eight-inch sewer line, 1,250 linear feet of 4-inch sewer line, and 2,500 linear feet of 4-inch sewer line will be installed. The grant award was announced by Governor Kaine in May 2008.

Reasonable Assurance for Implementation

8.1.1. TMDL Compliance Monitoring

DEQ will continue monitoring benthic macroinvertebrates and habitat at station 6ABLC002.30 in accordance with its biological monitoring program and TDS and TSS at station 6ABLC000.85 in accordance with its ambient monitoring program. DEQ will continue to use data from these monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the general water quality standard.

DMLR requires all NPDES discharge permittees to monitor total dissolved solids (TDS) in TMDL watersheds where aquatic life use impairments have been identified. Additionally, in a March 30, 2009 Memorandum to all coal mining permittees, DMLR is now requiring permittees to analyze for TSS during qualifying precipitation events, where previously only an alternative parameter – settleable solids – was required. Therefore, TSS data will be available for the full range of precipitation events up through the 10-yr, 24-hr design storm. BMPs specified in NPDES permits are currently required to control runoff from a 10-yr, 24-hr precipitation event (Title 40 §434, Electronic Code of Federal Regulations). The enhanced TMDL stressor monitoring will be in accordance with DMLR's monitoring guidance DMME, 2008.

Since TMDLs are expressed in terms of annual loads, discharge flow rates should be measured concurrently with water quality sampling, and recorded together with daily precipitation data monitored by DMLR-approved sources. When monitoring indicates that the TMDL TDS WLAs are being exceeded DMLR will implement the agency's Waste Load Reduction Actions.

Regulatory Framework

Federal Regulations

While section 303(d) of the Clean Water Act and current USEPA regulations do not require the development of TMDL implementation plans as part of the TMDL process, they do require reasonable assurance that the load and wasteload allocations can and will be implemented. Federal regulations also require that all new or revised National Pollutant Discharge Elimination System (NPDES) permits must be consistent with the assumptions and requirements of any applicable TMDL WLA (40 CFR §122.44 (d)(1)(vii)(B)). All such permits should be submitted to USEPA for review.

State Regulations

Additionally, Virginia's 1997 Water Quality Monitoring, Information and Restoration Act (WQMIRA) directs the State Water Control Board to "develop and implement a plan to achieve fully supporting status for impaired waters" (Section

62.1-44.19.7). WQMIRA also establishes that the implementation plan shall include the date of expected achievement of water quality objectives, measurable goals, corrective actions necessary and the associated costs, benefits and environmental impacts of addressing the impairments. USEPA 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 water quality standards, monitoring plans and milestones for attaining water quality standards.

For the implementation of the WLA component of the TMDL, the Commonwealth utilizes the Virginia NPDES program, which typically includes consideration of the WQMIRA requirements during the permitting process. Requirements of the permit process should not be duplicated in the TMDL process and implementation plan development, especially those implemented through water quality based effluent limitations. However, those requirements that are considered best management practices (BMPs) may be enhanced by inclusion in the TMDL IP, and their connection to the targeted impairment. New permitted point source discharges will be allowed under the waste load allocation provided they implement applicable VPDES and Virginia's Coal Surface Mining Reclamation Regulations (CSMRR) requirements (including any BMP, offset, trading or payment-in-lieu conditions established to meet any future reduction requirements).

<u>Stormwater Permits</u>

The impaired portions of Bull Creek watershed being addressed in this TMDL primarily contain land uses of active mining, abandoned mine lands, forest, and reclaimed lands. USEPA delegated the authority for stormwater management of historic and active mining lands to DEQ through Virginia's NPDES permit program. This program is currently administered through DMME (§45.1-254 of the Code of Virginia). DMME monitoring data and modeling have shown the major sediment loading source in this watershed to be stormwater runoff from AML and barren land uses.

Existing Active Mine Drainage Controls

In November 2005, DMME's Division of Mined Land Reclamation (DMLR) issued Guidance Memorandum No. 14-05 to address the implementation of coal mining-related TMDL wasteload allocations. The memorandum can be accessed at http://www.dmme.virginia.gov/DMLR/docs/operatormemos.shtml. As of December 1, 2005 the Division of Mined Land Reclamation (Division) has been implementing the steps outlined in the memorandum regarding permit applications in watersheds with adopted benthic Total Maximum Daily Loads (TMDLs), as described below.

Active mining operations are required to use sediment control measures and BMPs to prevent additional contributions of solids to streams and to minimize erosion to the extent possible by Virginia's Coal Surface Mining Reclamation Regulations (CSMRR; 4 VAC 25-130). The measures include practices carried out within and adjacent to the disturbed mining area and consist of the utilization of proper mining and reclamation methods and control practices, singly or in combination. These methods and practices include, but are not limited to:

1. Disturbing the smallest area at any one time during the mining operation through progressive backfilling, grading, and prompt revegetation;
2. Stabilizing the backfill material to promote a reduction in the rate and volume of runoff;
3. Diverting runoff away from disturbed areas;
4. Directing water and runoff with protected channels;
5. Using straw, mulches, vegetative filters, and other measures to reduce overland flow;
6. Reclaiming all lands disturbed by mining as contemporaneously as practicable.

Additional Active Mine Drainage TMDL Controls

In addition to the use of sediment control measures and BMPs within the disturbed area, CSMRR require coal mining haulroads to be designed and constructed to ensure environmental protection appropriate for their intended use. In a watershed where pollution load reductions for solids are necessary for active mining operations to meet an approved TMDL, haulroad design, construction, and maintenance shall be performed in consideration of the TMDL. This may include, but not be limited to:

1. Using non-toxic-forming substances in road surfacing;
2. Paving haulroads;
3. Increasing the detention capacity of haulroad sumps;
4. Increasing the frequency of inspection and maintenance of haulroad sumps.

Reduction in the sedimentation and mineralization of runoff attendant to mined land erosion and strata exposure may also be achieved with sediment control measures and BMPs. Operation and reclamation plans mandated by CSMRR can be designed and developed to incorporate a BMP approach for meeting waste load allocations and pollutant load reductions included in a TMDL for stream segments and watersheds where sediment and TDS have been identified as the benthic stressors, as outlined by the November 23, 2005 DMME guidance (DMME, 2005).

Significant sediment and TDS loads in the Bull Creek watershed arise from AML, and one of the most important existing incentives for addressing this source is the alternative effluent limitations regulations [Section 301(p) in the 1987 Clean Water Act Amendments], also known as the Rahall Amendment. These regulations provide an incentive to mine operators to gradually improve the water quality from these problem areas until reclamation is completed, at which time water quality standards should be met.

Generally, a BMP approach will be used in Virginia to meet WLAs in lieu of alternate effluent limitations for permitted coal mine point source discharges. DMME will track assigned and available WLAs. Prior to approval of new NPDES points within a TMDL watershed, the DMME Division of Water Quality staff will conduct a waste load evaluation to determine whether a WLA is available.

1. Redundant, additional, and/or over-engineered BMPs or practices within permitted mining acreages to better control stormwater transport of pollutants should be implemented.
    a. Enhancement or increasing stream bank buffers in permit acreage or along haul roads should be included;
    b. Streambank stabilization, where possible, in permit acreage or downstream affected areas.
2. Effective windrows (such as those required by Division of Gas and Oil, Department of Mines Minerals and Energy) should be installed below drainage paths of existing haul roads.
3. Prompt reclamation or restoration of disturbed lands should be implemented to reduce the generation and transport of sediment and TDS from the disturbed areas.

Implementation Funding SourcesImplementation funding sources will be determined during the implementation planning process by the local watershed stakeholder planning group with assistance from DEQ, DCR, and DMME. Potential sources of funding include Section 319 funding for Virginia's Nonpoint Source Management Program, the U.S. Department of Agriculture's Conservation Reserve Enhancement and Environmental Quality Incentive Programs, the Virginia State Revolving Loan Program, the Virginia Water Quality Improvement Fund, and the Abandoned Mine Lands program, although other sources are also available for specific projects and regions of the state. 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.

8.1.2. Reasonable Assurance Summary

Watershed stakeholders will have opportunities to provide input and to participate in the development of the implementation plan, which will also be supported by regional and local offices of DEQ, DCR, and other cooperating agencies.

Once developed, DEQ intends to incorporate the TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP), in accordance with the Clean Water Act's Section 303(e). In response to a Memorandum of Understanding (MOU) between USEPA and DEQ, DEQ also submitted a draft Continuous Planning Process to USEPA in which DEQ commits to regularly updating the WQMPs. Thus, the WQMPs will be, among other things, the repository for all TMDLs and TMDL implementation plans developed within a river basin.

Taken together, the follow-up monitoring, WQMIRA, the DMME guidance, the Rahall Amendment, public participation, the Continuing Planning Process, a focus on the legacy of impacts associated with historical coal mining in the Bull Creek Watershed through the state's AML Program, and the promotion of remining comprise a reasonable assurance that the Bull Creek TMDLs will be implemented and water quality will be restored.

CHAPTER 9: 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.

The first Technical Advisory Committee meeting was held on October 4, 2007 at the Harman Memorial Baptist Church on Route 609 in Maxie, Virginia, to gather information on and to verify existing data for the Bull Creek watershed. The meeting was preceded by a tour of the watershed led by Heather McDonald-Taylor, an area inspector with the DMME-DMLR. Copies of the presentation materials were available for public distribution at the meeting and at our web site forum, http://www.tmdl.bse.vt.edu/forums/. The TAC meeting was attended by 8 people.

The first public meeting was held later that same day at the Harman Memorial Baptist Church to gather further information about the Bull Creek watershed. Copies of the presentation materials were available for public distribution at the meeting and at our web site forum, http://www.tmdl.bse.vt.edu/forums/. The public meeting was attended by 10 people.

The benthic stressor analysis report for Bull Creek was circulated to all members attending both the TAC and public meetings on February 7, 2008. One comment was received in response, and responses to these comments have been included in the final TMDL report.

A public meeting which presented the draft sediment and TDS TMDLs report on Bull Creek for the benthic impairment was held on March 20, 2008, also at the Harman Memorial Baptist Church in Maxie, Virginia. This public meeting was attended by 12 stakeholders. The public comment period ended on April 20, 2008.

Due to revisions to the draft TMDLs, another public meeting was held on September 23, 2008 to present the revised draft sediment and TDS TMDLs. This meeting was also held at the Harman Memorial Baptist Church in Maxie, Virginia. This public meeting was attended by 8 stakeholders. The public comment period ended on October 22, 2008.

Uncertainties related to the modeling and source differentiation led to the development of phased TMDLs which will be presented at a public meeting scheduled for January 14, 2010. This meeting will be held in conjunction with a TMDL public meeting for a downstream impairment on Levisa Fork.

CHAPTER 10: REFERENCES

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Appendix A: Glossary of Terms

Glossary of Terms

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.

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.

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

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: direct deposits of fecal material to streams from livestock and wildlife.

E-911 digital data
Emergency response database prepared by the county that contains graphical data on road centerlines and buildings. The database contains approximate outlines of buildings, including dwellings and poultry houses.

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). The MOS may also be assigned explicitly, as was done in this study, to ensure that the water quality standard is not violated.

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 can be divided into source activities related to either land or water use including failing septic tanks, improper animal-keeping practices, forest practices, and urban and rural runoff.

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.

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.

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.

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.

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.

For more definitions, see the Virginia Cooperative Extension publications available online:

Glossary of Water-Related Terms. Publication 442-758.
http://www.ext.vt.edu/pubs/bse/442-758/442-758.html

and

TMDLs (Total Maximum Daily Loads) - Terms and Definitions. Publication 442-550.
http://www.ext.vt.edu/pubs/bse/442-550/442-550.html

Appendix B: Weather Data Preparation

Weather Data Preparation

Introduction

A weather data file for providing the weather data inputs into the HSPF Model was created for the period July 1989 through October 2006 using the Watershed Data Management Utility (WDMUtil). Raw data required for creating the weather data file included daily precipitation (in.), average daily temperatures (maximum, minimum, and dew point) (°F), average daily wind speed (mi/hr), total daily solar radiation (Langleys), and percent sun. The primary data source was the National Climatic Data Center's (NCDC) Cooperative Weather Station 443640 in Grundy, Virginia, which was located 4 miles (6.4 km) east of the watershed. Data from other NCDC stations were also including Richlands for average daily temperature. The raw data required varying amounts of preprocessing within WDMUtil to obtain the following hourly values: precipitation (PREC) (in), air temperature (ATEM) (°F), dew point temperature (DEWP) (°F), solar radiation (SOLR) (Langleys), wind speed (WIND) (mi/hr), potential evapotranspiration (PEVT) (in), potential evaporation (EVAP) (in), and cloud cover (CLOU) (tenths, range 0-10). The final WDM file contains these hourly datasets.

Raw data collection and processing

Weather data were obtained from the NCDC's weather stations in Grundy, Virginia (443640, Lat.Long. 37°17'N / 82°05'W, elev 1170 ft); Breaks Interstate Park (440982, 37°17'N / 82°18'W, elev 1893 feet) ;John Flannagan Lake (444410 lat.long 37°14'N / 82°21'W elev 1460 ft);Richlands, VA (447174, Lat./Long. 37°06'N / 81°48'W, elevation 1910 ft); Lebanon, VA (444777 Lat./Long. 36°54'N / 82°02'W, elevation 1912 ft); Bristol Tri City Airport, TN (401094 Lat./Long. 36°28'N / 82°24'W, elevation 1500 ft); and Lynchburg Airport, VA (445120, Lat./Long. 37°20'N/79°12'W, elevation 286.5 ft). While deciding on the period of record for the weather WDM file, availability of flow and water quality data was considered in addition to the availability and quality of weather data. Data collection for many of the parameters did not being until 1989, which set the starting point of the period of record. Percent sun (PSUN) data were available from Lynchburg Airport and then only through July 1996. The majority of the water quality data were collected from 2001 through 2003. In order to make the best use of the available water quality data, the period of record was chosen to be July 1989-October 2006. There are 6,332 days within this period. Substitutions for missing data are described below. The procedures used to process the raw data to obtain finished data required for input to HSPF are also described in the following sections.

1. <u>Hourly Precipitation</u>
   Daily precipitation (PRCP) data were downloaded from NCDC's web site for Grundy, VA for the July 1989-October 2006 period. Of the 6,332 possible daily values in this period, 49 values were missing. The closest station that records daily precipitation data overlapping the July 1999-October 2006 period was Breaks Interstate Park. Missing values from Grundy data were filled in with the daily precipitation (PRCP) from Breaks Interstate Park and or John Flannagan Lake prior to 1999. The resulting

file was imported into WDMUtil, disaggregated to hourly precipitation using WDMUtil's disaggregation routine and given the constituent label "PREC."

2. Temperature
Separate daily maximum temperature (TMAX) and daily minimum temperature (TMIN) files were downloaded from the NCDC website for Richlands. The TMAX dataset was missing 107 days of data; the TMIN dataset was missing 155 days of data. Data from the Lebanon station were used to fill in the missing days. Daily dew point temperature (DPTP) was taken as the daily minimum temperature. These data had units of tenths of degrees Fahrenheit. The *disaggregate temperature* function in WDMUtil was used to create an hourly average temperature file (ATEM). The *disaggregate dewpoint temperature* function in WDMUtil was used to create an hourly dewpoint temperature file (DEWP).

3. Average Daily Wind Speed
Average daily wind speed (AWND) was not recorded at the Richlands station; therefore, average daily wind speed was obtained from the Bristol Tri City Airport. The units of the data were tenths of miles per hour; therefore, the timseries was divided by a factor of 10 prior to use in the WDM file. The *compute wind travel* function in WDMUtil was used to calculate the total wind travel in miles/day. Then the *disaggregate wind travel* function in WDMUtil was used to calculate the hourly wind speed throughout the day (WIND) using the distribution coefficients shown in Table 1.

Table B.11.1. Hourly Distribution Coefficients for Wind Speed.

Hour	12	1	2	3	4	5	6	7	8	9	10	11
AM	0.035	0.034	0.034	0.034	0.034	0.034	0.034	0.034	0.035	0.037	0.041	0.046
PM	0.05	0.053	0.054	0.058	0.057	0.056	0.05	0.043	0.04	0.038	0.036	0.036

4. Cloud cover and solar radiation
In the absence of daily cloud cover, percent sun (PSUN) can be used to estimate DCLO. DCLO is used by WDMUtil to estimate hourly cloud cover in tenths (CLOU) as well as solar radiation (SOLR) in Langleys. The closest weather station that recorded PSUN was Lynchburg Airport, and these data was used to develop the weather file. As previously mentioned, PSUN was only available at this station for the period January 1984-July 1996. It is the experience of the authors that the model is rather insensitive to the parameters derived from PSUN; therefore, to bridge the gap of missing data, values from August 1996-December 2006 were filled in by copying the values from August 1986-December 1996.

   The *compute percent cloud cover* function in WDMUtil was used to calculate the daily percent cloud cover in tenths (DCLO) from PSUN. Because there is not a *disaggregate percent cloud cover* function available, the *disaggregate wind travel* function was used with hourly distribution coefficients all set to 1 to calculate the hourly percent cloud cover in tenths (CLOU).

The *compute solar radiation* function in WDMUtil was used to calculate the daily solar radiation in Langleys (DSOL) from DCLO and the Richlands station latitude (37°06'N). The *disaggregate solar radiation* function was then used to calculate the hourly solar radiation (SOLR).

5. Evaporation/Evapotranspiration
   Two types of evaporation/evapotranspiration are required for input to HSPF: potential evaporation from a reach or reservoir surface (EVAP), represented as Penman pan evaporation; and potential evapotranspiration (PEVT), represented as Hamon potential evapotranspiration.

   The *compute Penman pan evaporation* function in WDMUtil was used to calculate daily Penman pan evaporation (DEVP) from TMIN, TMAX, DPTP, TWND, and DSOL. Then the *disaggregate evapotranspiration* function was used to calculate EVAP from DEVP.

   The *compute Hamon PET* function in WDMUtil was used to calculate daily potential evapotranspiration (DEVT) from TMIN, TMAX, the Richlands station latitude (37°06'N), and monthly coefficients all equal to 0.005. Then the *disaggregate evapotranspiration* function was used to calculate PEVT from DEVT.

Summary of weather data preparation
The weather data were prepared for input to HSPF as described in the previous section. A summary of the NCDC input parameters, WDMUtil functions used, and final HSPF parameters is presented in Table B.11.2.

Table B.11.2. Weather parameters and processing in WDMUtil required for HSPF modeling.

NCDC Input Parameters	Intermediate Input	WDMUtil Functions	Intermediate Output	Final HSPF Parameter
PRCP	--	Disaggregate precipitation	--	PREC
TMAX, TMIN	--	Disaggregate temperature	--	ATEM
DPTP	--	Disaggregate dewpoint temperature	--	DEWP
PSUN	--	Compute percent cloud cover	DCLO	--
	DCLO	Disaggregate wind travel[1]	--	CLOU
	DCLO	Compute solar radiation	DSOL	--
	DSOL	Disaggregate solar radiation	--	SOLR
AWND	--	Compute wind travel	TWND	--
	TWND	Disaggregate wind travel	--	WIND
TMAX, TMIN, DPTP	TWND, DSOL	Compute Penman pan evaporation	DEVP	--
	DEVP	Disaggregate evapotranspiration	--	EVAP
TMAX, TMIN	--	Compute Hamon PET	DEVT	--
	DEVT	Disaggregate evapotranspiration	--	PEVT

[1]all hourly coefficients set to 1

Appendix C: HSPF Parameters that Vary by Month or Land Use

Table C.1. PWAT-PARM2 parameters varying by land use for Bull Creek.

	LZSN (in)	INFILT (in/hr)	LSUR (ft)	SLSUR (ft/ft)	KVARY (1/in)	AGWRC (1/day)
Low Intensity Res.	4	0.186	100	0.376	0	0.965
Med. Intensity Res.	4	0.186	200	0.163	0	0.965
High Intensity Res.	4	0.186	100	0.328	0	0.965
Extractive	4	0.186	50	0.408	0	0.965
Barren	4	0.186	100	0.445	0	0.965
Pasture/Hay	4	0.252	150	0.415	0	0.965
Croplands	4	0.286	200	0.206	0	0.965
Forest	4	0.284	30	0.496	0	0.99
AML	4	0.186	30	0.487	0	0.965
Reclaimed	4	0.186	30	0.540	0	0.965
Released	4	0.186	30	0.476	0	0.965

Table C.2. PWAT-PARM4 parameters varying by land use for Bull Creek.

	CEPSC (in)	UZSN (in)	NSUR	INTFW	IRC (1/day)	LZETP
Low Intensity Res.	0.13	0.8	0.1	1.5	0.5	0.7
Med Intensity Res.	0.25	0.8	0.07	1.5	0.5	0.6
High Intensity Res.	0.05	0.8	0.05	1.5	0.5	0.5
Extractive	0.05	0.8	0.011	1.5	0.5	0.4
Barren	0.05	0.8	0.05	1.5	0.5	0.4
Pasture/Hay	0.13	0.8	0.37	1.5	0.5	0.7
Croplands	0.25	0.8	0.27	1.5	0.5	0.6
Forest	0.05	0.8	0.6	1.5	0.5	0.5
AML	0.05	0.8	0.011	1.5	0.5	0.4
Reclaimed	0.05	0.8	0.011	1.5	0.5	0.4
Released	0.05	0.8	0.011	1.5	0.5	0.4

Table C.3. PWAT-STATE1 parameters varying by land use for Bull Creek.

	UZS	IFWS	LZS	AGWS
Low Intensity Res.	0.499	0	5.714	0.358
Med Intensity Res.	0.505	0	5.245	0.406
High Intensity Res.	0.472	0	5.488	0.411
Extractive	0.674	0.001	5.917	0.362
Barren	0.683	0.003	6.786	0.444
Pasture/Hay	0.499	0	5.714	0.358
Croplands	0.505	0	5.245	0.406
Forest	0.472	0	5.488	0.411
AML	0.656	0.001	6.159	0.388
Reclaimed	0.674	0.001	5.917	0.362
Released	0.683	0.003	6.786	0.444

Table C.4. MON-INTERCEP (monthly CEPSC) - Monthly Interception Storage.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
L/M/H Residential	0.09	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.09	0.09	0.09	0.09
Extractive	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Barren	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02
Pasture	0.08	0.09	0.13	0.16	0.18	0.2	0.2	0.2	0.19	0.14	0.1	0.08
Crop	0.06	0.07	0.1	0.18	0.21	0.26	0.26	0.23	0.2	0.18	0.08	0.06
Forest	0.1	0.1	0.13	0.16	0.2	0.32	0.32	0.32	0.2	0.14	0.12	0.1
AML	0.09	0.09	0.09	0.09	0.09	0.11	0.11	0.11	0.09	0.09	0.09	0.09

Table C.5. MON-LZETP - Monthly Lower Zone Evapotranspiration Parameter.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LDR	0.25	0.25	0.3	0.3	0.35	0.35	0.35	0.3	0.3	0.3	0.25	0.25
MDR	0.25	0.25	0.28	0.28	0.33	0.33	0.33	0.3	0.28	0.28	0.25	0.25
HDR	0.25	0.25	0.27	0.27	0.3	0.3	0.3	0.3	0.27	0.27	0.25	0.25
Extractive	0.1	0.1	0.1	0.1	0.15	0.15	0.2	0.2	0.2	0.15	0.1	0.1
Barren	0.1	0.1	0.1	0.1	0.15	0.15	0.2	0.2	0.2	0.15	0.1	0.1
Pasture	0.25	0.35	0.45	0.5	0.55	0.75	0.75	0.65	0.6	0.5	0.4	0.25
Croplands	0.25	0.35	0.45	0.5	0.55	0.75	0.75	0.65	0.6	0.5	0.4	0.25
Forest	0.35	0.35	0.45	0.5	0.55	0.75	0.75	0.65	0.6	0.5	0.45	0.35
AML	0.25	0.25	0.27	0.27	0.3	0.3	0.3	0.3	0.27	0.27	0.25	0.25

Table C.6. QUAL-INPUT -TDS input parameters for Bull Creek.

	ACQOP lb/ac.day	SQOLIM lb/ac	WSQOP in/hr	AOQC lb/ft3
Low Intensity Res.				0.01436
Med Intensity Res.				0.01436
High Intensity Res.				0.01436
Extractive	200	400	2.00	0.04683
Barren				0.01436
Pasture/Hay				0.01436
Croplands				0.01436
Forest				0.01436
AML	200	400	2.30	0.04683
Reclaimed	200	400	2.30	0.02342
Released				0.01436

Appendix D: Existing Mining Permits Distributed by Sub-watershed

Table D.1. DMLR Mining Permit Areas within Each Bull Creek Sub-watershed (as of 09/21/07).

DMLR Mining	Bull Creek Sub-watersheds (area in acres)																		Permit Area
Permit Numbers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**in Bull Creek**
1101701							3.37	4.22	0.23			13.93	25.96	0.22					**47.93**
1101736	8.66			2.85	92.08	17.92													**121.52**
1101903											2.73								**2.73**
1101979																	20.21	43.80	**64.01**
1200129											0.85								**0.85**
1200281		1.83	4.28																**6.10**
1200343			5.38																**5.38**
1201678														0.33	1.45	0.85			**2.63**
1201922													7.59	4.43					**12.02**
1201940														5.48	0.19				**5.67**
1601788		160.45	17.56	5.28		3.43			58.80	36.38									**281.91**
Permit Area by Sub-watershed	**8.66**	**162.28**	**27.22**	**8.13**	**92.08**	**21.35**	**3.37**	**4.22**	**59.03**	**36.38**	**3.58**	**13.93**	**33.55**	**10.46**	**1.64**	**0.85**	**20.21**	**43.80**	**550.73**

TMDL AMENDMENT DATED APRIL 12, 2011

Amendment to the TMDL document, titled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* (Initially submitted to VADEQ April 2010)

1. INTRODUCTION

In addressing provisions of the Clean Water Act and agreements with the United States Environmental Protection Agency, Virginia's Department of Environmental Quality initiated the TMDL development process for Bull Creek and its tributaries − Left Fork Bull Creek (Convict Hollow), Belcher Branch, Deel Fork, and Cove Hollow in Buchanan County, Virginia. During development of the TMDL, uncertainties and differences of interpretation regarding predictive tools, monitoring data, and field conditions used to allocate pollution loads were identified. Although the TMDL has been submitted as a final draft based on the available data, additional monitoring will be needed and a second phase of TMDL development will be necessary. Therefore, the report is being presented as a "phased" TMDL in accordance with EPA guidance.

This is an amendment to the draft phased TMDL report. The pollutant loads have been calculated as described in Section 2 of this document, and the tables presented here supersede those that are in the draft report. New or modified discharge permits for coal mining operations in the watershed will be issued consistent with the WLAs presented in this amendment.

2. ALLOCATION

Details of changes made to the pollutant loads developed for the report titled, *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia*, are provided here by pollutant. Given the two-year time frame for revising the TMDL, no allocation for "future growth" was included.

2.1 Total Suspended Solids (TSS)

For TSS, the only changes to the TMDL were made to the WLAs. The WLAs for mining were derived in the following manner; NPDES bimonthly monitoring data in the watershed was obtained for each year from 1995 to 2009 for each constructed discharge location. The data utilized consisted of sample date, flow, and concentration for TSS. Each sample record was weighted for the number of days the sample represents and multiplied by the flow and concentration to get the loading in kilograms for that particular sample. Then each record was summed for the year to get an annual waste load. The median of the annual waste loads was then assigned as the mining WLA for the watershed. The median was selected because the data set did not have a normal distribution. The median value is less than the WLA calculated in the draft TMDL, but accurately reflects the current condition in the watershed. Additionally, use of the median is protective of the watershed, as compared to using either the mean or maximum of the data set.

A load for gas and oil permitted discharges was included in the draft TMDL, however there are no discharge permits currently issued for any gas and oil facilities. While gas and oil permits are issued for construction of gas and oil well pumping facilities, these are not discharge permits. . Contributions from gas and oil operations in the watershed are transient, and regulations require that any disturbed acreage during construction and drilling must be stabilized within 30 days. Any contributions from these areas are included in the Load Allocation (LA) of the TMDL. The LA and TMDL were not adjusted. The MOS was adjusted to maintain the original TMDL. The MOS is roughly 10% of the TMDL value.

Table 1 shows the average annual TMDL, which gives the average load of TSS that can be present in the stream in a given year, and still protect aquatic life. Starting in 2007, the USEPA has mandated that TMDL studies include a maximum daily load as well as the average annual load previously shown. The approach to developing a daily maximum load was described in Section 7.1.3 of the original TMDL. To be consistent with the original TMDL development, the WLAs were calculated by dividing the annual WLA by 365 days/year. The maximum daily in-stream loads for the study area are shown in Table 2.

Table 1. Average Annual TMDL TSS allocation (t/yr) in the Bull Creek watershed.

WLA	LA	MOS	TMDL
4.62	2451.20	303.88	2759.70

Permit No.	*WLA*
1101701	*0.40*
1101736	*1.02*
1101903	*0.02*
1101979	*0.54*
1200129	*0.01*
1200281	*0.05*
1200343	*0.05*
1201678	*0.02*
1201922	*0.10*
1201940	*0.05*
1601788	*2.36*

Table 2. Maximum "daily" TSS loads (t/day) in the Bull Creek watershed.

WLA	LA	MOS	TMDL
0.0127	55.28	6.23	61.52

Permit No.	*WLA*
1101701	*0.0011*
1101736	*0.0028*
1101903	*0.0001*
1101979	*0.0015*
1200129	*0.0000*
1200281	*0.0001*
1200343	*0.0001*
1201678	*0.0001*
1201922	*0.0003*
1201940	*0.0001*
1601788	*0.0065*

2.2 Total Dissolved Solids (TDS)

The TDS loads were calculated using the in-stream water quality endpoint determined in the original TMDL report (369 mg/l) in combination with the average annual flows from the watershed and the permitted discharges. The Department of Mines, Minerals and Energy (DMME) provided the average annual flows from the permitted discharges and overall watershed. The flow data used are appropriate because they represented the best available information collected directly from the impaired watershed. There is no continuous gauging station in the stream. Bimonthly monitoring data collected between 1995 and 2009 was used for the flow calculations. Data was summarized for each constructed discharge location, and representative stream flow locations in the watershed. The data utilized consisted of sample date and flow. Average annual flow volumes were calculated based on the monitored flow values and the time frame represented by the sample. These data provided the best available measure of annual flow, representing varied hydrologic conditions within years (seasonal) and among years (longer-term cycles).

The TMDL is the average load delivered at the outlet of the watershed if the TDS concentration is held constant at 369 mg/l. Similarly, the WLA is the average load delivered from permitted discharges at the same concentration level (369 mg/l). The LA was then calculated as the difference between the TMDL and the WLA. Because this water quality endpoint (369 mg/l) was calculated as the 90^{th} percentile of 34 DEQ-monitored TDS samples taken at station 6ADIS001.24, which has an unimpaired benthic community, it incorporates an implicit margin of safety into the TMDL calculation.

As noted above, a TDS end point concentration of 369 mg/l, based on reference stream measurements, and approximately 15 years of instream data from the impaired creek, covering the full range of precipitation events for that period, was utilized. This approach accounts for background pollutants, critical conditions and seasonal conditions because it makes use of monitored flow data, representing flow contributions from the entire watershed, collected over multiple years. The TMDL, based on the desired water quality endpoint (369 mg/l), is composed of loads from background sources, as well as permitted and non-permitted anthropogenic sources. Critical and seasonal conditions are accounted for, because the flow data were collected over multiple years, including all seasons and various flow regimes.

Table 3 shows the average annual TMDL, which gives the average load of TDS that can be present in the stream in a given year, and still protect aquatic life. Starting in 2007, the USEPA has mandated that TMDL studies include a daily load as well as the average annual load previously shown. The approach to developing a daily maximum load was described in

Section 7.1.3 of the original TMDL. A coefficient of variation (COV) of 0.6 was assumed for TDS. To be consistent with the original TMDL development, the WLAs were calculated by dividing the annual WLA by 365 days/year. The maximum daily in-stream loads for the study area are shown in Table 4.

Table 3. Average Annual TMDL TDS allocation (kg/yr) in the Bull Creek watershed.

WLA		LA	MOS	TMDL
117,033		3,040,950	Implicit	3,157,983
Permit No.	*WLA*			
1101701	*16,751*			
1101736	*21,858*			
1101903	*9,668*			
1101979	*6,167*			
1200129	*3,014*			
1200281	*1,209*			
1200343	*1,377*			
1201678	*12,804*			
1201922	*2,820*			
1201940	*2,828*			
1601788	*38,537*			

Table 4. Maximum "daily" TDS loads (kg/day) in the Bull Creek watershed.

WLA		LA	MOS	TMDL
321		34,287	Implicit	34,608
Permit No.	*WLA*			
1101701	*46*			
1101736	*60*			
1101903	*26*			
1101979	*17*			
1200129	*8*			
1200281	*3*			
1200343	*4*			
1201678	*35*			
1201922	*8*			
1201940	*8*			
1601788	*106*			

PUBLIC COMMENTS RECEIVED

Alpha Natural Resources

March 29, 2011

Allen Newman, PE
Department of Environmental Quality,
Southwest Regional Office
355 Deadmore Street
P.O. Box 1688
Abingdon, VA 24212-1688,

Dear Mr. Newman:

We are submitting these comments in response to the TMDL document, entitled *Bull Creek Draft Phased TMDLs for a Benthic Impairment, Buchanan County, Virginia* and its amendments. It is understood that the TMDL is being presented as a final draft based on the available data; although, a second phase of development will be necessary in order to complete an "accurate TMDL" as stated in the amendment document. We have several major concerns about the TMDL and the current amendment; we request that the following comments be addressed before the document is finalized.

1) **Additional Data Needs**: The amendment states that the TMDL is being developed in two phases due to the "uncertainties and differences of interpretation regarding predictive tools, monitoring data, and field conditions used to allocate pollution loads..." We commend the agencies for identifying these deficiencies prior to final submittal; however, due to the uncertainties we feel that it is imperative that wasteload allocations developed using anything less than adequate data not be enforced during the interim period. The protection of water quality during this two year time frame is of the utmost importance and therefore we recommend new permits or expansions compensate with offsets, instead of enforcing the wasteload allocations identified as having uncertainties. This will initiate water quality improvements through BMPs and offsets while additional data is collected.

2) **Reference Watershed**: Total dissolved solids (TDS) were identified as being one of the most probable stressors in the Bull Creek TMDL. TMDL development in Virginia has historically used the reference watershed approach for those parameters that do not have water quality criteria. The Bull Creek TMDL identifies upper Dismal Creek as the appropriate reference watershed; however, lower Dismal Creek was used for TDS. This is an inappropriate choice due to one of the most important aspects of reference watershed selection, size. Lower Dismal Creek is 22,069 ha in comparison to Bull Creek which only consists of 3,129 ha. Lower Dismal is almost seven times the size of Bull Creek which makes it a less than desirable choice for a reference watershed. Burns Creek and Bailey's Trace were both eliminated as potential reference watersheds because of their size incompatibility with Bull Creek; therefore, it would stand to reason that the use of lower Dismal Creek is also inappropriate.

3.) **TDS:** The amendment describes the WLA process as the average load delivered from the permitted discharge at a pollutant concentration of 369 mg/l. This process essentially utilizes 369mg/l as an instantaneous limit for each mining discharge in the watershed. The reference watershed approach was never designed to be used as an

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instantaneous limit. If there is appropriate data, the reference watershed concentration is utilized as an end point to establish a loading at the outlet of the impaired watershed not for each discharge in the watershed. In a recent Virginia Tech study it was shown that TDS demonstrates temporal variability. For this reason alone a reference watershed endpoint cannot be utilized as an instantaneous limit for discharges due to the variability. This temporal variability also increases the need to have adequate data in order to determine a representative endpoint. To accurately create a TDS endpoint from a reference watershed, continuous conductivity data is needed to better understand the fluctuations that occur. This is something that can be better addressed during the phased interim and again justifies the importance of not enforcing waste load allocations until the reference watershed issues can be resolved.

4.) **TSS:** When calculating TSS wasteload allocations the permit limit (70mg/L) should be used instead of the monitored data. This is standard procedure when assigning a WLA to an NPDES discharge for all other industries. Monitored data should only be used for looking at existing loads.

We appreciate the opportunity to comment on the Bull Creek TMDL and hope that the agencies will continue to work collaboratively with industry to ensure a representative and effective TMDL document.

Sincerely,

Shelley D. Williams

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Virginia Mining Issues Group

March 30, 2011

Mr. Allen Newman
Virginia Department of Environmental Quality
Southwest Regional Office
P.O. Box 1688
Abingdon, Virginia 24212

Proposed Modifications to TMDL Reports for
Bull Creek and Pound River

Dear Mr. Newman:

The Virginia Mining Issues Group (VMIG) offers the following comments on DEQ's recent notice "[t]o seek public comment and announce a public meeting on modifications to water quality improvement studies" for Bull Creek and the Pound River. For whatever reason, this notice was not listed as an official public notice on DEQ's website but rather was embedded within an "upcoming public meeting" announcement. We also note that nothing else on DEQ's website made clear that any action had occurred on the TMDLs since the "final public comment periods" ended in February and March 2010, respectively. In short, we question whether the public received proper notice that new modifications were being contemplated or were released for public review.

As you know, VMIG is an *ad hoc* unincorporated association of mining stakeholders located throughout Virginia's coalfields. Our goal is to promote resource protection and water quality restoration through regulatory proceedings that are driven by sound science, as well as cost-effective and practical decision-making.

VMIG has been active in these TMDL proceedings since their inception in 2008. We submitted an initial round of written comments in October 2008, and a second round of written comments in February 2010. We received DEQ's responses to our comments by letter dated April 9, 2010. Between then and now, we have received no further notice or information to bear out the revisions that DEQ committed to make in its responses to our comments, or in parallel meetings between VMIG and DMLR.

The modified TMDL reports that have been posted for public review appear to be unchanged from the versions posted for public review in 2010, with the exception of a 4-page "Amendment" tacked on to the end of each report. The Amendments have the effect of dramatically lowering the wasteload allocations (WLAs) assigned to mining dischargers for both TSS and TDS. For example, in Bull Creek, the TSS WLAs went from 32.5 tons/year to 4.62 tons/year, and the TDS WLAs went from 1,708,803 kg/year to 117,033 kg/year.

To promote meaningful public engagement in these vitally important proceedings, VMIG requested that DEQ make available the full record for the Amendments, including (1) a summary of the proposed changes, (2) the reason for these changes, and (3) the supporting technical record. We also requested a 30-day extension of the comment period. However, all of our requests were denied.

We believe that TMDLs can serve as vital planning tools to help restore impaired waters. But for this to occur, TMDLs must be based on a solid technical foundation, and must be articulated in a way that provides fair notice of regulatory expectations. We respectfully submit that the proposed modifications to the TMDL reports for Bull Creek and the Pound River are infirm in both respects.

1. The Amendments are Fundamentally Inconsistent with a Phased Approach

In developing these TMDLs, DEQ adopted a "phased" approach due to concerns regarding the sufficiency of the available data. Under this phased approach, DEQ committed to conduct additional monitoring and modeling, and thereafter to establish revised TMDLs.

The Amendments present a level of precision and certainty that cannot be supported by the underlying data, models or phased approach. In fact, the Amendments rely on an entirely different set of data and calculations than the original TMDLs.

VMIG generally supports the concept of phased TMDLs to achieve progress in the face of uncertainty. However, we believe that there must be some minimum threshold for data and information, below which there is simply not enough confidence in the regulatory outcome to proceed. In the present TMDL proceedings, DEQ has not made any of its data or calculations available for public review. As a result, interested stakeholders like VMIG cannot independently verify whether DEQ has met the minimum threshold to move forward with the TMDLs. We respectfully submit that DEQ cannot proceed until it has made those data and calculations available.

The Amendments also present individual WLAs for individual point sources, taking the TMDLs to a level of detail beyond any of Virginia's existing coalfield TMDLs. DEQ suggests that these individual WLAs will not be adopted into the WQMP regulation (9 VAC 25-720) or applied directly into NPDES permits. If these are DEQ's "assumptions and requirements," then we urge DEQ to make them explicit in the Amendments themselves. We have recently seen EPA take issue with the assumptions and requirements of earlier TMDLs (characterizing them as implementation components rather than enforceable aspects of the WLAs), and we are concerned that DEQ's failure to be explicit will lead to confusion and conflict in the NPDES permitting process. DEQ can help to avert such confusion and conflict by adding the following language to the Amendments:

> The assumptions and requirements of these individual WLAs are as follows. Existing permitted mining sources will be required to monitor their discharges for TSS and/or TDS (as the case may be in the different impaired segments). However, wasteload allocations for these parameters will not be adopted into the Water Quality Management Planning Regulation or incorporated into individual mining permits.
>
> New mining sources seeking permits after the first phase TMDL is established and approved will be required to monitor their discharges for TSS and/or TDS (as the case may be in the different impaired segments) and offset any additional loading caused by their dischargers.
>
> As part of the second phase TMDL, DMLR will validate or amend, based on all available data and information, its original assumptions about the most probable stressor(s), the water quality target(s) and the modeling output(s). Thereafter, if specified and approved under the second phase TMDL, DMLR may seek to establish individualized wasteload allocations, adopt them into the Water Quality Management Planning Regulation, and then incorporate them into individual mining permits.

2. The Daily Loads were not Calculated Properly

The Amendments present "daily loads" that were calculated by dividing the annual WLAs by 365 days/year. This is flatly inconsistent with applicable EPA guidance.

Congress directed states to establish "total maximum daily loads" but in the thousands of pages of legislative history associated with the Clean Water Act, Congress never explained what it meant by this phrase. For over twenty years, EPA interpreted it to authorize total maximum *non-daily* loads whenever appropriate to implement the applicable water quality standards. EPA's interpretation survived court challenges in 2000 and 2001, and is reflected in many of the tens of thousands of TMDLs in effect today. However, in 2006, a federal appellate court invalidated EPA's interpretation. According to the court, "'daily' means 'daily' and nothing else." Friends of the Earth, Inc. v. EPA, 446 F.3d 140 (D.C. Cir. 2006). In reaching this conclusion, the court rejected EPA's claim that *non-daily* loads may best correlate to the attainment of water quality objectives. According to the court, "all waterbodies can achieve water quality standards if their TMDLs are set low enough -- if all else fails, they can be set to zero -- and the two requirements therefore never conflict with each other."

EPA elected not to seek review of the court's decision and, instead, issued a new national policy styled *Establishing TMDL "Daily" Loads in Light of the Decision by the U.S. Court of Appeals for the D.C. Circuit in Friends of the Earth, Inc. v. EPA et al., No. 05-5015 (April 25, 2006) and Implications for NPDES Permits* (November 15, 2006). In this policy, EPA directs states to express all TMDLs in terms of daily time increments. EPA also offers states an opportunity to "include alternative, non-daily pollutant load expressions in order to facilitate implementation of the applicable water quality standards." In other words, TMDLs *must* include daily loads and *may* include alternate non-daily loads.

After establishing the new policy, EPA issued a series of technical guidance documents on deriving appropriate daily loads, including (1) *Options for the Expression of Daily Loads in TMDLs* (June 2007), and (2) *An Approach for Using Load Duration Curves in the Development of TMDLs* (August 2007). These guidance documents explain different techniques that states may use, including the statistical approach from EPA's Technical Support Document for Water Quality-Based Toxics Control (1991), and a flow variable approach using EPA's load duration curve.

Simply dividing by 365 is not one of these techniques, and in fact was specifically rejected by EPA as unacceptable. As a result, DEQ must revise the daily loads using one of the techniques authorized by EPA. DEQ should also make clear that the daily expression will not be used for permitting purposes but instead will only be used to inform post-TMDL monitoring and tracking.

3. <u>DEQ Needs to Specify Offset Ratios and Options</u>

The TMDLs provide a mechanism for offsets, allowing new mining sources to reclaim existing AML features to, in effect, offset the additional loading from their discharges. We strongly support the use of offsets, which are authorized under both federal and state law. However, we urge DEQ to specify the minimum ratios for allowable offsets. Currently, the TMDL reports simply provide for "positive ratios." This is inadequate to inform affected sources of their obligations/opportunities, and it creates a risk of subjective agency review of offset proposals. Based on our experience, offset ratios of between 1:1 and 2:1 may be appropriate to account for local watershed conditions. Offset ratios above 2:1 appear to be excessive.

We also urge DEQ to acknowledge that reclaiming AML features is simply one (*i.e.*, not the only) offset option. Mine reclamation alone will not be sustainable as the only method to conduct offsets as a mine progresses; therefore, alternate methods will be necessary. Sources should have the freedom to identify and demonstrate load reductions through a variety of means, including, for example, preventive and maintenance activities related to sediment control and other activities based on local watershed conditions and opportunities. In some settings, reductions from other point or nonpoint source contributors may be more feasible, cost-effective and/or environmentally-advantageous than reductions from AML. DEQ has no legal, practical or technical basis to preclude such other options.

4. <u>DEQ's Stressor Analysis is Incomplete</u>

In a welcome departure from past practice, DEQ considered at least one non-pollutant stressor (i.e., hydrologic modification) in its benthic stressor analysis and, in fact, concluded that this stressor was a primary cause of impairment in one of the contributing creeks. However, DEQ failed to consider any other non-pollutant stressors, and also failed to account for hydrologic modification, once identified, in any meaningful way. Instead, DEQ simply concluded that "since 'hydrologic modification' is not classified as a 'pollutant' by USEPA in the Clean Water regulations, a TMDL will not be developed for this stressor." DEQ's conclusion completely misses the mark.

Existing federal guidance compels states to <u>fully</u> <u>assess</u> the condition of their waters. Only then can a state make an informed decision about whether to embark on a TMDL, or alternatively, pursue some other type of control strategy.

DEQ seems to think that it is limited by Section 303(d) of the Clean Water Act, which compels states to establish TMDLs for <u>pollutants</u> causing impairment. But the statute goes on to say that states must establish TMDLs "at a level necessary to implement the applicable water quality standards." If a state cannot meet this standard because non-pollutant stressors are not only dominant, but the primary cause, then no amount of attention on pollutants will meet the statutory mandate. Attainment of TMDL expectations needs to be practicable and achievable.

For the TMDL process to be effective, DEQ must start with a stressor analysis that considers <u>all</u> contributors to the impairment, whether pollutant or non-pollutant. If the dominant stressors are pollutants, then the TMDL process should continue. On the other hand, if the dominant stressors are non-pollutants, then the TMDL will be ineffectual at attaining standards. In this scenario, some other type of control strategy (e.g., a use attainability analysis) must be pursued.

We have repeatedly made this point, and DEQ has repeatedly ignored it. Recently, EPA authored a report about one of the creeks subject to one of DEQ's existing TMDLs. "*Evaluating Appropriate Existing and Designated Uses of Straight Creek (Lee County, VA) Using Current Macroinvertebrate, Habitat and Water Quality Data*" by Margaret Passmore and Gregory Pond (2009). In that report, EPA admitted that non-pollutant stressors, like habitat modification, may be causing the impairment. If this is true, then it makes absolutely no sense to ignore such stressors until after a TMDL is in place and pollutant reductions are imposed on regulated sources. Inaccurately or incompletely identifying stressors in this manner will result in either wasted resources caused by chasing a problem that does not exist, or unacceptable environmental consequences caused by ignoring a problem that in fact does exist. Either way, DEQ's practice of ignoring non-pollutant stressors cannot stand.

5. <u>DEQ's Interpretation of the General Standard in the TMDLs is Unlawful</u>

DEQ purports to use a reference approach to interpret the applicable water quality standards and derive water quality targets for TSS and TDS in the TMDLs. But doing so is a *de facto* change in standards subject to Section 303(c) of the Clean Water Act. The statute provides a mandatory process for the review and revision of water quality standards by states and, where necessary, EPA.

In this case, neither Virginia nor EPA established numeric criteria or a numeric translator procedure for the general standard at issue in the TMDLs, or for the particular pollutant parameters identified for reduction (TSS and TDS). Such criteria or procedures are clearly needed for the TMDL process to be effective, but DEQ cannot simply adopt them in an *ad hoc* manner. Rather, DEQ's only recourse is to initiate a rulemaking under Section 303(c). By avoiding this mandatory process, DEQ has in effect denied interested stakeholders any meaningful opportunity to review or contest DEQ's decision. DEQ has also undermined its own ability to demonstrate (as it must) that the TMDLs are "necessary" to implement the applicable standards (as compared to "more than necessary" or "less than necessary" based on inherent differences between the reference and target creeks).

The reference approach is simply too imprecise, and too subjective, to meet DEQ's core statutory obligations. To underscore this point, we note that the creek selected as a reference for TDS in Bull Creek was seven times larger (Lower Dismal Creek 22,069 ha; Bull Creek 3,129 ha), a differential that was not adjusted or addressed in any meaningful way. Moreover, both Burns Creek and Bailey's Trace were eliminated as possible reference watersheds due to their size. How can these decisions be squared as anything other than imprecise and subjective?[1]

6. <u>Modeling Issues Need to be Addressed</u>

DEQ admits that model refinements will be needed before embarking on the second phase TMDLs. However, even the first phase TMDLs demand more. At a minimum, DEQ needs to provide: (1) a quality assurance plan; (2) a written statement of modeling objectives that includes the variables of concern, the stressors driving the variables, appropriate temporal and spatial scales, and the necessary degree of model accuracy and precision; (3) data quality objectives and a statement of the acceptable range of uncertainty; (4) calibration reports; and (5) sensitivity and uncertainty analyses. *See, e.g.*, EPA Guidance on the Development, Evaluation and Application of Environmental Models (March 2009).

We are concerned that defects in the existing modeling analyses may overstate the impacts from some land uses and understate the impacts from other land uses. For example, the run-off curve numbers used for disturbed forests in the models appear to be grossly inaccurate. These types of inaccuracies undermine the TMDL calculations, the allocations to different sources, and DEQ's expectations regarding reductions and reasonable assurance.

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[1] We note, as well, that the Amendments would apply DEQ's *ad hoc* in-stream TDS target as an instantaneous limit. However, the reference watershed approach was never designed to be used in this manner. Rather, if there are appropriate and sufficient data, then the reference concentration is supposed to be used to derive a target loading at the outlet of the impaired water -- not at each point source discharge. Moreover, in a recent Virginia Tech study, it was shown that TDS demonstrates significant temporal variability, which cuts against using any kind of instantaneous limit.

We submit that it would be premature for DEQ to proceed with even the first phase TMDLs until these modeling issues are addressed.

7. The TMDL Amendments Must be Submitted to the State Water Control Board

These particular TMDLs were scheduled to be established by May 1, 2010, in accordance with the Consent Decree and Settlement Agreement in American Canoe Association v. EPA, June 11, 1999. In an effort to meet this schedule, DEQ bypassed Board review and submitted the TMDLs directly to EPA for approval. EPA has not officially acted on this submittal. Instead, we understand that the Agency offered informal comments that prompted the Amendments at issue now. Those comments have not been made available for public review.

We have grave concerns that the process employed here deprives interested stakeholders of their rights before the State Water Control Board. From time to time in the past, DEQ has attempted to bypass Board review in the face of objection from interested stakeholders. In each case, the Board has provided stern and unequivocal instruction to DEQ never to do so again. The reason for this instruction is simple:

> For the public process to be meaningful, the Board must have an opportunity to review and approve TMDLs before they are submitted to EPA. Following such review and approval, affected members of the regulated community -- including dischargers regulated under Va. Code § 62.1-44.16 -- must be afforded an opportunity for a hearing under Va. Code § 62.1-44.25. Absent that opportunity, DEQ could inadvertently bypass the public, administrative and judicial review processes by developing and submitting a TMDL to EPA without formal Board approval and, later, adopting the EPA-approved TMDL under a claimed exemption in the State Administrative Process Act.

We urge DEQ to take the Board's instruction to heart and submit the TMDL Amendments first to the Board, then to EPA.

We respectfully request specific responses to the specific concerns raised in this letter before DEQ moves forward with these TMDL proceedings. Needless to say, we would be pleased to meet with you to discuss our comments in more detail, or to provide any additional information that may facilitate your efforts to derive a legally defensible and appropriate TMDLs.

Please feel free to contact me (bsmith@hunton.com / 804-787-8086) with questions.

Sincerely,

Brooks M. Smith
Common Counsel

cc: Members of the Virginia Mining Issues Group
Mr. Joey O'Quinn, DMLR

From: Yagow, Gene [eyagow@exchange.vt.edu]
Sent: Friday, March 04, 2011 2:55 PM
To: O'Quinn, Joey (DMME)
Cc: Newman, Allen (DEQ); Smith, Michael F. (DMME); Benham, Brian; Kline, Karen
Subject: Comments on the February 2011 Amendments to the Bull Creek and NF/SF Pound River TMDLs

Joey,

After reviewing the amendments, I have the following comments on the amendment that I hope you will use to strengthen your submission to EPA.

Different procedures were used for the derivation of the TSS and the TDS TMDLs. I think that the justification to EPA may be stronger if the same procedure is used for both. That being said, I have suggestions for alternative calculations for each.

- The current calculation for TSS is really a calculation of the “existing” load, which may differ considerably from some protective long-term average load (the TMDL). I also think that using the “existing” load is inequitable to the mining permit holders as it penalizes those that are doing a good job by assigning them a lower WLA and gives a relatively more generous WLA to those that are not controlling their sediment. I would suggest applying the historical flow time-series to the average daily permitted TSS concentration (35 mg/L), in order to be protective of the maximum daily permitted TSS concentration of 70 mg/L (never to be exceeded). Also be aware that if you use the current calculations, using an “average”, rather than a “maximum”, annual load based on the historical time-series means that 50% of the time, the permittees will be exceeding their WLAs due to annual weather variations.
- The TDS TMDL calculated by your procedure results in a considerably larger value than in the simulated TMDL which considered 369 mg/L as a “maximum” value, never to be exceeded, rather than an average value, as in your calculations. I would therefore recommend using the same historical flow time-series and apply it to some average TDS concentration, which would then be assumed to be protective of the identified maximum allowable TDS concentration (369 mg/L) for calculating the surface runoff contribution to the respective WLAs. The average TDS concentration could be arrived at from the average in the simulated time series (which for Scenario 9 was 188 mg/L) or assumed to be half of the maximum (184.5 mg/L), similar to the ratio of the average daily and maximum TSS values. I would then recommend applying this average daily TDS concentration, to the historical flow time-series at the watershed outlet and applying the individual permit outfall flow time-series to the average concentration for the individual WLAs. (This is a similar procedure to what I think you used, except for using an average daily, rather than a maximum daily, TDS concentration).

Why was a coefficient of variation (COV) “assumed”, rather than “calculated”, according to EPA guidance? It is not clear how the daily values were calculated from the annual values. How was the COV used in this process? If the EPA guidance was used to interpolate a multiplication factor, that should be clearly stated and the guidance cited to strengthen the justification.

Were the responses to the questions from EPA on June 23, 2010 also incorporated into the revised report? I can't locate the exact emails where I sent my responses back to you, but I know it was during the week following your June 23, 2010 email. I had incorporated all of the responses into a June 28, 2010 revision to the Draft reports for both Bull Creek and NF/SF Pound, but I couldn't find any record of having transmitted those revisions to you. I have put them both at the following ftp site, in case you want to incorporate those revisions that would not have been affected by your proposed amendments:

ftp://bsesrv214.bse.vt.edu/Yagow/BullCreek/BLC-BenthicTMDLReport_062810.doc
and
ftp://bsesrv214.bse.vt.edu/Yagow/PoundRiver/NFSF_Pound_BenthicTMDLReport_062810.doc

The calculations for the TDS TMDL imply that mining areas only contribute TDS via surface runoff, whereas TDS in groundwater is clearly impacted by mining activities. While I realize the difficulty this may present in calculating a load from each permit, if this source is not acknowledged, there is no way that needed TDS reductions can ever be addressed. It is a dilemma. By recognizing groundwater as a mining source, it means that the WLA for each permit would be increased by the portion of load attributed to groundwater and that some mechanism must be developed to quantify this contribution. By ignoring this source, the WLAs will be a much smaller load (and therefore, a smaller target), but their existing loads will also be tremendously underestimated, in my opinion, so that control measures needed to reduce groundwater contributions won't even be considered.

I hope these comments will be useful in the processing of your amended submittal to EPA.

…Gene

Gene Yagow
Senior Research Scientist
Biological Systems Engineering Dept.
Virginia Tech
306 Seitz Hall (0303)
Blacksburg, VA 24061
Phone: 540-231-2538
FAX: 540-231-3199

RESPONSE LETTERS TO PUBLIC COMMENTS

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
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L. Preston Bryant, Jr.
Secretary of Natural Resources

David K. Paylor
Director

Dallas R. Sizemore
Regional Director

April 11, 2011

Dr. Gene Yagow
Virginia Tech
306 Seitz Hall
Blacksburg, VA 24061

Dr. Yagow:

Thank you very much for your comments regarding the addendums to the Draft North Fork/South Fork Pound River and Bull Creek Phased Total Maximum Daily Load (TMDL) Reports. Your comments have been reviewed and are being considered.

As you are aware, Virginia's Departments of Environmental Quality (VADEQ), Mines, Minerals, and Energy (VADMME), and Conservation and Recreation (VADCR) prepared and submitted four phased coalfield TMDL reports to EPA Region III during April 2010. The VADMME is the agency that has led the technical development of the phased portion of the TMDLs since they are the agency that regulates coal mining in Virginia. EPA has approved two of the four reports (Levisa Fork River and Powell River) and is finishing their review of the final two (Bull Creek and NF/SF Pound River). EPA's review has a May 1, 2011 deadline. Once all four phased reports are approved by EPA, then VADEQ, VADMME, and VADCR will begin the second phase of TMDL development. During the second phase, planned for a two year period following EPA approval, stakeholders will have opportunity to actively participate with the state agencies in the collection of supplemental data and the preparation of the anticipated second phase revisions to the initial TMDL reports. In fact, we are proposing to schedule the public participation early in the process. During this public participation we propose to discuss the TMDL development and seek input from stakeholders on the TMDL development plans, including additional monitoring needed to develop the TMDL. We are proposing to consider all stakeholder comments during the phased TMDL process.

To ensure that your comments, as well as those of other stakeholders, are considered and addressed, the comments will be attached to the first phase report addendum(s) and the following language will be included in the preface of the report(s); *Written public comments received on the addendum to the report are attached and will be considered and addressed during the second phase of TMDL development.*

We are looking forward to working with you on these phased TMDLs.

Sincerely,

Allen Newman, PE
Water Permit Manager

cc: Mr. Joey O'Quinn

COMMONWEALTH of VIRGINIA

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L. Preston Bryant, Jr.
Secretary of Natural Resources

David K. Paylor
Director

Dallas R. Sizemore
Regional Director

April 11, 2011

Mr. Brooks Smith
Riverfront Plaza, East Tower
951 East Byrd Street
Richmond, Virginia 23219-4074

Dear Mr. Smith:

Thank you very much for your comments regarding the addendums to the Draft North Fork/South Fork Pound River and Bull Creek Phased Total Maximum Daily Load (TMDL) Reports. Your comments have been reviewed and are being considered.

As you are aware, Virginia's Departments of Environmental Quality (VADEQ), Mines, Minerals, and Energy (VADMME), and Conservation and Recreation (VADCR) prepared and submitted four phased coalfield TMDL reports to EPA Region III during April 2010. The VADMME is the agency that has led the technical development of the phased portion of the TMDLs since they are the agency that regulates coal mining in Virginia. EPA has approved two of the four reports (Levisa Fork River and Powell River) and is finishing their review of the final two (Bull Creek and NF/SF Pound River). EPA's review has a May 1, 2011 deadline. The Public Participation Guidance allows DEQ to submit to EPA prior to Board action if timing to meet EPA deadlines is an issue. DEQ will make an effort to inform the Board of this action and all public comments received will be included as part of the EPA submittal package. Once all four phased reports are approved by EPA, then VADEQ, VADMME, and VADCR will begin the second phase of TMDL development. During the second phase, planned for a two year period following EPA approval, stakeholders will have opportunity to actively participate with the state agencies in the collection of supplemental data and the preparation of the anticipated second phase revisions to the initial TMDL reports. In fact, we are proposing to schedule the public participation early in the process. During this public participation we propose to discuss the TMDL development and seek input from stakeholders on the TMDL development plans, including additional monitoring needed to develop the TMDL. We are proposing to consider all stakeholder comments during the phased TMDL process. Individual permit WLAs developed in the Bull and Pound TMDL reports are not inconsistent with past mining TMDL development. DEQ's approach to Board approval and adoption of the WLAs into the Water Quality

Management Planning Regulation, for phased TMDLs and those that are known to contain significant data gaps that may drive modification or amendment, is to defer Board action until the revisions are more certain. EPA has historically approved Virginia TMDLs utilizing this method of daily load calculation.

To ensure that your comments, as well as those of other stakeholders, are considered and addressed, the comments will be attached to the first phase report addendum(s) and the following language will be included in the preface of the report(s); *Written public comments received on the addendum to the report are attached and will be considered and addressed during the second phase of TMDL development.*

We are looking forward to working with the Virginia Mining Issues Group in the development of these phased TMDLs.

Sincerely,

Allen Newman, PE
Water Permit Manager

cc: Mr. Joey O'Quinn, DMME

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April 11, 2011

Ms. Shelley Williams
Alpha Natural Resources, LLC
One Alpha Place
Post Office Box 2345
Abingdon, Virginia 24212

Dear Ms. Williams:

Thank you very much for your comments regarding the addendum to the Draft Bull Creek Phased Total Maximum Daily Load (TMDL) Report. Your comments have been reviewed and are being considered.

As you are aware, Virginia's Departments of Environmental Quality (VADEQ), Mines, Minerals, and Energy (VADMME), and Conservation and Recreation (VADCR) prepared and submitted four phased coalfield TMDL reports to EPA Region III during April 2010. The VADMME is the agency that has led the technical development of the phased portion of the TMDLs since they are the agency that regulates coal mining in Virginia. EPA has approved two of the four reports (Levisa Fork River and Powell River) and is finishing their review of the final two (Bull Creek and NF/SF Pound River). EPA's review has a May 1, 2011 deadline. Once all four phased reports are approved by EPA, then VADEQ, VADMME, and VADCR will begin the second phase of TMDL development. During the second phase, planned for a two year period following EPA approval, stakeholders will have opportunity to actively participate with the state agencies in the collection of supplemental data and the preparation of the anticipated second phase revisions to the initial TMDL reports. In fact, we are proposing to schedule the public participation early in the process. During this public participation we propose to discuss the TMDL development and seek input from stakeholders on the TMDL development plans, including additional monitoring needed to develop the TMDL. We are proposing to consider all stakeholder comments during the phased TMDL process.

To ensure that your comments, as well as those of other stakeholders, are considered and addressed, the comments will be attached to the first phase report addendum(s) and the following language will be included in the preface of the report(s); *Written public comments received on* *the addendum to the report are attached and will be considered and addressed during the second phase of TMDL development.*

We look forward to working with you on the phased TMDLs.

Sincerely,

Allen Newman, PE
Water Permit Manager

cc : Mr. Joey O'Quinn, DMME