Disclaimer

The Draft Powell River TMDL Report included TMDL results for both Straight Creek and Callahan Creek. A major change between the draft Powell River TMDL Report and the Revised Straight Creek TMDL Report and Revised Callahan Creek TMDL Report is that the two TMDL studies are now separate documents. The division into two separate revised reports results in fewer chapters and fewer pages in each document. Consequently, revised sections do not correspond on a page to page, chapter to chapter or table to table manner with the Draft Powell River TMDL Report. To review the changes in each document, refer to the "Summary Comments on the draft Powell River TMDL Report". This document lists the locations in the Draft Powell River TMDL Report that were revised and the titles of the revised sections and tables in the new reports. Please refer to the chapter or section titles and table names rather than chapter numbers or table numbers described in the "Summary Comments on the Draft Powell River TMDL Report" document to identify and review changes in the Revised Straight Creek TMDL Report and the Revised Callahan Creek TMDL Report, (e.g. Originally, Chapter 10 "Modeling Procedure: Linking the Sources to the Endpoint" was the location for the following revised Tables named “GWLF parameters for existing conditions in the impaired and reference watersheds”, “GWLF parameters by land use for existing conditions in the impaired and reference watersheds”, “Land use areas for the impaired, reference and area-adjusted reference watersheds” and “Existing sediment loads for the impaired and reference watersheds.” These tables are in chapter 9 of the Revised Straight Creek TMDL Report.)

Comment Document #1

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April 12, 2005

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RE: TMDL Development for the Powell River Basin
Draft TMDL

Dear Joey:

Thank you for the opportunity to comment on the draft "Fecal Bacteria and General Standard Total Maximum Daily Load Development for the Powell River Basin", in particular, the sections relating to Straight Creek. As you are well aware, public participation in the formulation of a TMDL, and any subsequent Implementation Plan (IP), is essential to the development of a realistic and workable plan. In light of this, I hope the following comments are of value in the development of the Powell River Basin TMDL. In order to facilitate your review of these comments, the applicable page number from the draft TMDL is being included with the comment.

1. General comment: The Contractor for the Agencies combined the draft TMDL for both Callahan Creek and Straight Creek into a single document. Though many of the same issues exist in both streams, providing separate documents would facilitate the review and comment by various interested parties. In its current form, the document is very cumbersome, both physically and figuratively.

2. Page xxxvii (Executive Summary): As stated in the draft TMDL, *"Hydrology validation was not performed for either Callahan Creek or Straight Creek due to lack of data. It was determined that using all available data for calibration would result in a more accurate model."* Validation of any model is critical through ground-truthing, whenever possible, in order for a model to be accepted. The statement contained in the draft is self-contradictory, as in the first part mentions a lack of data, while the second says that using all available data would result in a more accurate model. Furthermore, the USGS gaging station used for calibration (page xxxvi) is

located near Jonesville, and measures from for a drainage area of 319 mi^2. Considering that Straight Creek is located several miles upstream of the gaging station, with numerous large subwatersheds influencing this station, it is unreasonable to assume that even semi-accurate flow response due to precipitation in Straight Creek can be back calculated. It is a fact that rainfall does not fall evenly over a 319 mi^2 drainage area.

3. Page xxxvii: Middle Creek has been chosen as the reference stream for Callahan and Straight Creeks. As commented upon for the draft Russell Prater TMDL, page 3-37 of that document qualifies a reference stream as being non-impaired with similar attributes, land use, soils, stream characteristics and in the same ecoregion. The choice of Middle Creek is lacking in several respects, some of with include: stream order; bed slope; area; and land use distribution.

   DEQ's response to this comment for the Russell Prater TMDL was: "*Ideally, a reference watershed would be the "twin" watershed to that being studied, however, we do not have such an unimpaired stream. The stream characteristics that you list are taken into account in the stream model. Middle Creek is the best reference watershed available.*

   As it appears that Middle Creek will be used as a reference stream, though it does not fit the parameters identified by the Contractor, please provide the methodology (if other that two dimensional proportional relationships) used to account for the variances.

   Furthermore, the current draft TMDL specifies a TDS limitation of 334 mg/L. This is very striking, since there are numerous references to the McClure River, which DEQ assumes is not impaired, and the 90th percentile TDS value for the McClure is 525 mg/L. Again, assuming that the data has been used correctly, why would a standard of 334 mg/l be applied to Callahan and Straight Creeks, which is more strict than EPA's secondary drinking water standard of 500 mg/L?

4. Page xl: This page lists reductions necessary to meet the water quality limitations for fecal concentrations. One only has to refer to the map shown on page 2-12 to note that the fecal monitoring station from which the source tracing was conducted excludes the Stone Creek and Puckett Creek watersheds. Along the excluded creeks, there is no public sewage service, whereas, approximately 135 residences and businesses are served along Straight Creek. This failure to include significant portions of the watershed invalidates the "source tracking" for fecal bacteria.

5. Page xlii: The statement "*no written comments were received*" is premature, especially in light of the numerous conversations held between DEQ/DMME and the Straight Creek Stakeholders Group.

6. Page 2-2: The statement *"If the waterbody exceeded either criterion more than 10% of the time, the waterbody was classified as impaired…"* implies that all excedences are equal, with an excedence of 1 unit is no different than an excedence of 1,000 units.

7. Page 4-2: USGS station 03530500 is listed as the gauging station from which the Straight Creek HSPF model was calibrated. This station was discontinued in September 1995. Considering this, the model has not been calibrated to reflect current conditions in the watershed, especially considering the near drought conditions that existed for several years, and then the extraordinary rainfalls of 2003 and 2004. During 2003 and 2004, the measured rainfall at the LMPI rain gage indicated 2 and 1.5 times the normal annual rainfall respectively.

8. Chapter 6: References to the Virginia Stream Condition Index (VASCI) should be removed, as the VASCI remains in review status. Continued inclusion of these references would give the appearance of validation of the VASCI. Furthermore, the document "*A Stream Condition Index for Virginia Non-Coastal Streams, 9/2003*" clearly specifies that the Central Appalachian ecoregion is an exception, and that further study is required prior to implementation of the VASCI to this ecoregion. Also stated is "*The index does not apply to stream classes or types not sampled in the database, in particular, limestone springs and high-order rivers*." It should be noted that the North Fork of the Powell River passes through two distinct geologic regions (periods), with the lower portion of the creek passing through limestone predominant strata.

9. Page 6-20: The report indicates the another contractor for DEQ (ECI) found no marginal scores for habitat at Station SA, and the reason given is the "*This could indicate some improvement in conditions in this portion of the stream since 1999, but the two sites are at different locations and it is possible that the ECI site had better habitat."* Due to the significantly different scores between Stations SA and 6BSRA003.62, wouldn't it have been prudent to re-score both stations at comparable times, or to re-evaluate the appropriateness of station 6BSRA003.62 as a habitat survey station.

10. Page 7-32: Merricks, 2003, is cited as a reference relating high conductivity values to poor benthic health. The poor benthic health was not significantly correlated to high conductivity in all data sets (1 of 3 sets). In the one set where the correlation was strong, conductivity never exceed the 90th percentile of the McClure River (800), which is assumed to be non-impaired. The discussion portion of the Merricks thesis does describe benthic community changes in the streams below hollow (valley) fills, with the more tolerant species being found. But Merricks also states that the less tolerant species are found below the settling ponds associated with the hollow fills. He further indicates that poor habitat below the fills may contribute to the community

shifts, as well as the energy available to the less tolerant species found downstream of the settling ponds. Furthermore, this is a student's Masters of Science thesis, and has not been subjected to adequate peer review to be used as support for a document of the importance of a TMDL.

Also, various States have established TDS limitations ranging from a low of 1100mg/L to more than 1500 mg/L, though DEQ is inclined to ignore the requirements of the various states.

11. Page 8-33: Organic matter is considered as a "possible stressor", though the Agency's analysis indicated that organic matter is excessive, as compared to the reference of the McClure River (5.74 as compared to 3.81). Voshell (2000) is correctly cited, and organic matter should be moved into the "probable stressor" category. We are in agreement that reduction of the organics in the Straight Creek watershed will reduce the stress on the benthic community.

12. Page 8-37: The report states "*TDS is a measure of the actual concentration of the dissolved ions, dissolved metals, minerals, and organic matter in water. Dissolved ions can include sulfate, calcium carbonate, chloride, etc. Therefore, even though they are two different measurements, there is a direct correlation between conductivity and TDS*." A correlation can be made between conductivity and TDS in a given watershed, but as a general statement, such as when comparing two watersheds, the specific components comprising the TDS must be known in order for a correlation to be established. Geology, land use activities, and disturbance activities contribute to TDS, and the conductance values of the constituent ions varies.

    An example of this is shown within the draft TMDL. For Straight Creek, a limitation of 334 mg/L is considered to be acceptable, based on the choice of Middle Creek as a reference stream. Yet, in this same document, the McClure River is cited as being non-impaired, yet the 90th percentile value for TDS is 525 mg/L, or approximately 157% of the proposed limitation. Simply citing TDS as an impairing factor without providing supporting evidence is very unsound.

13. Page 9-1: The statement "*Middle Creek watershed is a good choice as the reference watershed, as information that is needed to select numeric endpoints is readily available from water quality monitoring performed by DMME*." Ignores the fact that Middle Creek differs in area, slope, and the distribution of land uses. To clarify this point, the non-impaired stream (reference stream) should be similar in stream order, corridor, slope and the area is to be not less than one-half the subject stream. Middle Creek is largely un-inhabited, with dwellings clustered near the stream confluence. Straight and Callahan Creeks are populated, and impacted for nearly their entire lengths. Lying between the homes and the creek is a heavily traveled public road. Located within much of Straight Creek is a public sewer main, which is

repeatedly disturbed for repairs. The choice of Middle Creek is very questionable.

14. Page 10-9: "*For TMDL development, the total area for the Middle Creek reference watershed was equated with the area of Callahan Creek and Straight Creek watersheds. To accomplish this, the area of landuse categories in reference watershed, Middle Creek, was proportionately increased based on the percentage landuse distribution."* Using a proportioning based upon percentage of land use ignores the location of the land uses as described in (13), above. The effect of large forested areas is mitigated by the fact that the forestlands are upslope, while the human influences (housing, roads, railroads, etc.) intercept and contaminate much of the overland flow from the forested areas prior to the flow entering the streams.

15. Page 10-31: It would appear that the GWLF model for Middle Creek was calibrated with data output from the HSPF model. Considering that the data from the gauging station used to calibrate the HSPF model was obtained by "back calculating" the gage data, does the GWLF model retain any validity? Again, we appear to be modeling from a model.

16. Page 10-37: The runoff curve numbers (RCN) listed for the different land uses vary significantly form those published by the SCS as commonly used for flow generation by the TR-55 method. Some examples from the Straight Creek values are as follows:

Land use	RCN (TMDL)	RCN (SCS)	Condition
Barren	67.996	82, 87	Disturbed (bare)[1]
Forest–Disturbed	66.309	66, 77	Poor[1]
Forest	66.309	55, 70	Good[1]
Pasture	67.967	61, 74	Good[1]
Pasture	67.967	79, 86	Poor[1]
Pasture	67.967	69, 79	Fair[1]
Pasture	67.967	59, 75	Fair, Contoured[1]
Residential-Prev	76	70, 80	½ Acre Lot[1]
Wetlands[1]	67.86	85	
Water[1]	36	100	
Permitted Bench	63.188	69	Subsurface Disturbed[2]
Spoils/Tailings	63.188	86	Bare/Graded[2]
Permitted Mining	63.188	86	Active Mining[2]

1. From SCS NEH-4 and TR-55 Handbook
2. From the Kentucky DSMRE, Technical Reclamation Memorandum #6

As stated on page 10-20, the parameter RCN is very sensitive, and variances will result in unreliable estimates of both runoff and erosion. As such, it would be prudent to ground-truth the RCN values applied to the models.

Again, I thank you for the opportunity to submit comments for the Draft TMDL. Additional comments are being submitted by the Straight Creek Stakeholders Group, of which, Lone Mountain Processing, Inc; Arch Coal, Inc.; Powell Mountain Coal Company, and Progress Fuels, Inc. are members. Those comments are of a more technical nature.

As the TMDL process develops, the Straight Creek Stakeholders group is interested in providing assistance in the development of the Implementation plan for the Straight Creek watershed. Given our knowledge of the watershed, and the technical expertise we can draw upon, we feel that the group will bring value to the IP development.

Should you feel it necessary to discuss any of these points, please contact me at the above address or telephone number, or by email at kmohn@archcoal.com

Thank you,

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Supervisor, Environmental Services

CC: File
Chris Imbrogno, Progress Fuels
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Comment Document #2

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April 12, 2005

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Dear Nancy,

Below are my comments in regards to the Callahan Creek and Straight Creek DRAFT TMDL.

Overall Document Comments:

- Stakeholder input is very important in the TMDL process and I feel with this size of this document citizen stakeholders and others may be overwhelmed or intimidated before they even view the document. To encourage stakeholder input the document should be divided into the main tributaries.
- Along with the fact the length of the document (511 pages); it is very difficult to determine what page to go to with the chapter numbering system. This will give additional ease of viewing the document for stakeholders.

Section 12 Implementation

- Section 12.3.5: De-Emphasize 319 as Potential Funding Source for TMDL Implementation (See Attachment). There are a number of other potential funding sources available to stakeholders. Emphasis should be placed on determining funding sources during the Implementation Plan Development. Based on the number of TMDLs that are being produced, this program is not able to sustain a "potential funding source " to implement all TMDLs once an implementation plan is prepared. Also, language has been used in TMDL reports that DCR and in some cases DMME will identify funding sources for implementation. This implies to the public that these agencies will be responsible for obtaining implementation funds. DCR will work with stakeholders to assist them in identifying potential funding sources, but cannot be held responsible for obtaining funding. DCR suggests that 319 be mentioned in context with other funding sources in the TMDL implementation chapter but not be singled out as a primary source.

Thank you for organizing comments concerning Callahan Creek and Straight Creek TMDLs.
I look forward to seeing the final remarks.

Sincerely,

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cc: Charles Lunsford, DCR
Charles Martin, DEQ
Joey O'Quinn, DMME
Jutta Schneider, DEQ

Attachment

Callahan Creek and Straight Creek TMDL Development Draft Comments:

12.3.5 Implementation Funding Sources

Cooperating agencies, organizations and stakeholders should identify potential funding sources available for implementation during the development of the Implementation Plan in accordance with the *Guidance Manual for Total Maximum Daily Load Implementation Plans.* Potential sources for implementation may include Virginia Agricultural Best Management Practices Cost-Share Program, Virginia Small Business Environmental Assistance Fund Loan Program, USDA Environmental Quality Incentives Program (EQIP), EPA 319 Funds, Southeast Rural Community Assistance Project (Southeast RCAP) and others.

Deleted: Funding sources for implementations will be identified by VADCR and DMME and the¶ stakeholders.

According to DMME's website, "Over 71,000 acres of land in Virginia have been affected by coal mining. It is estimated that it would take approximately 55 years at the present rate of funding and reclamation construction to reclaim just the high priority Abandoned Mine Land (AML) sites" (DMME, 2004). In addition, it would cost more than $300 million to reclaim the AML sites causing environmental degradation. Additional funding sources may be available through the U. S. Office of Surface Mining.

Deleted: One potential source of funding for TMDL implementation is Section 319 of the Clean¶ Water Act. In response to the federal Clean Water Action Plan, Virginia developed a¶ Unified Watershed Assessment that identifies watershed priorities. Watershed restoration¶ activities, such as TMDL implementation, within these priority watersheds are eligible¶ for Section 319 funding. Increases in Section 319 funding in future years will be targeted¶ towards TMDL implementation and watershed restoration.

Comment Document #3

Straight Creek TMDL Group

April 12, 2005

By Email and U.S. Mail

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Re: Draft Total Maximum Daily Load (TMDL) for Straight Creek

Dear Ms. Norton:

The Straight Creek TMDL Group ("Group") appreciates this opportunity to provide comments on the draft TMDL for Straight Creek, issued by DEQ for public comment on February 7, 2005. The draft TMDL addresses bacteria and benthic impairment in Straight Creek, which is located in Lee County, Virginia. As described in this submittal, we believe the draft TMDL raises significant legal and technical issues that need to be resolved before the TMDL is finalized, submitted to EPA for approval or implemented.

The Group is comprised of members that may be directly or indirectly affected by the TMDL. The Group's goal is to protect the water quality of Straight Creek through a regulatory process that is driven by sound science, as well as cost-effective and practical decision-making.

As you know, the Straight Creek TMDL proceeding is governed by the federal Clean Water Act, 33 U.S.C. § 1251 et seq., the state Water Quality Monitoring, Information and Restoration Act, Va. Code § 62.1-44.19:4 et seq., the state Administrative Process Act, Va. Code § 2.2-4000 et seq., and various implementing rules and policies. Those authorities make clear that DEQ must provide, at a minimum: (a) meaningful opportunities for public participation; (b) reasoned responses to public comments; (c) an analysis of the costs, benefits and environmental impacts associated with the allocations contained in the TMDL; and (d) substantial evidence to support the final TMDL decision. DEQ also must ensure that the analytical methods, modeling techniques and database necessary to develop a technically-defensible TMDL are available. See 43 Fed. Reg. 60,662 (Dec. 28, 1978).

Although DEQ has developed over 200 TMDLs in the past 5 years, this particular TMDL proceeding raises novel questions of law and fact, including:

- How should the general water quality standard codified at 9 VAC 25-26-20 be interpreted and applied in the TMDL?

- How should the stressor(s) contributing to impairment of the benthic community be selected or excluded?

- How should the stressor source(s) contributing to impairment conditions be identified and controlled?

- Should "reference" sites or conditions be established and, if so, how should they be selected and applied for comparative water quality impairment or attainment decisions?

- How should DEQ identify and assess the costs, benefits and environmental impacts of the TMDL?

- What minimum safeguards should be established and applied to ensure data quality, quantity and relevance?

- When in the process should DEQ decide whether to conduct a use attainability analysis in support of a designated use adjustment in lieu of TMDL development or implementation?

As described in the detailed comments that are attached to this letter, we believe that the draft TMDL fails to appropriately address these questions and, as a result, is legally infirm. We urge DEQ to take the time to correct the infirmities in the draft TMDL, and we pledge our full cooperation in that effort. Since similar questions will arise in many other benthic TMDL proceedings, it will be especially important for DEQ to answer them fairly and accurately here.

The administrative proceeding also was compromised by missing and inconsistent technical data and information, including missing GWLF files for Straight Creek and Callahan Creek (separate from Middle Creek reference data), and inconsistent KLSCP values, which represent erodibility for the Universal Soil Loss Equation. Providing public access to information relevant to a TMDL decision is a minimum requirement of the state Administrative Process Act. Without access to relevant and accurate data and information (despite repeated requests for the materials noted above), the Group was deprived of a full and fair opportunity to independently verify DEQ's calculations and to comment on the accuracy, reasonableness and appropriateness of the draft TMDL.

Straight Creek is a valuable resource and we, like DEQ, believe that its integrity must be protected. The draft TMDL does not meet that objective. The significant legal and technical issues described in this submittal must be resolved before legitimate decisions can be made about the nature, extent and source of particular pollutant reductions that may be necessary to protect Straight Creek.

Please feel free to contact either of us with questions.

Sincerely,

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Attachments

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Straight Creek TMDL Group

Draft Straight Creek TMDL Comments

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April 12, 2005

EXECUTIVE SUMMARY

BMI was retained by the Straight Creek TMDL Group to independently verify the underlying TMDL assumptions and calculations, and to comment on the accuracy, reasonableness and appropriateness of the draft TMDL. BMI focused, in particular, on (1) DEQ's impairment assessment; (2) DEQ's stressor identification; and (3) DEQ's allocation modeling. As described in more detail in Sections 1, 2 and 3, BMI believes that each of these aspects of the TMDL has been compromised by missing, incomplete, invalid and/or inaccurate data, information and conclusions. Based on BMI's review and analysis, the Group believes that the TMDL is unsuitable for adoption or implementation, and urges DEQ to postpone further action on the TMDL until it addresses and resolves the issues noted herein.

The methods employed for impairment evaluations in Straight Creek were insufficient for determining key aspects of the stressor analysis. There was not sufficient taxa resolution for aid in stressor identification. The RBP screening approaches were not useful for determining either spatial or temporal co-location of the suggested cause (TDS, TSS) with the effect.

The Straight Creek Benthic TMDL Stressor Identification process was conducted improperly. Although the VA DEQ is not constrained to follow a particular technique, it must support its choice of a probable stressor with sound science and clear logic. Vague and anecdotal logic were used to arrive at conclusions. Literature used to support these conclusions was misused. Likely stressors were overlooked or omitted from consideration. The two most likely stressors overlooked were habitat quality and the influence of uncontrolled household waste.

The most critical allocation modeling issues included incorrect sediment loads for reclaimed mined lands, a non-representative hydrologic period for TDS and sediment and no model validation. Therefore, both the estimates for current loadings as well as the allocations derived there from are suspect. In the absence of the input data files that have been twice requested and only partially received, the stakeholders assume the values are

incorrect and the modelers have minimal confidence in the models. A meaningful evaluation of the models was not possible.

The Straight Creek TMDL Group respectfully request the following:

- Technical issues summarized in these comments need to be addressed prior to submittal to the State Water Control Board or the United States Environmental Protection Agency.
- More rigorous monitoring, chemical, physical and biological, needs to be performed to accurately define stressors and their causes.
- Omitted stressors, physical habitat and uncontrolled household waste needs to be considered probable stressors.
- All input data files for both models need to be made available to the Stakeholders for meaningful review and comment.

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1.0 IMPAIRMENT ISSUES

1.1 Introduction

The Virginia Department of Environmental Quality (VADEQ) concluded that the benthic community of Straight Creek was "impaired" by means of the Modified Rapid Bioassessment Protocol (mRBP) Level II, specifically the Paired Reference Watershed Approach. This method of determining impairment impedes the usefulness of the data for stressor identification. The possibility for inaccuracy within this mRBP determination is high for a number of reasons. Primarily, the inconsistency of reference stations over time results in the inability to determine temporal trends. The lack of these trends lowers the level of confidence for both the impairment determination as well as subsequent actions. In addition to a lack of dependable temporal data, mRBP assumptions, as applied to Straight Creek, ignored ecoregion significance.

Taxonomic identifications of the benthic community were based on a lower level identification (family) than alternative options that identify to genus/species. Regarding its role in the Straight Creek Total Maximum Daily Load (TMDL) process, this mRBP approach fails to supply data that can affirmatively link cause with effect.

Considering these issues, it would be more appropriate to use another assessment tool to support impairment and stressor determinations. Multi-Metric Indexes (MMIs) are appropriate for such needs and are successful in balancing out the disadvantages of the Rapid Bioassessment Protocols (Virginia Water Resources Research Center, 2004). Instead of having reference stations that change, MMIs are so named because they are multiple aggregate values of metrics from numerous reference streams. These reference condition values remain the same year to year. In other words, the scientific "yard-stick" remains the same over time and therefore seasonal trends, impairment, or improvements can be determined with a high degree of confidence. MMIs are typically calibrated to ecoregion variability. Alternatively, the mRBP used to assess Straight Creek compared this target stream to nine different reference stations from 1991 to 2004 and six of those reference stations were located in different ecoregions from Straight Creek. These infirm

methodologies were used to establish the foundation of the Straight Creek TMDL and consequently raise cause for concern about the technical validity of the TMDL.

1.2 Rapid Bioassessment Protocol

1.2.1 Taxonomic Identification Level

The benthic data used for determining the impairment status of Straight Creek were also used with chemical data for determining stressors that caused the impairment. The benthic data for this case originated from methodologies of the mRBPII. Rapid Bioassessment Protocols are classified into three categories: RBPI, RBPII, and RBPIII. The three categories differ in level of effort, taxonomic identification level, expertise required to perform them, and in the usefulness of obtained data (Younos and Walker, 2003). Essentially, RBP I and II are adequate when conducting cursory or initial investigations, but are inadequate for identification of the cause of impairment.

In the case of the Straight Creek TMDL, it would have been more appropriate to use RBPIII. This RBP method identifies benthic macroinvertebrates to the lowest practical level, genus/species, as opposed to simply family level with mRBPII. Increased taxonomic resolution would have provided more certainty with impairment determinations while allowing for determination of a biological gradient as related to the stressor.

Although identification to family level (mRBPII) provides a general idea of the impairment status for a target stream, it is possible to find benthics having various tolerance levels within the same family. For example, the family Chironomidae is typically associated with poor benthic health. However, there are two different species within this family that behave oppositely when exposed to changes in conductivity, one being more tolerant. The species *Tanytarsus barbitarsus* has been observed in environments with more than 134 times the level of salinity than that of the *Procladius paludicola* species (James, 2003). This indicates that family level identification may not accurately portray impairment. Higher taxonomic resolution would have further defined stressors and their severity to the benthic community, while providing a biological

gradient to the chemical data. Also, a higher taxonomic resolution provides the investigator with more data to characterize a cause and effect relationship. The RBPIII approach would have provided detailed benthic information sufficient for trend analysis, a major element lacking in the current Straight Creek impairment and stressor identification process (Younos and Walker, 2003).

1.2.2 Sampling Index Period

A major discrepancy in the sampling of the data used by the DEQ to determine impairment and stressor was time and frequency of sampling. Index periods establish a recommended timeframe for the most appropriate portion of the year to collect benthic macroinvertebrates. Sampling outside of suggested index periods may result in data that does not reflect the true community of a site. Ideally, sampling should occur when insects are at or near maturity, as opposed to during resting stages while species are in early instars, smaller, and more difficult to identify. The National Water-Quality Assessment Program, created by the U.S. Geological Survey, suggests that for temperate climates maximum maturity and richness typically ranges from late fall to early spring (Cuffney et al, 1993). More specifically related to Straight Creek, the West Virginia Division of Natural Resources suggests a spring index period that starts on February 15 and ends on April 15 for this ecoregion. Likewise, a fall index period lasting from October 15 to December 15 is recommended for this ecoregion (West Virginia Division of Natural Resources, 2000). The Ecological Monitoring and Assessment Network (EMAN) elaborate:

> ". . . the presence of mature larvae, pupae, or adults may be short-lived and easily missed if seasonal development rates differ from year to year and mid-summer survey dates are chosen (EMAN website)."

With this in mind, several of the benthic surveys conducted in Straight Creek by DEQ are of particular concern. The data collected on September 22, 1999 was obtained in early fall as opposed to the late fall suggestion by the above EMAN citation. Also, the entire spring collection of DEQ survey data for Straight Creek was collected very late in the season (late spring / early summer). The dates of the surveys were late spring instead of early spring, and one survey occurred in midsummer on July 7th, 1997. When the

sampling is conducted this late in the season, there are several taxa that may not be represented in the data but may have been present earlier in the season, winter stoneflies for example (Merritt and Cummins, 1996). The concern of seasonal sampling time is exacerbated by the fact that some of the reference stations were sampled much earlier than Straight Creek, the target site.

More important than the temporal issue of sampling, is the need to minimize the time span between collecting benthic data at the target site and reference site that will later be used for comparison. Minimizing this time span would have helped avoid potential differences in the benthic communities that can be explained simply by the passage of time. There are several instances where these discrepancies were evident in the DEQ's benthic monitoring of Straight Creek. For example, the 1991 spring survey of Straight Creek was collected more than two months later than the survey of the "paired" reference station. In addition, half of the total sampling sets were taken over a month apart. The life cycles of benthic macroinvertebrates are heavily hinged upon water temperature, so it is highly important to maintain consistency between sampling dates (Merritt and Cummins, 1996). Essentially, the benthic data was based on poor sampling protocol in regards to index period recommendations and consistency between target and reference streams. However, this was the fundamental data used to determine impairment and furthermore, define the stressors of the Straight Creek TMDL.

1.2.3 Importance of Ecoregion

Ecoregions are an attempt to describe areas with similar climatic, geological, hydrological, vegetative and biological characteristics (Omernik 1987). This method ignores arbitrary political boundaries. The US EPA has developed four levels of ecoregion resolution (United States Environmental Protection Agency, 2000a). Level 1 is coarsest while level four is most resolute. Nearby states have established both biological and chemical criteria at the most resolute ecoregion level (Tennessee Department of Environment and Conservation, 1993). Ecoregion can explain differences found in benthic assemblages with greater clarity than physical habitat (Rabeni, 2000).

Straight Creek is located in the Central Appalachian Ecoregion (Level III 69); more specifically, the Cumberland Mountains Ecoregion (level IV 69d). Some of the references used to determine impairment for Straight Creek were located in other ecoregions (Level III 66, 67). Likewise, the reference chosen for allocation was located in a different ecoregion (67). Figure 1 presents a map of South-western Virginia with ecoregion overlaid as well as location of Straight Creek and its references. The map clearly shows that many of the references that Straight Creek is being compared are in different ecoregions. Curiously, through the years the State has changed reference stations based on ecoregion boundaries (Virginia Department of Environmental Quality, 2005). The purpose stated for changing reference stations was due to realignment of ecoregion boundaries making Whitetop Laurel Creek in a different ecoregion than Straight Creek. However, subsequent surveys have used reference stations outside of Straight Creek's ecoregion.

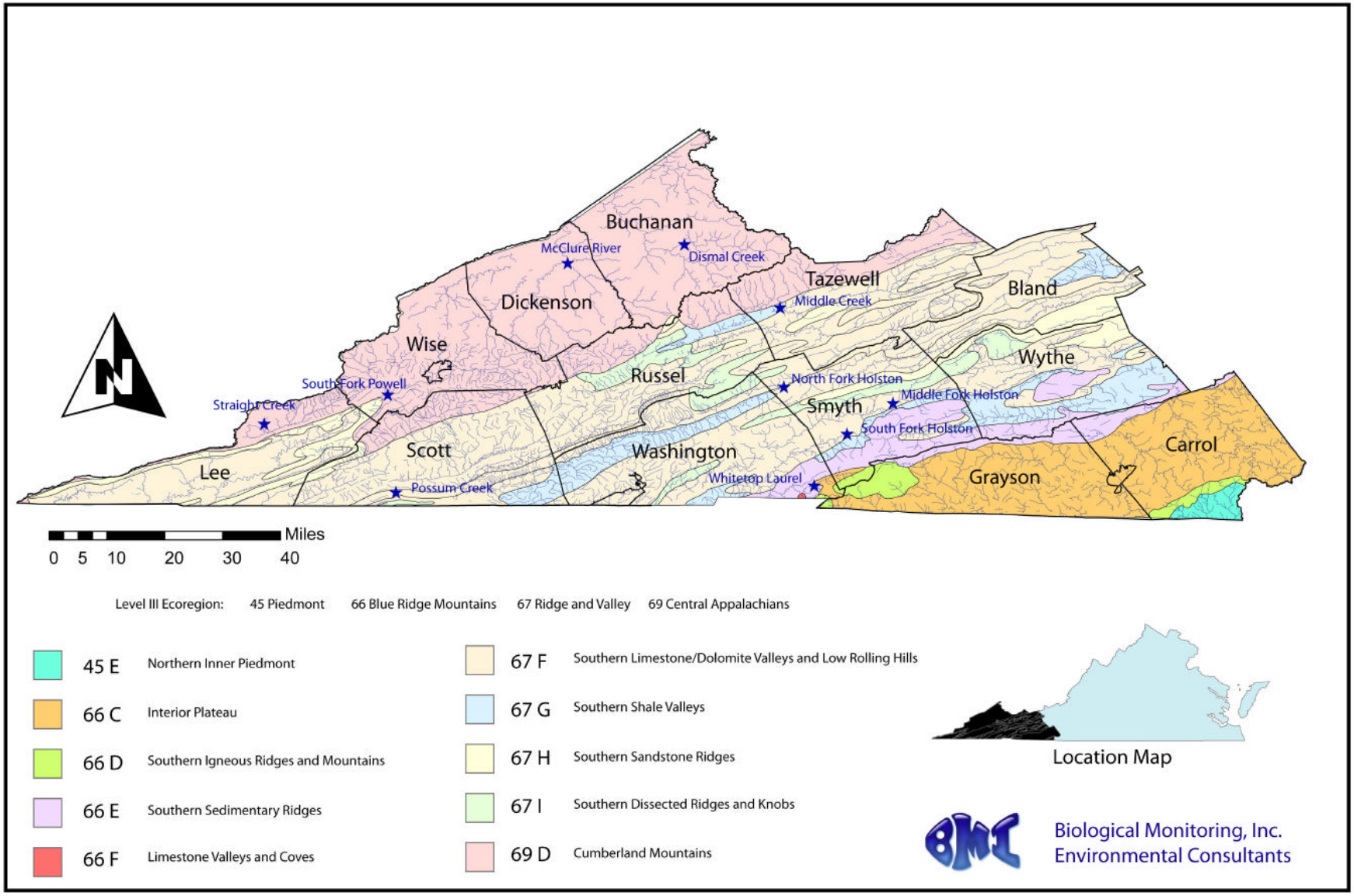

Figure 1 Ecoregion Map

1.3 Multimetric Indices

Multi Metric Indices (MMI) are a valuable biological assessment tool and can overcome many of the short comings of paired watershed snapshot type approaches. Virginia has developed a draft MMI (VASCI) for non coastal streams (Tetra Tech, 2003). However, the draft does not reflect data from the Central Appalachian ecoregion (including Straight Creek), and, as a result, is inapplicable to that ecoregion. Instead, the draft refers users to West Virginia's MMI for application in this ecoregion. West Virginia has an MMI (WVSCI) that is calibrated for use in the Central Appalachian ecoregion (Tetra Tech, 2000). Similar to other SCIs, the WVSCI uses a 0-100 point scale in evaluating benthic data. The State of West Virginia uses 60.6 as the threshold for impairment and subsequent 303(d) listing.

The benthic data from Straight Creek collected by the State were analyzed by BMI with the WVSCI. Table 1 presents a summary of the Straight Creek data. Figure 2 displays the data from Straight Creek with an added trend line.

This analysis of the data indicates that generally, the benthic health has been increasing over time.

Table 1 Summary of Straight Creek Benthic Data Using a Multi-metric Index

Station	Date	WVSCI Score
6BSRA000.40	May-91	41.79
6BSRA000.40	Nov-91	48.19
6BSRA000.40	Dec-92	53.0
6BSRA000.40	Nov-93	57.76
6BSRA000.50	Jul-97	60.03
6BSRA002.69	Jul-97	57.31
6BSRA003.84	Jul-97	51.74
6BSRA000.11	Sep-99	45.43
6BSRA000.40	Sep-99	47.84
6BSRA002.48	Sep-99	57.29
6BSRA003.62	Sep-99	52.55
6BSRA000.11	Dec-03	65.15
6BSRA003.62	Dec-03	56.97
6BSRA000.11	Jun-04	61.71
6BSRA003.62	Jun-04	45.81

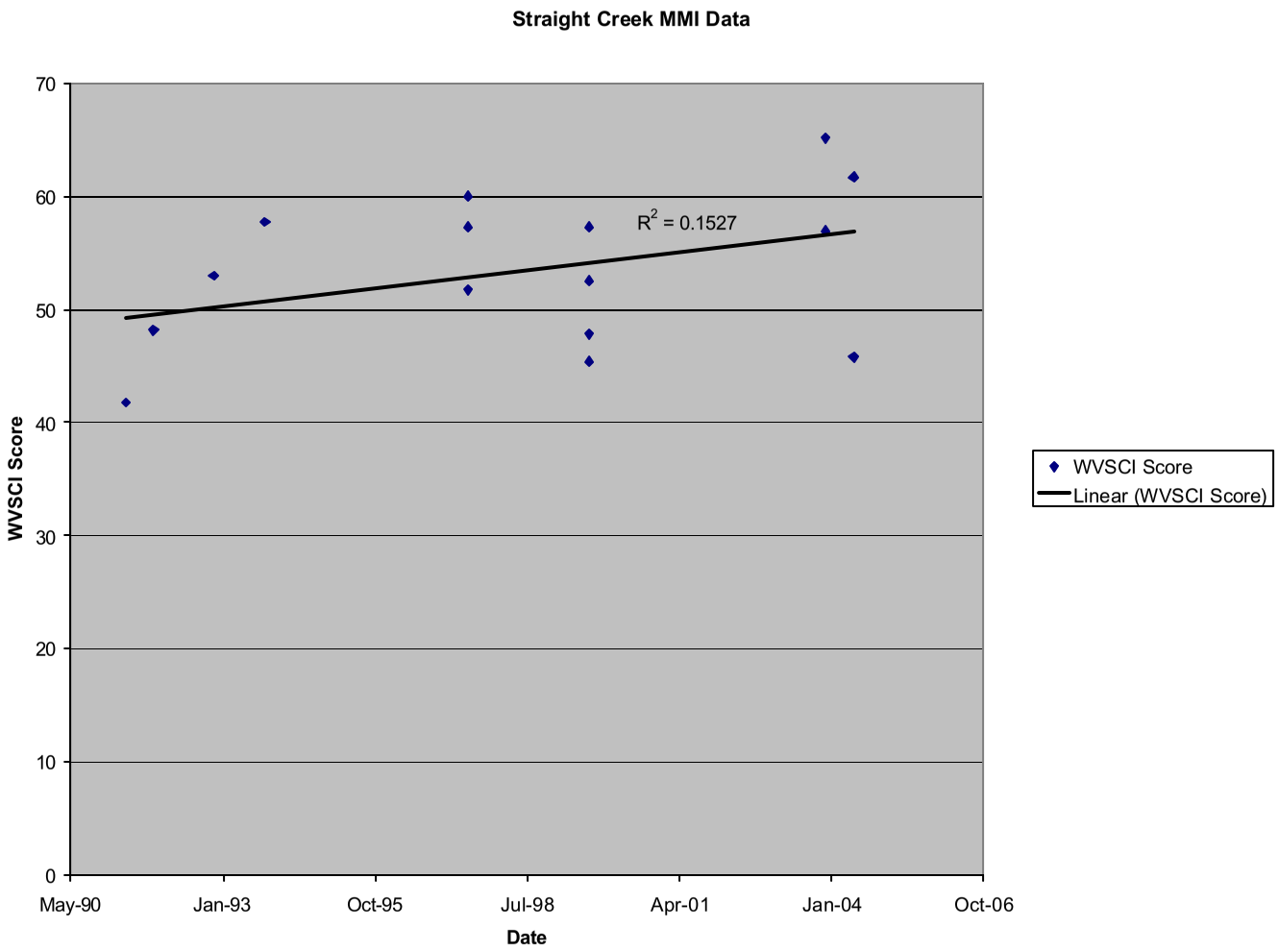

Figure 2 Straight Creek Benthic Scores (WVSCI) over time.

1.4 Conclusion

The methods employed for impairment evaluation in Straight Creek were insufficient for determining key aspects of the stressor analysis. There was not sufficient taxa resolution for aid in stressor identification. The RBP screening approaches were not useful for determining either spatial or temporal co-location of the suggested cause (TDS, TSS) with the effect. Therefore, the Straight Creek TMDL Group suggests more thorough data analysis and additional data collection prior to the finalization of any TMDL for Straight Creek.

2.0 STRESSOR IDENTIFICATION

2.1 Process Issues

The General Standard (Benthic) TMDL is predicated on narrative standards. As such, it requires a more complex, dedicated approach as compared to simpler (non-benthic) TMDLs where numeric water quality criteria serve as the target. Before calculating a traditional TMDL, one must simply identify the most likely source of the pollutant's input to the stream. As is the case with benthic TMDLs in general and Straight Creek in particular, there is no "pollutant" called "benthic impairment" with an easily identifiable "source" for which a maximum daily load can be modeled. Therefore, further investigation is required to identify a conventional pollutant (the CAUSE) that is responsible for the benthic impairment (the EFFECT).

The Stressor Identification (SI) process aims to characterize an effect and its cause, such that the cause is a traditionally defined "pollutant" for which a TMDL can be calculated. The challenge with the SI process is developing a *scientifically sound* basis for concluding that a specific pollutant is the CAUSE of an EFFECT. The Stressor Identification Guidance Document (United States Environmental Protection Agency, 2000b) (SIGD) provides a conceptual framework for overcoming that challenge with tools for analyzing data and providing evidence to support cause-and-effect relationships. More importantly, it gives structure and direction to the process, requiring analysis of scientific evidence and satisfaction of logical tests before drawing conclusions.

The entire Straight Creek Benthic TMDL process is critically reliant upon scientifically identifying and logically supporting a conventional pollutant as the CAUSE of benthic impairment. The goal of the SI process is to determine the most ecologically significant stressor responsible for the EFFECT. The allocation models, the implementation, and the assessment of success all hinge upon proper stressor identification. Therefore, it is crucial that the cause-and-effect relationship is scientifically justified.

Citation (pg 8-2): "*The process outlined in the Stressor Identification Guidance Document (EPA, 2000) was used to separately identify the most probable stressor(s) for Straight Creek*."

Comment: There is very little evidence of adherence to the recommendations in the SIGD. The narrative says certain actions were performed, but there is no detailed analysis to confirm this. According to said guidance, the SI process should involve the following four steps (in italics):

1. *List candidate causes & develop a Conceptual Model that shows cause-and-effect relationships.*
    a. Potential stressors are listed on page 8-2, but there is no discussion of whether other candidate causes were considered before deciding on the final list. The SIGD recommends documenting the rationale for exclusion of least-likely causes (SIGD, pg 2-5). The absence of such documentation, combined with the fact that all of the candidate causes conveniently have data available suggests that the **SI process did not fully consider all scientifically reasonable candidate causes**.
    b. It appears a conceptual model linking cause to effect was not used at any stage of the SI process. There is no structured, logical discussion of hypothesized stressors or sources, ecological relationships between cause and effect, exposure pathways/mechanisms of potential causes. **Omission of a conceptual model robs the TMDL document of an excellent tool for public communication.**
2. *Analyze the evidence, associating candidate cause with observed effect. The SIGD recommends developing associations between measurements of candidate causes and effects to provide causal evidence. This process seeks to provide evidence that:*
    - *Cause and effect are observed at the same time and place*
    - *When cause is not observed, neither is effect*
    - *Magnitude of cause is related to magnitude of effect*

    The narrative does not provide evidence of any of the above three conditions.

a. There is no discussion of spatial or temporal co-occurrence of cause and effect or the significance of such relations. **Moreover, it seems the analysis erroneously treats Straight Creek as spatially and temporally homogenous, implying that the stream was/is equally impaired throughout and that a cause at any location/time was responsible for impairment at any location/time**.

b. Data from 2003 are presented as part of the causal evidence for some physicochemical parameters, yet impairment existed a full decade before said exposure occurred. **When observation of an effect precedes observation of a candidate cause, the data cannot be considered evidence of causation.**

c. Biological monitoring stations have few concurrent chemical data to support co-location of cause and effect. Furthermore, a significant tributary of Straight Creek (Stone Creek) is not represented by many of the stations. .The association of cause with effect required that data from each of the four VADEQ Biomonitoring stations be associated with data from the numerous VADEQ and DMME physicochemical monitoring stations. The four biomonitoring stations are located 0.71, 0.74, 1.0, and 1.25 miles downstream of the nearest physicochemical station with a useful dataset. The majority of physicochemical data analyzed is from river mile 1.11, while the majority of benthic data is from river mile 0.40. **Such spatial separation would hardly qualify as ecologically significant co-occurrence. Although the effect does occur downstream from the cause, one cannot be certain that the parameter values measured upstream maintain similar levels over 0.71 river miles.**

d. There is no discussion of how the magnitude of effect varies with magnitude of exposure to the cause. If a candidate cause is truly responsible for impairment, it is logical to expect impairment level to change in a predictable way as exposure to the cause changes. No such relationship has been presented in the narrative. In fact, a relationship between cause level and impairment level over time or space is not discernable from the available data (see Technical Issues section).

3. *Characterize the most probable cause(s) through elimination, diagnosis, or weighing the strength of evidence. This step is where implausible stressors are eliminated and the strength of evidence for the remaining candidates is weighed. Evidence can come from the case itself, other cases, general ecological knowledge, and experimental data. Evaluation of confidence of conclusions is also recommended at the end of this step.*
    a. Some "possible stressors" were eliminated in the TMDL narrative for unscientific reasons. Two examples: "no water quality standards exist for that parameter in Virginia" and "toxicity data confirming bioavailability are absent." Citing the absence of information is not a scientifically sound method for eliminating candidate causes. Further investigation would have been prudent for such candidate stressors before elimination. For example, data gaps should have been generated through experimentation or additional biological and physicochemical monitoring.
    b. Logic of analogy is faulty. The narrative presents literature citations as examples of cause being associated with effect in various cases. However, magnitude, temporal, and spatial associations are weak, misinterpreted, used out of context, or ignored altogether when the analogy does not enhance causal evidence. These shortcomings will be discussed in detail in the Technical Issues section.
    c. There is no discussion of the confidence in the conclusions made in the narrative. Several times is the statement made to the effect "there seems to be little doubt from this evidence that…" As demonstrated in these comments, there is much doubt about the conclusions drawn from the evidence as presented. At no time does the narrative attempt to objectively evaluate or quantify the confidence of any conclusion.
4. *Finally, the SIGD suggests that iteration options may prove useful with complex systems, and recommends their use be considered at every stage of the SI process. These options include reconsidering the impairment and collecting more information.*
    a. The Straight Creek watershed contains active, abandoned, and reclaimed mine land, residential land with inadequate or no sewage treatment that discharges

directly into the stream (a condition sometimes referred to as "straight pipes", livestock and wildlife, and channelization impact, to name a few factors ultimately affecting water quality. It is therefore alarming that there is no description of iterative practices used during the SI process. There is no discussion the likelihood of Type I or II errors regarding impairment or causal assumption.

b. Experimental toxicity data, a more rigorous benthic macroinvertebrate survey at RBP III level, deeper literature searching, and collection of temporally and spatially related physicochemical data are just a few options that must be considered when attempting to provide conclusive evidence of causation.

2.2 Technical Issues

2.2.1 General

Successful Stressor Identification is dependent upon the presentation of strong causal evidence and the use of sound science and logic to justify all conclusions. In the case of the Straight Creek Benthic TMDL Stressor Identification, much of the evidence is, at best, unconvincing and, at worst, unscientific. There also are numerous unacceptable leaps of logic that fail to satisfy the SIGD requirements for causal evidence.

The strength of evidence is in the details and it is in the following technical details where the absence of sound science is evident in the SI document. Comments will cover general technical issues first, and then move on to stressor-specific details. As above, citations to the TMDL narrative are made where applicable, immediately followed by relevant comments.

1. The Stressor Identification Guidance Document provides a helpful worksheet to aid the investigator through the SI process. The information generated by the worksheet is included in both case studies presented in Chapters 6 & 7 in the SIGD. The inclusion of this information and its method of presentation made it very clear how the conclusions were reached in each case study. The Straight Creek Benthic TMDL does not present any information or evidence in a similarly clear or convincing

manner. For example, not a single mention is made in the TMDL narrative of any of the 12 causal considerations discussed in section 4.2.3 of the SIGD. Those considerations are: co-occurrence, temporality, biological gradient, complete exposure pathway, consistency of association, experiment, plausibility, analogy, specificity of cause, predictive performance, consistency of evidence, and coherence of evidence. **These considerations are recommended for a reason and should have been used in weighing the strength of evidence in the case of Straight Creek**.

2. **Citation (pg 8-2)**: *"A list of candidate causes was developed from published literature, VADEQ, and DMME staff input."*

   Comment: While candidate cause selection should consider all scientifically reasonable options, such was not the case with the Straight Creek SI process. From the outset of the SI process, the candidate causes under consideration were restricted to only those for which a dataset existed. Early in the Benthic TMDL development process, VADMME staff noted at a public meeting that the TMDL investigators were working on the assumption that existing data were sufficient for stressor identification, and that no new data would be collected (O'Quinn, 2004). Such an assumption suggests that **the most probable stressor(s) had already been determined *a priori*, with no causal evidence needed**. With the probable stressors determined, the SI process then simply required providing some literature references and manipulating the presentation of evidence using weak logic until it made the investigators' case.

2.2.2 Stressor Specifics

2.2.2.1 Total Dissolved Solids and Electrical Conductivity

1. **Citation (pg 8-1):** *"…for water quality parameters without established standards or screening levels, the 90th percentile for the parameters available from the McClure River (6AMCR000.20) were used to evaluate the water quality data in this stressor analysis. When a parameter exceeded the 90th percentile more than 10% of the time*

it was considered excessive…"[>90th percentile values are hereafter referred to as 'exceedance(s)']

Comment: The general fault with using the 90th percentile approach is that it 1) counts only occurrences and ignores the importance of the *magnitude* of exceedances, 2) does not allow for consideration of biological significance of the magnitude of the cause, and 3) assumes that Straight Creek will behave identically to the reference stream and that the McClure 'has all the answers', so to speak.

a. This logic assumes all exceedances are of sufficient magnitude to be harmful. The SI process requires that a biologically significant cause-and-effect relationship be determined. Since magnitude of effect can vary with magnitude of cause, this fact *must* be considered when determining whether a parameter reaches 'excessive' levels. **By using this logic, an electrical conductivity (EC) value of 801 or 8000 umhos/cm are both treated as equally harmful when all available literature suggests that an EC of 8000 umhos/cm presents a far greater risk to biota than an EC of 801 umhos/cm.**
b. Further, the logic assumes that simply exceeding the 90th percentile >10% of the time is evidence of harm done. What happens if the data exceed the 90th percentile >10% of the time, but all exceedances are below the maximum value observed in the McClure River? The McClure River data indicate maximum Total Dissolved Solids (TDS) of 1321 mg/L and EC of 2221 umhos/cm.
c. Additionally, where stressors are eliminated due to <10% exceedance rates, there is little or no discussion of whether the exceedances were of sufficient magnitude to cause an effect. **This logic also creates the potential for erroneously eliminating stressors.**

2. **Citation (pg 8-1)**: "*The presence of nine values was selected as a cut off in order to avoid using data from stations that were not sampled during different seasons of the year or different flow regimes of Straight Creek*."

Comment: The selection of nine data points as the cut off for inclusion in analysis seems a bit questionable since that cut off allows 6BSRA003.22 data to be included. Those data could be considered statistically extreme outliers when compared to the values found in the rest of Straight Creek during the same period of observation (7-03 to 3-04). Those data also suggest that Straight Creek has TDS and EC exceedances 78% and 89% of the time, which is not correct for Straight Creek as a whole (see comment #3 below for more information regarding TDS/EC data).

Regardless of how the data portray Straight Creek, the question still remains as to how the above-cited justification holds true. The explanation suggests that these nine data points have been confirmed to encompass different seasons and different flow regimes of Straight Creek. However, the data reveal that 1) there were no concurrent flow measurements made at the time of sampling, and 2) a 140-day segment is not captured in the data (March 4 to July 23), which includes all of the Spring season (approx. March 21 – June 21). **It cannot be reliably said that these data covered different flow regimes when no concurrent flow measurements are available. The absence of data from spring could be considered a significant shortcoming, since that season can often be a dynamic period with regard to flow**.

3. **Citation (pg 6-35)**: "*Conductivity and total dissolved solids are consistently high throughout the watershed.*"

   Comment: There is no quantification or definition of what is meant by 'consistently', 'high', or 'throughout'.

   a. If the assertion is that 'consistently' equates to 'constantly' elevated levels of TDS/EC, where are the data to support that assertion? Examination of the TDS/EC data from all stations over all years on Straight Creek reveal that **TDS and EC values have exceedances less than 18% and 16% of the time, respectively**. If, however, 'consistently' is meant to imply 'reliably' high values of TDS/EC were observed, the data again show otherwise. If TDS and EC were reliably high, one would expect minimal variance in the measured values. **The data for TDS and EC exhibit relative standard deviations of**

108% and 89%, respectively. **Such variability of the data does not suggest values could be reliably high.**

b. In addition, the majority of physicochemical data discussed in the narrative are from only 10 stations that contain approximately 620 samples collected from Jan 1990 to Mar 2004. The majority of samples were taken after 1995, and the median sampling interval was 30 days. **It seems reasonable to conclude that, given Straight Creek's hydrologic and land use characteristics, 12 samples per year cannot fully capture the true nature of TDS/EC in the stream.**

c. What level of TDS or EC is considered 'high'? The McClure River 90th percentile screening values are assumed to be the values used in the comparison, but this is not made clear.

d. How can data that are not evenly distributed through time or space be used to characterize an entire 17,700 acre watershed? The majority of samples mentioned above come from 1995-2004 data collected over a 2.8 mile section of Straight Creek. These data cannot support causation of impairment prior to 1995, and have no predictive ability for Straight Creek. **These data cannot be considered to represent conditions 'throughout' Straight Creek, either spatially or temporally.**

4. **Citation (pg 6-15 & Fig 6.6)**: *"The VASCI scores for all six [ECI benthic] surveys are below the impairment threshold of 61.3. Scores improved slightly from upstream to downstream."[although still impaired]*

   Comment: Despite the fact that the VASCI is not appropriate for use in the Central Appalachians, one would still expect the SI narrative to present good causal evidence using solid logic. Having physicochemical samples concurrent with benthic surveys, the ECI data are the only data for all of Straight Creek that satisfy the causal consideration of spatial and temporal co-occurrence. The SI narrative discusses benthic, TDS, and EC data from three stations sampled in July and November 2002. **TDS and EC at each sampling were ALL below the McClure 90th percentile**

screening values, yet the benthics remained impaired. These data demonstrate the absence of a causal link by failing to prove that when cause is absent, so is effect. **If TDS and EC are to be considered stressors, absence of the stressor should result in improved benthic scores. The ECI data demonstrate that is not the case with Straight Creek.**

5. **Citation (pg 8-34 to 8-41):** *Re: Temporal association of effect with TDS/EC exceedances, see generally Figures 8.38 - 8.49 & Tables 8.11 & 8.12*

   Comment: How can 2003 data be used as evidence of causation of prior impairment? The SI narrative uses data from VADMLR MPID 102127 and VADEQ stations 6BSRA001.11 and 6BSRA003.22 collected between May and December 2003 to bolster the claim that TDS/EC are excessive and causing impairment. These data are from an 8-month period when TDS and EC were much higher than data from prior and future years, suggesting an anomalous, unrepresentative time period. If spikes of TDS and EC are to be considered stressors, absence of the spikes should yield improved benthic scores. VADEQ benthic surveys from as early as 1991 indicate some level of impairment, despite the absence of TDS/EC exceedances. **It is impossible for spikes of TDS or EC in 2003 to be used as causal evidence when 1) the data do not suggest benthic integrity declined from the spikes, and 2) the data do not suggest benthic integrity was better prior to the 2003 spikes.**

6. **Citation (pg 8-33)**: "*High conductivity values have been linked to poor benthic health (Merricks, 2003)…*"

   Comment: The citation above spurred many comments regarding the (mis)use of Merricks' work as causal evidence for TDS/EC. The use of literature data falls under the SIGD category of "Other Exposure Response" evidence which contributes to the "Analogy" causal consideration.

   a. A Master's Thesis that has not been peer-reviewed should not be presented as scientific evidence of a predictable response of benthic macroinvertebrates to TDS/EC.

b. It should be noted that Merricks' Thesis is actually a collection of investigations, comprising four distinct studies that, among other data, included examination of benthic macroinvertebrate communities and their associations to various stresses in: 1) West Virginia headwater hollow-fills and associated ponds, 2) Virginia (Middle Creek & Clinch River) hollow-fill drainages and reclaimed mine land, 3) Virginia (South Fork of the Pound River & Powell River) hollow-fills and ponds, and 4) WV and VA hollow-fill/pond complexes of various maturity.

c. The TMDL narrative citation was likely influenced by the significant correlation that Merricks found between EC and two (of six) benthic metrics in Middle Creek/Clinch River data. **For those sites, EC may not be the cause of low benthic scores if correlation is only significant for 1/3 of the metrics.**

d. Of note in the Middle Creek/Clinch River study: 1) none of the benthic data show impairment, 2) none of the conductivity values exceed the McClure River's 90th percentile EC value of 800 umhos/cm, and most importantly, 3) Merricks himself concludes on page 67 that given the low significance of the correlations, that **"…measured physicochemical parameters were not the major hindering factor within the watershed." Was this statement missed or simply ignored? How can Merricks be cited as EC/impairment causal evidence, when Merricks himself concedes the relationship is weak?**

e. Correlation may exist, but EC measurements in Middle Creek and Clinch River never exceeded 800 umhos/cm. **Those sites are not impaired based on Merricks' own conclusions and there is no gradient of biological integrity that varies predictably with EC. Despite correlation, where is the evidence of conductivity CAUSING impairment?**

f. A full stressor/benthic-metric correlation was presented in a table for one dataset (Middle Creek/Clinch River), but not for other datasets (WV and VA SF Pound/Powell). The WV and Pound/Powell datasets selectively note correlations to a few metrics such as %Ephemeroptera and %Chironomidae where graphs are presented. **Considered in context, Merricks' thesis does**

not strongly support a robust, biologically significant correlation between impairment and conductivity. As such, the study cannot be used as causal evidence by analogy.

g. In WV data, Merricks notes correlation of conductivity with %Ephemeroptera & %Chironomidae (which are somewhat reciprocal and redundant). Total taxa richness and EPT taxa richness were not correlated in WV as they were in Middle Creek. In Five Mile Creek (WV), conductivity averaged in the 900 umhos/cm range (>McClure 90th percentile), yet Taxa Richness & EPT Richness were not significantly different from the reference (with conductivity ~250 umhos/cm), and only 1/3 stations had %Chironomidae significantly different from the reference. Of note in this dataset is that dissolved Aluminum is above the USEPA aquatic life chronic criterion of 87 ug/L for ALL other water bodies except Five Mile Cr. **This is an example of how potentially confounding variables can limit the confidence of labeling conductivity as the sole CAUSE of benthic impairment. Aluminum may have been a more appropriate cause in the WV case.**

7. **Citation (pg 8-38):** *"Ohio and Illinois have aquatic life TDS water quality standards set at 1,500 mg/L (OEPA, 2005; IPCB, 2005)."* **(pg 8-42):** *"…if TDS concentrations in freshwater effluents…is above 1,340 mg/L, the concentration of dissolved ions can be high enough to stress aquatic organisms (SETAC, 2004).*" **(pg 8-42):** *"…if the conductivity of a freshwater effluent exceeds 2,000 umhos/cm then the concentration of dissolved ions can be high enough to cause stress to aquatic organisms (Goodfellow et al., 2000)."*

Comment: If these various values have been shown to be biologically significant and/or adopted by States for aquatic life protection, why haven't these values been considered as the threshold values for assessing Straight Creek? What really matters in the case of the SI process is that a biologically significant magnitude of stressor be known. There is too much dissimilarity between Straight Creek and the McClure River to use the McClure 90th percentile as a threshold and assume any

exceedances equate to impact. **Thus, the logical choice would have been to use the published values for assessing Straight Creek**.

8. **Citation (pg 8-38):** *"The VADEQ stations and DMME MPIDs had a total of 14 TDS concentrations that exceeded 1,500 mg/L. The TDS concentrations at MPID 1020127 (river mile 3.26) exceeded 1,500 mg/L 11 times; eight of those times were between May and December 2003."*; **(pg 8-42):** *"Conductivity values exceeded 2,000 umhos/cm at both VADMME and VADEQ monitoring stations on Straight Creek."*

   Comment: These statements are a cursory attempt to assess Straight Creek with respect to the above cited TDS/EC levels, but the attempt deviates from the logic used elsewhere in the SI narrative. The data are here presented as absolute, rather than relative exceedances, with no justification given for the change. Examination of the data reveals that:

   a. The 14 TDS values over 1,500 mg/L amount to only 2.3% of all TDS samples for Straight Creek.
   b. The 8 TDS values over 1,500 mg/L at MPID 1010127 in 2003 are an isolated incident. The three other values over 1,500 are also isolated to a three-month span in 1999. Together these 11 data points account for only 11% of samples at that MPID.
   c. The most conservative TDS threshold discussed - 1,340 mg/L per SETAC - is only exceeded 2.6% of the time.
   d. Conductivity did indeed exceed 2,000 umhos/cm in Straight Creek, about 1.9% of the time. Conductivity also exceeded 2,000 umhos/cm in the McClure River about 3.4% of the time.

   The statements on pgs 8-38 and 8-42 do not provide any solid evidence that TDS/EC have caused benthic impairment in Straight Creek.

9. **Citation (pg 8-42):** *"…high concentrations and significant changes in TDS over long periods of time can place a lot of stress on the organisms."* And shortly thereafter: *"It is clear from the data available that conductivity and TDS values are too high and there have been very large fluctuations over the sampling period."*

Comment: These statements raise important questions:

- What are considered 'high concentrations'/'too high'?
- What are considered 'significant changes'/'large fluctuations'?
- What are considered 'long periods of time'?
- What is considered 'a lot of stress'?
- Where are the references supporting these claims?

This statement is so utterly unscientific and speculative that it does not support the case for TDS/EC as a most-probable stressor in any way. In the SI process, it is not enough to vaguely describe, without citation and quantification, how a potential stressor *might* affect aquatic life. **It is the duty of the SI investigators to provide evidence that *this* stressor at *this* magnitude, as observed at the site in question, has indeed caused *that* effect to *that* organism. This duty has not been fulfilled in the TMDL narrative.**

a. There is no clear explanation of what values are considered to be 'high' or 'too high' for TDS/EC. One assumes the reference is to the 1,340/1,500 mg/L TDS and 2,000 umhos/cm EC values discussed on pg 8-42, but it could be the McClure 90th percentiles of 800 umhos/cm EC and 525 mg/L TDS. Regardless of which threshold is chosen, there has been no evidence presented showing that the alleged 'too high' values did indeed cause an effect within the benthic community.

b. There are no data to support discussion of temporal variances with any certainty. With median sample intervals of 30 days, and without concurrent benthic data to support the cause/effect pair, nothing reliable can be said about how changes in TDS or EC may be affecting organisms in Straight Creek over time.

c. Equally absent are references supporting a rate of change of dissolved ions that is detrimental to aquatic life. Even the home aquarist knows that significant, abrupt changes in water chemistry are more stressful than the same change over 'long periods of time'. What size fluctuation is needed to induce a malignant response?

d. How has the determination been made that the benthic community has been caused 'a lot of stress' in Straight Creek? How does one determine that endpoint? There is no such discussion or quantification of organism-specific stressor exposure effects anywhere in the narrative.
e. Finally, claims such as these must be supported by the literature or through experimentation.

10. **Citation (pg 8-42):** *"Sudden large spikes in TDS concentration can be fatal."*

Comment: This statement ignores temporal associations of cause with effect. While large, rapid changes in water chemistry could result in acute toxicity, river ecosystems can recover from such events. The data for TDS and EC indicate two periods in which spikes occurred. In 1999 and 2003, data indicate an increase in TDS/EC that is much greater than the previous month's value. One fact that is not discussed in the SI narrative is that benthic macroinvertebrates are relatively proficient at recolonizing a disturbed stream segment after the disturbance abates. The data do not indicate any large spikes of TDS/EC prior to 1999 or during 2000-2003 to suggest that poor benthic scores during those times were the effect of TDS/EC spikes. Not only are the data inconclusive on this point, but the fact remains that the concept of recolonization was never discussed as a stream ecosystem process. Even given optimal water chemistry, non-supporting habitat can still prevent recolonization. The fact that benthic impairment persisted for years with no known spikes suggests that habitat may be the most limiting factor for a healthy benthic community in Straight Creek. This aspect of Straight Creek's ecology should have been considered in more detail in the SI process.

2.2.2.2 Total Suspended Solids and Sedimentation

1. If the suspected stressor is sedimentation, then sedimentation should have been measured directly. There are many techniques that could have been used to collect samples and assess the true source of sediment. Measuring a surrogate introduces opportunity for unacceptable errors.

2. The use of Straight Creek total suspended solids (TSS) data in the SI process is not an accurate method to estimate biologically significant sedimentation.
3. **There are no high-flow TSS data.** TSS data at only low-flow underestimates true suspended solid loading of the stream. This is especially problematic when reference stream TSS is measured similarly. The evidence presented in the SI narrative uses the same McClure River exceedance logic as was used with TDS and EC. If the McClure River had lower flows when its TSS samples were taken, then it would falsely create exceedances in Straight Creek. There is no reliable way to compare TSS in Straight Creek to TSS in any other stream unless the data are collected over a wide range of flow conditions.
4. **Inaccuracies in the TSS sampling method lead to unacceptable estimate of suspended solids.** The Suspended Sediment Concentration (SSC) method is a less biased, more reliable way to accurately determine suspended particle loading (United States Geological Survey, 2000). The TSS method is fundamentally flawed for the reliable analysis of natural waters (United States Geological Survey, 2000). Without more accurate estimates of suspended sediment in either Straight Creek or the McClure River, one cannot reliably compare one to the other and make determinations of what is excessive.
5. Ignoring the inaccuracy of TSS data for a moment, even the data available don't support the argument that TSS is responsible for sedimentation leading to benthic impairment. **The incidence of TSS exceedances in Straight Creek is insignificant in the stream overall: TSS in Straight Cr exceeds McClure 90th percentile only 16% of time**.

2.2.3 Habitat Stressors

2.2.3.1 General

The role of habitat and land use on the impairment status has been largely overlooked in the TMDL process for Straight Creek. The role of habitat is particularly important where urbanization has occurred and may contain multiple stressor environments. In areas where channelization, morphology changes, or riparian vegetation removal have occurred, these are probable stressors responsible for at least some part of impairment.

Research has shown a significant correlation between habitat quality and benthic health (Rogers et al, 2001).

A summary of the Rapid Bioassessment Protocol (RBP) habitat scores is anecdotally presented in the Stressor Identification portion of the TMDL. However, the impact of this information is not thoroughly presented or the ramifications of poor habitat addressed as contributing to the impairment determined for Straight Creek. It is possible that current land uses preclude the attainment of the designated use (Virginia Water Resources Research Center, 2004).

Habitat plays an important role in the types and numbers of organisms found in a stream. Furthermore, land use in the entire watershed determines the quality and quantity of stream habitat available for benthic organism colonization. Straight Creek has a long history of human influences within the watershed. Human influences include; roads, agriculture / farming, residences, timbering, and mining. The stream channel itself has undergone morphological changes in order to accommodate these land uses (e.g. diversion, bridge abutments, etc.).

The Straight Creek watershed has largely been developed within the floodplain of the stream channel. The developments are dense along the creek due to the narrow valley floor and subsequent lack of flat ground. The majority of the housing and associated human influence is concentrated immediately adjacent to the stream (Figure 3). This map illustrates that >75% of the structures in the Straight Creek watershed are located within 200 ft. of the stream. This small area surrounding the stream now incorporates row housing, railroad tracks and a state road. Straight Creek has undoubtedly been adversely affected by this development. In tabularized land use data it would appear that a small portion of the watershed is perturbed. In reality, the majority of the watershed closely surrounding Straight Creek has been perturbed.

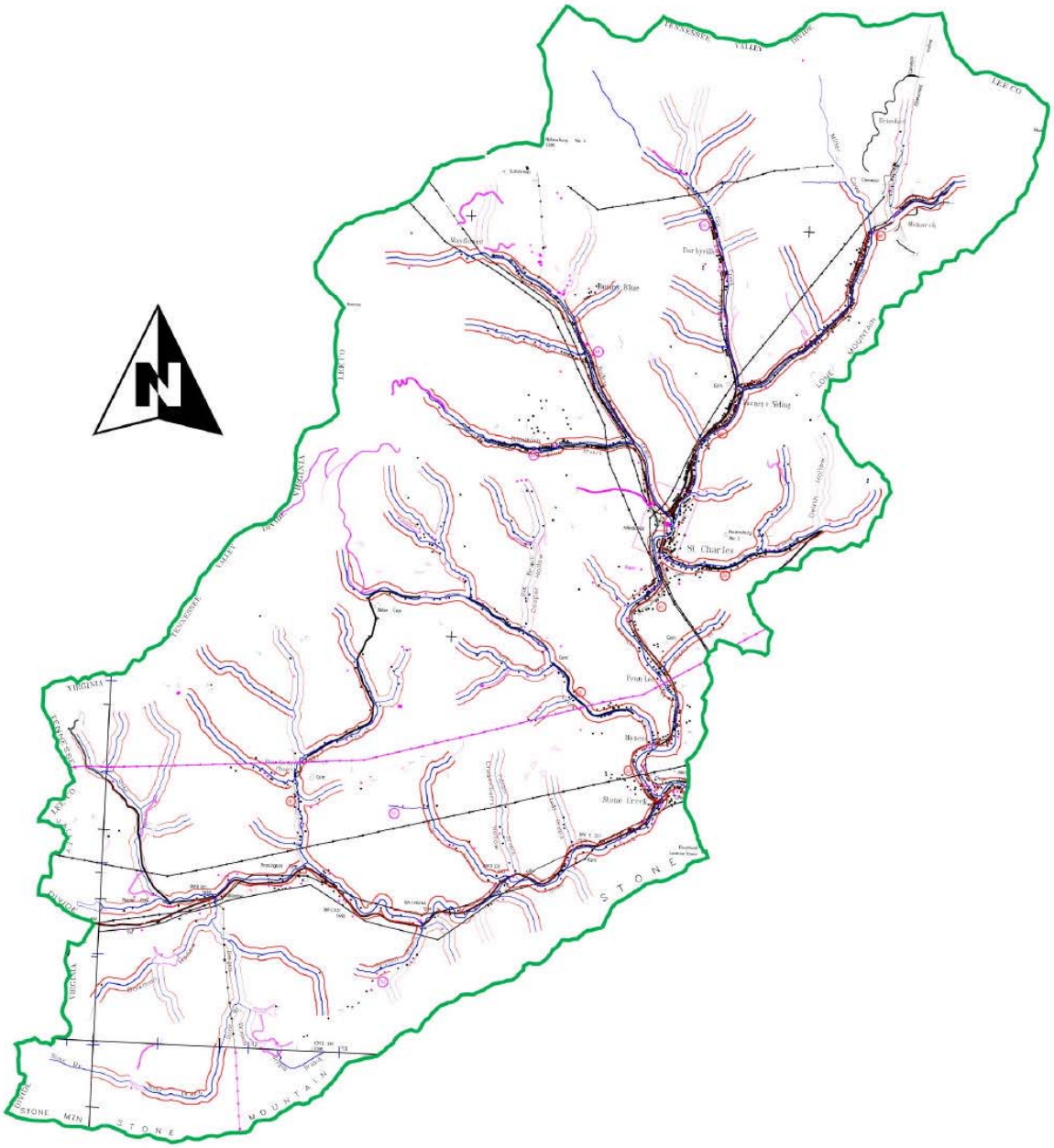

Figure 3 Land Use Map

One of the primary impacts related to urbanization and development is the alteration of the stream channel morphology. Bridges are commonplace in the Straight Creek watershed. A cursory investigation revealed more than 25 bridges on Straight Creek itself. Tributaries of Straight Creek contain even more bridges. Bridges and related structures (culverts, etc.) are notorious for altering stream channel morphologies both above and below the bridge structure (citation). Increased stream bank erosion rates and bottom scouring are some of the impacts related to bridges and culverts (United States Fish and Wildlife Service, 2003).

Many reaches of Straight Creek have been channelized. This has been accomplished in a variety of ways, including: high concrete walls along the stream banks and large piles of stone and dirt. No matter which method was used to channelize the stream flow, the result was a stream that is constricted within its own channel, disconnected from its floodplain, and that follows a course different form the stream's natural slope and meander pattern. This altered morphology is at least partly responsible for increased stream velocities. Increased stream velocity has been shown to alter benthic communities even when substrate movement and sedimentation are not altered (Bond and Downes, 2003).

2.2.3.2 Qualitative Habitat Assessments

Each time benthic macroinvertebrates were collected, a Rapid Bioassessment Protocol (RBP) habitat assessment was performed. The RBP habitat assessments consisted of 10-12 parameters that were based on key physical characteristics of the water body and surrounding land. Each parameter is related to overall aquatic life use and is a potential source of limitation to the aquatic biota (United States Environmental Protection Agency, 1999). When benthic data are compared between stations with different habitats, data must be interpreted cautiously. The US EPA RBP habitat assessment suggests that this method is not comprehensive enough to evaluate impacts related to habitat. Further investigation is necessary when habitat differences are noted.

The VA DEQ and its contractors have changed methods over time, further hampering interpretation of the habitat data. Also, the station locations have varied slightly over time. However, in order to evaluate the data temporally, percentage of available habitat scores relative to maximum score can be evaluated from stations representative of impairment status. Table 1 presents a summary of the habitat data collected from the most downstream stations in Straight Creek (6BSRA000.11, 6BSRA000.40, 6BSRA000.50). Figure 1 displays these data with a trend line added.

These data suggest two things; first, it is evident that the habitat is suboptimal for benthic colonization and ultimately "use attainment", second, habitat assessment score increased over the sampling period (r2=0.27). It should be noted that the VA DEQ staff conducting these habitat assessments noted that habitat was limiting at the time of sampling (Virgina Department of Environmental Quality, 2005). The increase in habitat assessment score coincides with an increase in benthic health score, using a physiographically calibrated, temporally stable Multi-metric Index (WVSCI). Figure 2 presents a chart of WVSCI score with added trend line for the same stations over time.

Table 2 Summary of Habitat Assessment Data

Parameter	Avail. Score	May-91	Nov-91	May-92	Dec-92	Nov-93	Avail. Score	Jul-97	Sep-99
Bottom Substrate/Instream Cover	20	17	17	17	17	16	20	12	16
Embeddedness	20	7	7	7	9	6	20	16	13
Habitat Diversity	20	8	7	7	7	11	20	8	6
Canopy Cover	20	7	6	7	16	16	20	15	13
Channel Alteration	15	11	12	6	13	13	20	14	14
Bottom Scouring / Deposition	15	9	8	8	8	8	20	7	5
Pool / Riffle Ratio	15	10	8	6	9	7	20	15	7
Lower Bank Channel Capacity	15	12	9	5	6	4	20	16	7
Bank Stability	10	5	4	4	4	4	20	6	8
Bank Vegetative Stability	10	6	7	4	6	6	20	17	15
Streamside Cover	10	4	4	4	4	5	20	8	14
Riparian Vegetative Zone Width	10	4	7	4	4	2	20	8	5
	180	100	96	79	103	98	240	142	123
% Available Score		0.56	0.53	0.44	0.57	0.54		0.59	0.51

Parameter	Avail. Score	Dec-03
Epifaunal Substrate/Available Cover	20	18
Embeddedness	20	17
Velocity / Depth Combinations	20	16
Sediment Deposition	20	11
Channel Flow Status	20	15
Channel Alteration	20	15
Frequency of Riffles	20	16
Bank Stability	20	6
Bank Vegetative Protection	20	6
Riparian Vegetative Zone Width	20	6
	200	126
% Available Score		0.63

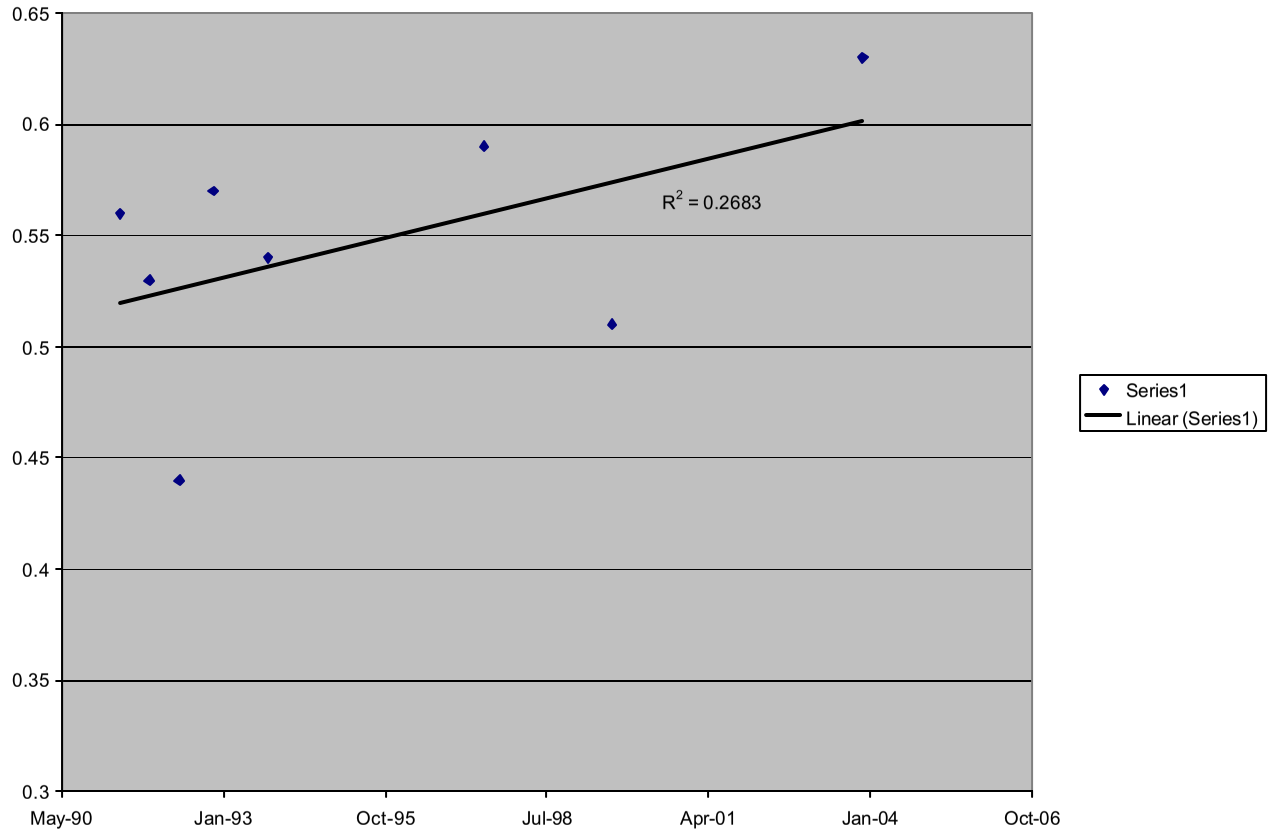

Figure 4 % Available Habitat Score Over Time

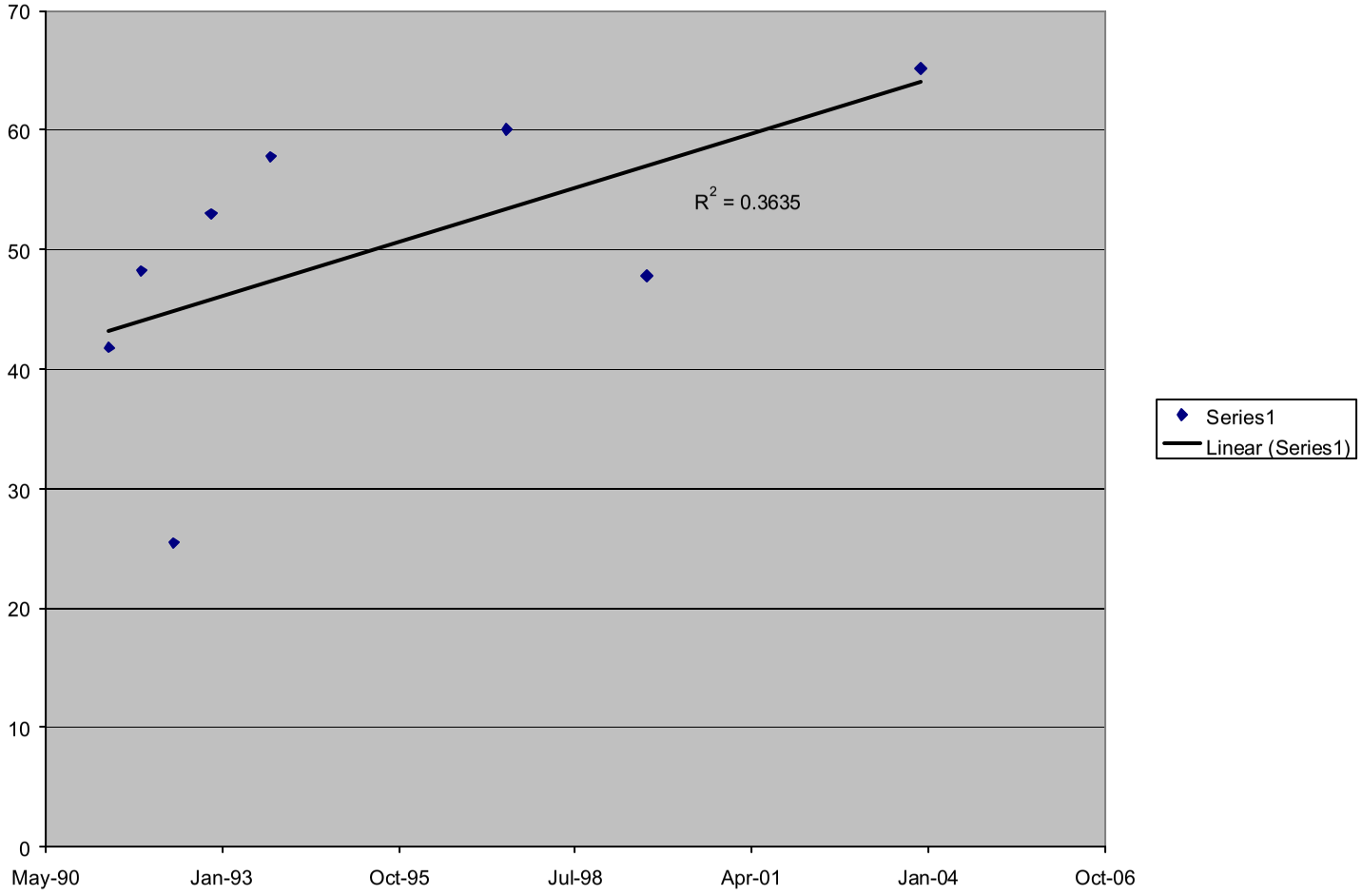

Figure 5 WVSCI Benthic Assessment Data Over Time

2.2.3.3 Stream Morphology

There are several methods for quantifying stream channel morphology. Stream channel morphology plays a vital role in bed stability and subsequently habitat quality. Changes to stream channel pattern result in changes to flow pattern, sediment deposition and scouring. These changes can affect benthic macroinvertebrate scores.

Preliminary stream morphology measurements were made at Straight Creek, Middle Creek and the McClure River. Methods used followed *Applied River Morphology* (Rosgen, 1996). Stream geometry and channel stability functions were focused on. It was readily apparent from the data that the channel has been altered for the purposes of urbanization. The key features that were different in Straight Creek than its references were: Entrenchment Ratio, Dominant Channel Materials, Sinuosity, Meander Pattern and Riparian Vegetation. Following is a summary of the morphology characteristics and consequences:

- **Entrenchment Ratio** – an index which is used to describe the degree of vertical containment of a river channel.
- **Dominant Channel Materials** – a "pebble count" of the dominant materials making up the stream channel pavement.
- **Sinuosity** – the ratio of stream length to valley length. This metric is directly affected by channel confinement.
- **Meander Pattern** – generally describes plan view pattern of lateral adjustments to the stream channel.
- **Riparian Vegetation** – composition, vigor and density of riparian vegetation directly affect physical protection, shading, water temperature, erosion control and energy input (allocthanous).

Straight Creek is characterized by deep entrenchment that can be associated with confinement of the stream channel. Furthermore, Straight Creek for much of its length is disconnected from its flood plain. This is likely a result of urban land use. Dominant channel materials for Straight Creek, specifically in Riffle/Run complexes, were estimated to be small gravel/large sand. This dominant bed material is likely the result of

stream bank erosion and uncontrolled land disturbances. This result directly affects habitat suitability for benthic organism colonization. Sinuosity is nearly non existent for portions of Straight Creek. This has been created by channelization and re-routing of the stream channel for urbanization. Likewise, meander pattern has been affected by channelization and re-routing such that Straight Creek is truncated.

Urbanization of the Straight Creek watershed has led to changes in stream morphology. These changes have led to habitat degradation and ultimately impairment of the benthic macroinvertebrate community. Success of the TMDL is not likely unless habitat is considered a primary cause of impairment and, ultimately, "Use Attainment".

2.2.4 Household Waste Discharges

The role of untreated domestic waste on benthic macroinvertebrate impairment has largely been overlooked in the Straight Creek TMDL development. The Straight Creek watershed contains approximately 1200 structures based on the USGS map. Most of these structures are located immediately adjacent to the stream. A very small proportion of these structures are connected to the sanitary sewer system (~130). Therefore, an enormous amount of untreated domestic waste is being discharged, either directly (straight pipes) or indirectly (failed septic systems), into Straight Creek. Streams have been 303(d) listed in the central Appalachian ecoregion with the only source of benthic impairment being straight pipes (Lowman, 2005).

2.2.5 Example Stream

Biological Monitoring, Inc. has performed surveys in a stream in the central Appalachian ecoregion (Twentymile Creek) twice annually for five years (Biological Monitoring, Inc., 2005). This example watershed is of similar size and order to straight creek. One major difference between the watersheds is land use and ultimately habitat quality. Twentymile Creek has a similar proportion forested and more extensive mining than Straight Creek. However, Twentymile Creek has no improved roads or housing in the valley floor. Likewise, there are no uncontrolled household waste discharges into Twentymile Creek. Habitat is near optimal at stations with elevated conductivity / TDS.

Conductivity / TDS are quite elevated in Twentymile Creek. More than 85% of samples collected exceeded the 90th percentile of the McClure River for both conductivity and TDS. Low flow samples that have been collected yielded results of conductivity of 3000 umhos/cm and even greater. In spite of these elevated levels of conductivity / TDS, benthic macroinvertebrates have remained unimpaired. That is, all samples collected have scored in the "Very Good" range for the West Virginia Stream Condition Index. This indicates that this stream is comparable to the best reference stations in the ecoregion. Therefore, the use of the 90th percentile of the McClure River in order to establish cause is an arbitrary yardstick. Furthermore, given these data it is unlikely that conductivity / TDS are responsible for the benthic impairment in Straight Creek. It is more likely that habitat and uncontrolled household waste discharges are the limiting factors for benthic macroinvertebrate health.

2.3 Stressor Conclusion

The Straight Creek Benthic TMDL Stressor Identification process was conducted improperly. Though the USEPA's Stressor Identification Guidance Document may not require specific techniques, it does require that sound science and clear logic be used to support the choice of probable stressor. The Stressor Identification narrative does not present a conceptual model of stressor and impairment associations in the Straight Creek watershed. The causal evidence presented does not consider spatial and temporal co-occurrence or gradients of cause and effect. Confidence of conclusions has not been evaluated. No consideration was given to the fact that the gathering of further data may have been necessary before a probable stressor could be chosen. These shortcomings result in an unscientific, illogical, and ultimately unusable Stressor Identification document.

Errors in the Stressor Identification process stem from several faults with the approach to data analysis. Use of the 90th percentile logic in general ignores the biological significance of exceedances. Straight Creek is improperly treated as spatially and temporally homogenous. Given the homogenous assumption, data should not have been

selectively presented in a manner which did not represent the condition of Straight Creek as a whole. Important stressors were not considered fully in the development process. Both habitat quality and uncontrolled domestic waste discharges likely play a significant role in the impairment of the Straight Creek benthic macroinvertebrate population. Conclusions were justified with vague, anecdotal language with poor use of literature support and poor quantification of assertions. What literature support there was for biological significance was not used quantitatively. Collection of additional biological, chemical or habitat data was rejected as an option.

Given the numerous gaps in logic and absence of sound scientific causal evidence, it is respectfully requested that the following actions be taken:

1. Withdraw total dissolved solids and conductivity as probable stressors.
2. Perform a more rigorous sampling of Straight Creek, including RBPIII invertebrate surveys with concurrent physicochemical sampling. Use these data for determination of spatial and temporal associations between cause and effect.
3. Consider fully habitat's potential role as a primary stressor and the limiting factor to use attainability.
4. Consider fully uncontrolled domestic waste discharges as a primary stressor and a limiting factor to use attainability.
5. Properly measure suspended sediment loadings using the Suspended Sediment Concentration method for both Straight Creek and any stream used in comparisons. Use these data to develop a more accurate causal relationship between suspended and deposited sediment in Straight Creek.

3.0 ALLOCATION MODELING

3.1 Introduction

A critical review of the Powell River TMDL models was conducted to understand the methodologies, assumptions, and data used to develop the TMDL and set allocations. While most of the TMDL modeling process appeared transparent as written in the TMDL document, quite a few issues were identified through the review. Most of these issues were due to a lack of clarity in the document. However, a couple of these issues were significant and indicate fundamental flaws in the modeling process that could invalidate the TMDL allocations.

First and foremost were that model results indicated zero sediment loads from reclaimed mine lands. This was a completely unreasonable result, particularly when compared to the loads from the reference watershed. Given the size of the reclaimed mine lands in Callahan and Straight Creeks, this was not a trivial issue. If the result were based on the assumption that all reclaimed mine lands discharge through permitted point sources, this too was a flawed assumption. Any TMDLs based on this result should be considered invalid.

Secondly, the modelers set allocations using the calibration hydrologic period rather than a representative hydrologic period for TDS and sediment. A calibration hydrologic period is based on availability of data. A representative hydrologic period is based on the TMDL requirement of protecting the resource during critical conditions. These are independent considerations. This problem has been compounded because the models were not validated with a set of data independent of the calibration data. The choice of using the calibration hydrologic period as the representative hydrologic period demonstrated the lack of confidence in the models' ability to represent different hydrologic conditions, which could have been avoided by the important step of validating the model.

3.2 General

When critically reviewing a mathematical model of natural systems, it is important to recognize that models, by definition, are imperfect representations of actual conditions. Any model, under scrutiny, may be deemed flawed. However, models are valuable and necessary tools for planning and management of complex natural systems. Therefore, a critical review of a model should focus on two questions: 1) was the selected model appropriate for the systems and the goals of the plan, and 2) have the models been used appropriately for the given system?

For the purpose of the TMDL for the Powell River basin, there is little reason to address the first question. The HSPF and the GWLF programs have been accepted by the VA DEQ and been used for many of its approved TMDLs. So even though one could legitimately argue that GWLF is far too simplistic to be used for something as complex as sediment load allocations, there was limited utility in this argument, particularly this late in the process.

So accepting that these models were appropriate for the purpose of developing TMDLs for the Powell River basin, the critical review focused on whether these models were used appropriately for the application. A review of this type included assessing the suitable use of parameters, hydrologic time frames, allocation methods, etc. The following critical review addressed those concerns.

3.3 Critical Review

It is apparent that the developers of the Powell River basin TMDL document have made a good-faith effort to use the HSPF and GWLF models appropriately. Their efforts to represent all sources and physical processes governing pollutant loads were well documented (with some exceptions to be identified later). The modeling approach was comprehensive and generally technically sound.

Nevertheless there exist some modeling issues that were of concern. Three of these issues could be considered critical flaws in the TMDL development process. Other issues might be critical, but require further explanation from the modelers. Several minor issues that might not be important to the overall process have been also identified. A description of these issues, and relevant clarifications are described herein. These issues are listed in a decreasing level of importance.

1. Modeling of Sediment Ponds and Reclaimed Mine Land in GWLF

While the sediment ponds are modeled very explicitly in HSPF for TDS, the document ignores them when describing the modeling process for GWLF. Given that the GWLF was used for sediment allocations, it is a curious omission that sediment ponds are not specifically addressed at best in the document, and at worst in the model.

It is important to know which are the drainage areas that contribute to the sediment ponds. Without this clearly documented, it is impossible to interpret the sediment loads for the models. It is critical to understand this because **the GWLF results indicate zero sediment loads from reclaimed mine land.** (pgs 10-40, 41). Considering that approximately 2,100 hectares in Callahan Creek and 525 hectares in Straight Creek (pgs 10-38,39) were modeled as reclaimed mine lands, it is highly questionable that these areas produce no sediment load. Table 11-8 categorizes reclaimed mine loads with the permitted mine loads, which seems to imply that 100% of the reclaimed mine land discharges to these sediment ponds, **but this is not true**. The lack of sediment loads from reclaimed mine lands is unreasonable, particularly when compared to the loads from reclaimed mine lands in the reference watershed. Therefore, it appears the model contains a **fundamental flaw**, which would invalidate the TMDL allocations.

2. Selection of representative hydrologic period for TMDL allocations

For TDS and sediment TMDL allocations, the hydrology used for Powell River was not selected to be representative of critical or average conditions. According to the document *"The allocation precipitation time periods were selected to coincide with the calibration time periods. Modeling during the calibration periods provides the highest confidence in*

allocation results." (pg 4-22). This is not a valid statement. Modeling during representative hydrologic periods provides the highest confidence in allocation results. Representative hydrologic periods for TMDL allocations should be based on the goals of protecting water quality during critical periods, not based on when calibration data were available. The authors of the Powell River TMDL understand this because they provide an excellent example on selecting representative conditions in the approved Catoctin Creek TMDL (Map Tech, Inc., 2002).

It is unclear why the authors did not provide a similar analysis for the Powell River TMDL. And while a very limited analysis was provided to determine a representative hydrologic period for the fecal bacteria TMDL allocation, no analysis was provided for TDS and sediment allocations. Note that the calibration period for Callahan Creek used rainfall from 1/1/95 through 09/30/99, which was a period of record that included severe long-term drought conditions. Therefore an allocation of sediment, which is highly dependant on significant rainfall events, has been based on rainfall during an extensive dry period.

3. No model validation

Compounding the problem of using the calibration period for TMDL allocations was the fact that the models for the Powell River basin were not validated. The validation step is important to ensure that calibration results were applicable over a range of conditions, and meaningful applications should be validated with data independent of the calibration data (Thomann and Muller, 1982).

The authors state that insufficient data and changing land use conditions precluded both calibration and validation. However, other approved TMDLs in Virginia have provided calibration and validation steps with similarly limited data (e.g., Four Mile Run TMDL) (Northern Virginia Regional Commission, 2002). A model that is not validated increases the uncertainty of the model results (DePinto et al, 2004). The modelers have demonstrated a lack of confidence in the model's ability to represent conditions with

different hydrologic conditions by using the calibration period instead of a representative hydrologic period for TMDL allocations.

4. Selection of a Representative Modeling Period for Calibration

The TMDL document described one of the more difficult issues for watershed modelers. How does one calibrate a model over a period of record and develop a baseline condition when the land use is variable during the calibration period? In this case, mining activities, including disturbing land and reclaiming land, causes changes in land use conditions annually. The modelers attempted to find hydrographically stable periods that also coincided with periods of data availability. The report says *"the hydrographic landscape of the watershed was relatively stable during the hydrology calibration periods, 10/1/2001-9/30/2003, for the Upper Powell River…."(pg 4-19)*. This assertion seems contradictory to Figure 4-8 that shows that this period had a substantially variable record of land disturbances by mining activities (pg 4-20). If, in fact, the hydrographic landscape was as variable as Figure 4-8 suggests, calibration during this time period should be evaluated cautiously.

5. Selection and Calibration of Curve Numbers

It would be helpful if the documentation identified specifically how curve numbers were selected for each watershed (Table 10.10, pg 10-37). It is not clear why forest areas in Middle Creek would have a higher curve number than forest areas in Callahan and Straight creeks, given that all three watersheds contain Type B soils. Intuitively, one would assume that Middle Creek, which is 98% forested land (Fig 9-3, pg 9-4) would have a lower area-weighted curve number than Callahan Creek, which is 68% forested and 31% permitted mining. (Fig 9-3, pg 9-4). However Middle Creek had the highest area-weighted runoff curve number of all three watersheds (Table 10.8, pg 10-36). The soil erodibility was also highest for Middle Creek.

Additionally, within each watershed, the curve numbers were the same for forest areas, disturbed forest areas, pasture-hay, pasture-overgrazed, pasture-unimproved, and pasture-

improved (Table 10-10, pg 10-37). This was not consistent with TR-55 guidance for curve number selection.

Adding to the confusion on how curve numbers were selected was the sensitivity analysis for curve numbers. For sensitivity analyses, the modelers ran four scenarios for each parameter. These four scenarios varied the base value of the parameter by -10%, -50%, +10%, and +50%. Changes in model output were reported in Table 10.4 (pg 10-21). The relevance of varying these parameters by percentage is questionable; however it is the results that were more questionable.

Where the curve number was increased or decreased by 50%, the percent change in runoff was only 4%. Note that a 50% increase in the base value curve number increases it from 65 to 97.5. This would be equivalent to changing the land use from 100% pasture to 100% parking lot. Either the documentation does not adequately describe these sensitivity analyses, or it is *highly questionable* whether the sensitivity analyses for curve number were valid. However, this might have been an artifact of using a drought period for calibration and allocation. It doesn't matter how much one changes the land surface. In the absence of rain, these changes won't matter.

3.4 General Comments

The following section includes some general comments about the document and the technical data within. Some of these could lead to additional critical reviews of the modeling effort. These are presented in a bullet list in the order they appear in the TMDL document.

- The sensitivity analyses tabulated in Tables 4-8 and 4-9 would have been better served by using percent change in model output (pgs 4-25,26).

- The hydrologic calibration of HSPF described in Section 4.7.1 defines the parameters that were adjusted, but later refers to the parameter AGWETP that was not defined. This parameter needs to be defined in the documentation (pgs 4-41,2).

- Calibration plots featuring peak and base flows can often mask results due to the order of magnitude differences between these flow regimes. Specifically, since no measurements were taken during peak flows shown on Figures 4-25 and 4-26, there is no utility in providing calibration output showing modeled peak flows. These Y-axes should be truncated or shown on a log scale so that calibration results for low flow conditions can be assessed. (pgs. 4-47,48) Additionally, Figure 4.24 would benefit from using a log scale for the Y-axis (pg 4-46).

- In Section 7.4.2, the report states, *"It is clear from the data available that conductivity and TDS values have very large fluctuations over the sampling period."* (pg 7-37). This statement was not made in context of natural fluctuations in these parameters nor based on statistical tests. The TDS and conductivity data show some fluctuations, but within an order of magnitude. Compared to fluctuations in the other regulated parameters, fecal coliform and sediment, these fluctuations were not nearly as large.

- Many of the longitudinal median concentration plots provided (e.g., Fig. 8.48) were misleading because the datasets from individual monitoring stations were not statistically comparable. These plots can lead to false conclusions about "hot spots" within the stream reach, when in fact the variation was a result of some stations containing a short-term sampling period and some stations containing a longer-term sampling period.

- The documentation describes the analysis of data submitted by BMI. Specifically the report state, *"The chemical data was very similar to the data provided by DMME that was discussed in Chapter 6. The analysis of this data did not alter the decision that sediment and TDS are the probable stressors in Straight Creek."* (pg 8-49). A summary of the comparative analysis should have been provided to document that the data provided by BMI were very similar to the data provided by DMME.

- A statistical summary should have been provided for the injection well data that was used to determine the direct mine discharge of 1,000 mg/L for TDS (pg 10-14).

- The application rates for road salt and road brine should have been provided in the documentation (pgs 10-14, 15).

- The maximum calibration numbers for groundwater TDS concentration and interflow TDS concentration for Straight Creek were 800,000 and 475,000 mg/ft^3, respectively. These values were considerably higher than the calibrated maximum values in Callahan Creek, which were 225,000 and 200,000 mg/ft^3, respectively (Tables 10.5-6, pg 10-23). These values do not seem reasonable. Furthermore, given that Straight Creek has less mining land use, it does not seem reasonable to have this difference between the two watersheds.

- When calibration was conducted by varying specific parameters, it is not clear whether the changes in parameter values were global throughout the watershed, or if any were modified locally within the watershed?

- Most of the table numbers in Section 10 are incorrect because table numbers 10.3 and 10.4 were repeated.

3.5 Modeling Conclusion

The Straight Creek TMDL Group recommends the withdrawal of this TMDL based upon the numerous issues cited above. The most critical issues included incorrect sediment loads for reclaimed mined lands, a non-representative hydrologic period for TDS and sediment and no model validation. Therefore, both the estimates for current loadings as well as the allocations derived there from are suspect. In the absence of the input data files that have been twice requested, the stakeholders assume the values are incorrect and the modelers have minimal confidence in the models. A meaningful evaluation of the

models was not possible. Therefore, the State should reevaluate the loadings and subsequent allocations with more site-specific data.

4.0 LITERATURE CITED

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Comment Document #4

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MID-ATLANTIC ENVIRONMENTAL LAW CENTER

April 13, 2005

Nancy T. Norton, P.E.
Virginia Department of Environmental Quality
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Dear Ms. Norton:

The following comments on the Proposed Total Maximum Daily Loads ("TMDL") for Fecal Bacteria and General Water Quality (Benthic) to Powell River Basin in Virginia ("Powell River TMDL") are submitted by the Mid-Atlantic Environmental Law Center ("Commentors").

REGULATORY BACKGROUND

The TMDL program of the Clean Water Act (CWA) section 303(d) sets forth a clear process that all states must follow when compliance with standards has not been achieved for all waters. In short, each state, must (1) identify all of its impaired waters, the current effluent limitation for which are 'not stringent enough to implement water quality standards" ("WQS") and (2) for each identified water, establish daily pollutant load limits-TMDLs- of each pollutant contributing to the impairment. 33 U.S.C. § 1313(d). TMDLs are to be calculated at a level that will ensure attainment of water quality standards and are to be implemented by allocating the loads among the water's point sources and non-point sources of pollution. Id.; 40 C.F.R. §§130.2(g), (h), (i), 130.7.

MID-ATLANTIC ENVIRONMENTAL LAW CENTER

Mid-Atlantic Environmental Law Center ("MAELC") is a not-for-profit environmental law firm that provides legal services to public interest organizations in environmental matters, such as submitting comments to agencies. MAELC's mission is to restore and protect the environment by providing superior legal services to help resolve environmental challenges in the Mid-Atlantic United States, including Virginia. MAELC aims to ensure that environmental requirements are met, and the legislation and regulations are adequately implemented by the responsible federal, state, and local agencies. MAELC is keenly interested in TMDLs, having

successfully obtained several consent decrees requiring the development of TMDLS consistent with the CWA.

GENERAL COMMENTS

- The purpose of establishing TMDLs is to ensure that the water quality standards in the water body can be met after implementation of the TMDL. To ensure that the water quality standards are met, a conservative approach to all aspects of the TMDL, including waste load allocations ("WLA"), load allocations ("LA") and margin of safety ("MOS") must be utilized.

- Commentors commend Virginia DEQ for producing such a well-developed and thorough TMDL. Additionally, commentors are pleased with the Implementation Plan that is included in the TMDL. Powell River TMDL § 12. A proper implementation plan is important to ensure that the TMDL will be followed and enforced. This implementation plan adequately describes control actions and/or management measures that will be implemented to achieve the TMDL. Commentors would also like to see a time-line for implementing control actions and/or management measures as well as a description of the legal requirements under which the control actions will be carried out.

FECAL BACTERIA COMMENTS

- A proper explanation as to why the National Land Cover Data ("NLCD") is the appropriate dataset for establishing this particular TMDL has not been included in the TMDL. Additionally, the TMDL does not properly explain what is considered when using NLCD to establish a TMDL. Powell River TMDL § 3.1. This information is important because it allows the reader to ascertain whether NLCD is appropriate for this particular TMDL. Without setting forth detailed information regarding NLCD, the TMDL is inadequate.

- A proper explanation as to how it was determined that cats and dogs, among pets, are the predominant contributors of fecal coliform in the watershed is absent. Therefore, it is unclear from the text of the TMDL as to how this was determined that cats and dogs were to be the only pets considered in the analysis. Powell River TMDL § 3.3.2. This information is needed to allow the reader to determine whether it is appropriate to only account for cats and dogs and not other pets. Without detailing how it was determined to only account for cats and dogs, the TMDL is inadequate.

- It is indicated in the TMDL that the USGS Hydrologic Simulation Program – Fortran ("HSPF") water quality model was used as the modeling framework for this TMDL. Powell River TMDL § 4.1. Additionally, the TMDL does not properly explain what is considered when using the HSPF water quality model to establish a TMDL. This information is important because it allows the reader to ascertain whether the HSPF water quality model is appropriate for this particular TMDL. Without setting forth detailed information regarding the modeling analysis, the TMDL is inadequate.

- It is indicated in the TMDL that die-off of fecal coliform can be handled implicitly or explicitly. Additionally, it is indicated that it was represented implicitly for purposes of this TMDL. Powell River TMDL § 4.2.2. The TMDL does not properly explain how it was determined that implicit representation is appropriate for purposes of this particular TMDL. This information is important because it allows the reader to ascertain whether implicit representation of die-off of fecal coliform is proper for this TMDL. Without setting forth detailed information regarding why implicit representation was selected, the TMDL is inadequate.

- A proper explanation as to how modeling periods were selected is absent. Therefore, it is unclear from the text of the TMDL as to how this was determined. Powell River TMDL § 4.5. This information is needed to allow the reader to determine whether the representative modeling periods are appropriate. Without detailing how the representative modeling periods were determined, the TMDL is inadequate.

- The TMDL does not provide adequate information regarding whether a MOS is incorporated in the TMDL. The TMDL only gives examples of the implicit MOS used in the development of the TMDL. Powell River TMDL § 5.1. The absence of a MOS indicates a deficiency in the TMDL because a true TMDL consists of WLAs for point sources, LAs for nonpoint sources and a MOS. Therefore, the TMDL is inadequate because it does not provide a safeguard to ensure that the TMDL will actually be met.

- The TMDL is established in cfu/yr. However, the commonly accepted method of describing the loading is in units of mass per day. Therefore, the TMDL is inadequate because it does not accurately reflect the definition of a Total Maximum Daily Load, which requires a daily load.

- The TMDL does not provide adequate information regarding allowance for future growth. Accounting for future growth in the area is important to ensure that the TMDL implementation will be effective. The TMDL is inadequate because it does not account for any reasonably foreseeable future growth in the area.

GENERAL WATER QUALITY (BENTHIC) COMMENTS

- A proper explanation as to why a reference watershed approach was appropriate in establishing this particular TMDL has not been included in the TMDL. Powell River TMDL § 9. This information is important because it allows the reader to ascertain whether a reference watershed approach is appropriate for this particular TMDL. Without setting forth detailed information regarding the reference watershed approach, the TMDL is inadequate.

- It is indicated in the TMDL that the USGS Hydrologic Simulation Program – Fortran ("HSPF") water quality model was used as the modeling framework for this TMDL. Powell River TMDL § 10.1. Additionally, the TMDL does not properly explain what is considered when using the HSPF water quality model to establish a TMDL. This

information is important because it allows the reader to ascertain whether the HSPF water quality model is appropriate for this particular TMDL. Without setting forth detailed information regarding the modeling analysis, the TMDL is inadequate.

- A proper explanation as to why it was assumed that nonpoint source contributions from the fourteen landuse categories are delivered to the stream flow system in surface runoff, interflow and groundwater is absent. Therefore, it is unclear from the text of the TMDL as to how this was determined. Powell River TMDL § 10.3.1.2. This information is needed to allow the reader to determine whether it is appropriate to assume that nonpoint source contributions from the fourteen landuse categories are delivered to the stream flow system in surface runoff, interflow and groundwater. Without detailing how this was determined, the TMDL is inadequate.

- It is indicated in the TMDL that three source areas identified as the primary contributors to sediment loading include surface runoff, point sources and streambank erosion. Powell River TMDL § 10.3.2. The TMDL does not properly explain how it was determined that those three source areas were identified as the primary contributors to sediment loading. This information is important because it allows the reader to ascertain whether the primary contributors are proper for this TMDL. Without setting forth detailed information regarding why the three sources were selected, the TMDL is inadequate.

- A proper explanation as to how modeling periods were selected is absent. Therefore, it is unclear from the text of the TMDL as to how this was determined. Powell River TMDL § 10.4. This information is needed to allow the reader to determine whether the representative modeling periods are appropriate. Without detailing how the representative modeling periods were determined, the TMDL is inadequate.

- The TMDL does not provide an adequate explanation regarding why a 10% explicit MOS is proper for this TMDL. Powell River TMDL § 11.3. This information is needed to allow the reader to ascertain whether the MOS is appropriate. Without detailing how the MOS was selected, the TMDL is inadequate.

- The TMDL is established in mg/yr. However, the commonly accepted method of describing the loading is in units of mass per day. Therefore, the TMDL is inadequate because it does not accurately reflect the definition of a Total Maximum Daily Load, which requires a daily load.

- The TMDL does not provide adequate information regarding allowance for future growth. Accounting for future growth in the area is important to ensure that the TMDL implementation will be effective. The TMDL is inadequate because it does not account for any reasonably foreseeable future growth in the area.

The Commentors appreciate the opportunity to provide these comments for your review. Please contact me if you should have any questions regarding this submission.

Very truly yours,

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Comment Document #5

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COMMENTS OF CUMBERLAND RESOURCES CORPORATION TO TMDL DEVELOPMENT FOR THE POWELL RIVER BASIN

Introduction.

The Virginia Department of Mines, Minerals and Energy ("DMME") and the Virginia Department of Environmental Quality ("DEQ") published a draft document dated February 7, 2005 entitled "Fecal Bacteria and General Standard Total Maximum Daily Load Development for the Powell River Basin" ("The Draft Report"). The Draft Report was prepared for DMME and DEQ by MapTech, Inc. of Blacksburg, Virginia and is a part of the process mandated by Va. Code § 62.1-44.19:7 entitled "plans to address impaired waters." The Draft Report purports to support the adoption of Total Maximum Daily Loads ("TMDLs") for fecal coliform, sediment, and total dissolved solids (TDS) in Callahan Creek in Wise County and Straight Creek in Lee County, both tributaries of Powell River.

Affiliates of Cumberland Resources Corporation, 152 West Valley Street, Abingdon, Virginia 24210 ("CRC") lease coal reserves and operate coal mines and coal preparation and loading facilities on Callahan Creek and its tributaries. The Cumberland affiliated entities so engaged are listed on Attachment A. These comments are submitted on behalf of CRC and each and all of the Cumberland affiliates (together "Cumberland").

Cumberland leases over 13,000 acres of land for coal mining within the Callahan Creek watershed. Within that area, it holds 15 CSMO and 15 VPDES permits, each issued by Virginia Division of Mined Land Reclamation ("DMLR"). It currently operates, directly or through independent contract mining companies, 12 surface and underground mines, a coal preparation plant and a refuse disposal area within the Callahan Creek watershed. Cumberland and supporting enterprises employ approximately 370 people on Callahan Creek. Cumberland intends to continue its mining operations and expand them in future years.

For the reasons set out below, the Draft Report is insufficient to warrant adoption of the recommended TMDLs by the State Water Control Board ("SWCB") and should be revised as stated below.

I. The Draft Report does not meet mandatory legal requirements.

The Draft Report is part of a statutory procedure mandating that the SWCB adopt and implement plans to "address impaired waters." Va. Code § 62.1-44.19:7. It is a critical part of the process of fixing TMDLs which, if approved by SWCB, will constitute a regulation within the Administrative Process Act, Va. Code § 2.2-4000 et seq. ("APA"), and the adoption of a water quality standard under Va. Code § 62.1-44.15.

TMDLs are not set by federal law. While the SWCB is mandated by § 303(d) of the federal Clean Water Act ("CWA") to establish TMDLs for impaired waters, there are no federally imposed mandatory limits for total dissolved solids ("TDS") or sediment concentrations, both of which are used to set TMDLs under the Draft Report. Some of the water quality standards which the Draft Report seeks to validate differ materially from federal law and regulation and are more restrictive than federal law. The standards proposed in the Draft Report are state standards, not federal ones.

The process in which the Draft Report is being proposed violates applicable law in the following respects:

a. TDS and sediment are not pollutants identified by the Administrator of EPA under §§ 303(d)(1) and 304(a)(2) of the Federal Clean Water Act ("CWA") and therefore are not proper subjects for TMDLs.

b. The proposed standards for TMDLs have not been provided to the appropriate committees of both houses of the General Assembly as required by Va. Code § 62.1-44.15(3a).

c. The Draft Report gives no basis for the SWCB to give due consideration to the economic and social costs and benefits which can reasonably be expected to occur as a result of the adoption of the proposed standards as required by Va. Code § 62.1-44.15(3a).

d. The Draft Report gives no basis for the SWCB to determine the associated costs, benefits, and environmental impact of the adoption of the TMDLs recommended therein as is required by Va. Code § 62.1-44.19:7.

e. The Draft Report is, in part, a proposed regulation. As such, it is required to be promulgated in accordance with the APA, including § 4007. The draft report and the standards it proposes have not been subjected to the mandatory processes of the APA for promulgation of regulations.

f. The Draft Report gives no basis for the SWCB to conclude that the water quality standards proposed in the Draft Report are economically feasible. The SWCB must act reasonably at all times. Its duty to do includes the duty to assess economic feasibility of its water quality standards.

g. The Draft Report does not distinguish in its analysis of benthic impairment and fecal bacteria between the discrete segments of Callahan Creek as set forth in the official Notice published in the Virginia Reporter, Volume 21, Issue 11, February 7, 2005, page 1419, and as required by Va. Code § 62.1-44.19:5(c)(1).

h. The Draft Report does not "include an assessment . . . for the attribution of impairment to point and nonpoint sources," as required by Va. Code § 62.1-44.18:5(c)(2). Without an assessment for attribution between point and nonpoint sources, any allocation of TMDLs between point and nonpoint sources will necessarily be arbitrary.

II. Generally, the TMDL Process has not been properly applied.

a. Among other things, federal regulations require TMDLs to consider the impacts of background pollutant contributions (i.e., natural background water chemistry which is primarily influenced by geology), critical stream conditions (e.g., low flow), seasonal variations, and reasonable assurance that the TMDLs can be met. 40 CFR §130.7.

The Draft Report fails to meet the regulatory requirements. First, the standards are set before the causes of impairment are known or sufficiently evaluated, and before a meaningful evaluation of implementation and remediation methodologies and reasonable assurance of achieving the standards is completed. [1]

b. Second, data quality and appropriate monitoring station selection are critical in TMDL development. "Available data" is not necessarily adequate data. The Virginia Water Resources Research Center, Water Quality Advisory Committee (2004) recommends additional sampling to confirm benthic impairment particularly given the high variability of environmental data. EPA's *Stressor Identification Guidance Document* (EPA 2000), provides that the stressor identification process includes an evaluation of the available data to determine whether it is sufficient to actually identify the cause of impairment, as well as whether the data is of a sufficient quality to make anything more than a rough estimate of the stressors. As the available data comes from many sources, collected by different procedures, thorough documentation is critical. Such documentation is lacking in the Draft Report. The documentation presented does not support the conclusions as to the identity of the stressors. Rough estimates are not adequate.

c. Because of the far-reaching consequences of imposed TMDLs, it is critical that the sound scientific standards be applied in setting them. In many respects the Draft Report

[1] If TMDLs are set now, it would be more appropriate for them to be provisional with adjustments to be made in the future as additional data is collected, data evaluation is completed, and the actual causes of impairment are known.

reflects an inadequate investigation and analysis of the stated benthic impairment, and the proposed remedies through TMDLs. These deficiencies are well-stated in the Straight Creek TMDL Group's comments under the heading "Process Issues," which are equally applicable to Callahan Creek and are embraced and incorporated by Cumberland. Given the lack of water quality data, flow data and rigorous calibration procedures, the use of a model with its inherent assumptions likely produced inaccurate results.

III. The Draft Report is inadequate to show that TDS and sediment are "stressors" in Callahan Creek.

a. Use of Available Data

The Draft Report indicates all available data was used to evaluate water quality. In fact there are at least eight additional monitoring stations sampled by Cumberland along the main stem of Callahan Creek. Data from these monitoring stations was submitted to DMME prior to the development of the TMDL and was available for the TMDL study but was not considered. The attached map shows the monitoring stations sampled by Cumberland throughout the Callahan Creek watershed. Locations 98.09/AS-1, 123.10/AS-1, 400.06/AS-2, 123.21/SW-3, 123.10/AS-6, 123.21/SW-2, 123.10/AS-7, and 811.01/AS-5 are in the main stem and should have been included in the study. These locations are monitored semiannually for both water quality and benthic impairment. The data shows varying TDS and conductivity levels with positive benthic health indicators. This is consistent with published studies indicating good benthic health with TDS levels up to 1,000 mg/L, with only the most sensitive organisms showing an adverse effect up to TDS levels of 2,000 mg/L (Kennedy *et al.* 2004, Kennedy *et al.* 2003).

Additionally, the EPT indices calculated at Cumberland's monitoring stations generally range from 7 to 14 with six data points less than 7 and eleven data points greater than 14.

Similarly, taxa richness was highest for these data points compared to all sample points. This indicates the creek's ability to support not only a diverse assemblage of invertebrate fauna but an assemblage composed of intolerant fauna as well.

Cumberland can find no indication in the Draft Report that this significant data was even considered by DEQ before identifying TDS as a probable stressor.

b. Reduction in TDS

According to the Draft Report, TDS concentrations need to be reduced 76% from nonpoint sources and 91% from direct sources. TDS loading in the basin comes from various sources, including the straight pipe discharges and water/rock reactions.

Remediation of the human component of TDS in the watershed (i.e., straight pipe discharge) is achievable using best management practices (BMPs). Remediation would show immediate reductions in measured TDS concentrations in Callahan Creek and would also decrease or eliminate the impacts of the observed biological impairment.

Remediation alternatives of the water/rock interactions producing TDS in the watershed (including significant alterations of mining and reclamation methods as proposed in the Draft Report) would be far more difficult and costly to implement, and probably could not achieve the proposed TDS standard of 334 mg/L. The proposed standard is significantly lower than the EPA secondary drinking water standard of 500 mg/L.

c. Effects of Habitat Impairment

In general, macroinvertebrates are highly sensitive to modifications in substrate and adjacent terrestrial habitat characteristics. Examples of these modifications include streambed alteration and/or redirection, streambed channelization, homogeneous bank stabilization (i.e. concreted or netted rip rap), and removal of riparian vegetation and/or canopy cover. The resulting stream effects typically include:

- Decrease in allochthonous inputs paired with increased light penetration. The increase in solar radiation increases mean seasonal water temperatures and stimulates autotrophic production by attached algae.
- Increased dissolved nutrient concentrations, especially nitrates and phosphates, due to increased runoff reaching the stream. This, combined with increases in light penetration and temperature, promote algal production.
- Overall change in allochthonous input quality due to terrestrial vegetation change from mature to successional species.
- Loss of large woody debris dams decrease channel complexity, channel stability, and retention of coarse and fine particulate organic matter (CPOM and FPOM). This ultimately leads to a shift in the composition of trophic relational communities (i.e. loss of macroinvertebrates with a shredder trophic habit).
- Increase in sediment inputs as a result of increased runoff. Sediment transport effects may continue for many years after the disturbance and may be further increased due to the lack of debris dams.

Coal has been mined in the Callahan Creek watershed since the late 19th century. The attached historical photographs illustrate that the creek was at the center of a major industrial complex. The creek was rerouted as necessary to accommodate mining operations. The attached recent photographs demonstrate that habitat degradation is likely the primary cause of the apparent impairment. The photographs illustrate eroded banks, lack of vegetation, manicured lawns continuing up to the creek bank, rip rap, gabions, bridge abutments, etc. The majority of sediment load produced in the basin is from pre-law mining and abandoned mined lands. Callahan Creek has not been in its "natural state" for 100 years. To expect that water quality changes will restore such a state appears unreasonable given the limits of available habitat.

Cause and effect relationships are difficult to establish among individual habitat assessment criteria and changes in invertebrate fauna. Likewise, specific water quality parameters such as TDS and conductivity are often unreliable indicators of benthic impairment. In fact, studies indicate that increases in conductivity support an increase in percent Ephemeroptera for levels under 2000 μS/cm (Kennedy *et al.* 2004). This trend is also noted for both conductivity and TDS in macroinvertebrate samples collected from Callahan Creek by Appalachian Technical Services, Inc. from December 2001-2004, but habitat assessment scores for Callahan Creek tend to fall in the suboptimal quality range.

Numerous studies have compared benthic macroinvertebrate community responses to a known stressor. However, few studies have compared the relative benthic macroinvertebrate metric response of stressors (e.g., TDS, conductivity) to their coexisting habitat conditions (i.e., habitat assessment scores). Such a study conducted by the EPA demonstrated that plecoptera and ephemeroptera richness (EPT metrics), proportional abundance of tolerant taxa, and tolerant taxa richness were sensitive indicators of habitat degradation rather than water quality (Yuan and Norton 2003). Of the seven metrics calculated for Callahan Creek, the lowest scoring metrics were taxa richness, % dominant taxa, EPT index, and community loss index. The similarities in richness and tolerance measures of the Callahan Creek metrics adds to the likelihood that benthic impairment originates from habitat degradation rather than TDS.

d. Chronic Toxicity Testing

EPA completed a chronic toxicity study using fathead minnows (*Pimephales promelas*) and *Ceriodaphnia dubia* on an ambient water sample collected from Callahan Creek at station number 6BCAL000.03. According to the report, the tests were completed "to determine if water column toxicity is stressing the benthic community." The test results, dated February 23, 2005, show that water quality is not stressing the benthic community. This conclusion is consistent

with Merricks' thesis, cited in the Draft Report, which does not support a strong correlation between benthic impairment and elevated conductivity. A master's thesis which has not undergone peer review, should not be relied upon as the sole scientific evidence of such a correlation, particularly where no strong correlation is stated by the author and the correlation is not supported by qualified scientists. See Dr. Peter De Lisle's comments, attached.

Conductivity of the water during the test ranged from 476 μmhos to 625 μmhos; this corresponds to approximate TDS concentrations of 319 mg/L to 419 mg/L. Five of the seven conductivity measurements exceeded the 334 mg/L standard proposed in the TMDL. This supports the previous discussion regarding the effect of TDS concentrations on aquatic life. It is not surprising that a TDS level of approximately 419 mg/L had no stressing effect on the fathead minnows or *Ceriodaphnia*, since the published literature indicates that levels in excess of 1,000 mg/L have no effect (Lasier *et al.*, 2004, Kennedy *et al.* 2004, Kennedy *et al.* 2003, Lasier *et al.*, 2002, Chapman *et al.*, 2000, Gas Research Institute, 1994, Prosser, 1973).

This result, conclusions reached from other studies discussed above, and Cumberland's evaluation of the Draft Report indicate that TDS is not a stressor in Callahan Creek. In order to further evaluate our conclusion, we solicited the opinion of Dr. De Lisle, President of Coastal Bioanalytics, Inc., and an expert in toxicity testing. Therefore Cumberland requests that TDS be deleted as a probable stressor in Callahan Creek.

IV. <u>The Draft Report is inadequate to support the TDS and Sediment TMDLs</u>.

a. Reference Watershed Selection

The Reference Watershed Candidate Comparisons table prepared by MapTech dated October 18, 2004 (attached) which was used to evaluate potential reference watersheds and to select Middle Creek as the reference watershed, contains incorrect percentages for land use categories in Callahan Creek. Page 9-4 of the Draft Report. For example, the watershed is listed

as 95% forested in the table whereas the report states it is 68% forested, and the table lists mining occupying 3.1% of the land area, whereas the report notes 31%. The percentages in the table are used to support Middle Creek as a reference watershed. The land use category percentages in the Draft Report however point out its significant shortcomings as a reference watershed. The report notes Callahan is 68% forested versus 97% in Middle Creek, 31% permitted mining in Callahan Creek versus 0% in Middle Creek; agricultural land use in Callahan Creek occupies 0.6% versus 1.3% in Middle Creek.

The soil types in the two watersheds are different, even when considering the grossly generalized soils categories used by STATSGO. The soils categories presented there are so generalized as to be meaningless at a watershed scale. As noted in the STATSGO Data Base Data Use Information publication (USDA, 1995), "STATSGO data are not detailed enough to make interpretations at a county level." Therefore, they are certainly inappropriate for decision-making at the level of detail necessary for evaluating a watershed the size of Callahan Creek. The geology of the two basins is not evaluated as noted above. Additionally the overall morphology of the watersheds is significantly different, leading to different characteristics in stream morphology and habitat. A comparison between such differing watersheds is inappropriate for use as the basis for establishing water quality standards.

Page 9-1 of the Draft Report states, the reference watershed should have a similar area, "not to exceed double or less than half that of the impaired watershed." Table 10.11 of the Draft Report shows that Middle Creek is less than half the size of Callahan Creek.

A reference watershed should be chosen based on its comparability to the watershed under evaluation. Based on the Draft Report and the Reference Watershed Candidate Comparison table, the criteria for evaluation included size, stream order, land use, soils, hydrologic group, slope, and erodibility. Geology has a major influence on the characteristics of

a watershed, including the geomorphology as well as the water chemistry as noted below in the discussion on natural background levels of TDS. Geology was not considered in the selection of a reference watershed. As a result, the conclusions based on a comparison between the Callahan Creek watershed and Middle Creek or McClure River watersheds are not justified.

The Callahan Creek watershed is underlain by Pennsylvanian-age rocks of the Lee Conglomerate, the Norton Formation, the Gladeville Sandstone, the Wise Formation, and the Harlan Sandstone. The Wise Formation includes the coal-bearing strata as well as siltstones, sandstones, and shales. The strata adjacent to the coal seams are unusually alkaline as noted on the attached Acid-Base Account Sheets. Based on the presence of brackish water and marine fossils and lithologic characteristics, these strata were likely deposited in a back-barrier depositional environment. This environment would have produced the carbonaceous sands, silts and shales present in this watershed. These alkaline strata are unique to the Callahan Creek watershed and two adjacent watersheds, Roaring Fork and Looney Creek.

The Middle Creek watershed is underlain by Mississippian-age limestones, shales, and sandstones. The coal seams are located in the Price Formation between sandstones and shales. These sandstones and shales are not the carbonaceous alkaline variety found in the Callahan Creek watershed. Therefore, as the rocks and minerals from these strata weather (particularly oxidation of pyrite in the shales) acid mine drainage (AMD) is formed and is not naturally buffered as it is in the Callahan Creek watershed. The documented benthic impairment in Middle Creek was caused by this AMD and associated water chemistry. The elevated pH measurements in the Middle Creek Delisting Report are likely due to treatment of mine discharges required to elevate the acidic pH prior to discharge. The reclamation efforts in Middle Creek were aimed at addressing the impairment resulting from this lower pH mining environment. This is very different from the Callahan Creek watershed where the naturally

alkaline strata surrounding the coal seams buffers discharge associated with the mining activities as evidenced by the differences in pH data between Callahan Creek and Middle Creek.

Therefore, although both watersheds were mined, the differing geology in the two watersheds results in very different characteristics of mine discharges and very different potential surface water impacts based on the different weathering of alkaline versus non-alkaline strata. The mining impacts causing the biological impacts to Middle Creek were easy to identify and mitigate compared to the impact of TDS on Callahan Creek.

DEQ has remarked that stakeholders were given the opportunity to provide input into the selection of the reference watershed at a previous public meeting during the Summer of 2004. As the public meeting to which DEQ refers was held before its determination of the potential stressors in Callahan and Straight Creeks, stakeholders had no practical ability to give such input. Selection of a reference watershed should take into account the proposed stressors, so that those specific stressors can be evaluated in a healthy watershed. By doing so, natural background can be more objectively evaluated.

One of the candidate reference watersheds, McClure River, does not meet the proposed TDS standard of 334 mg/L, supporting the conclusion that the proposed standard is unjustifiably low and should be withdrawn.

b. Nature of Total Dissolved Solids

Geologic, chemical, hydrologic, and biologic controls of total dissolved solids concentrations (TDS) in the Callahan Creek watershed have not been thoroughly investigated and evaluated, and the proposed standard for the watershed of 334 mg/L is not defensible or realistic. As noted in the attached comments from Dr. De Lisle, TDS composition as well as exposure magnitude, frequency and duration are critical components in determining toxicity of

TDS which were not evaluated. Problems with the TDS analysis in the Callahan Creek TMDL include the following.

Changes in TDS concentrations in Callahan Creek occur naturally based on groundwater versus surface water inputs to the watershed. Groundwater generally has higher concentrations of TDS than surface water. The details of naturally occurring and site specific groundwater are further discussed in the natural background section of these comments. This natural variation was not considered when developing a TDS standard for the Callahan Creek Basin. Figures 1 and 2 show data from stations 3822 and 3823 where the TDS exceedences were observed and show the correlation between TDS values and rainfall events. These figures show that TDS values in Callahan Creek increase when little or no rainfall occurs one week prior to sampling (inclusive of sampling date).

The natural component of TDS concentrations due to water/rock interactions and the corresponding weathering reactions in the watershed need to be determined for both the groundwater and surface water. The most important of the sedimentary components that weather to produce a portion of the observed TDS in Callahan Creek are the sandstones, shales, calcareous sandstones, and coal in the watershed. Minerals within these sedimentary units which weather the fastest and produce the majority of the constituents of TDS in the Callahan Creek watershed include; calcite ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), siderite ($FeCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$), and pyrite (FeS_2) (Rose, 1979; Drever, 1988; Lerman, 1990; Langmuir, 1997; Kowalewski, 2003).

Example equilibrium concentrations of dissolved constituents from naturally occurring mineral weathering reactions in groundwater are:

1) Gypsum weathering releases calcium concentrations ranging from 300 to 450 mg/L, sulfate ranging from 800 to 1500 mg/L, and TDS would range from 1100 to 2000 mg/L (Drever, 1988).

2) Calcite constituent concentrations are dependent on whether the solution is open to the atmosphere (surface water) versus closed to the atmosphere (groundwater) but will range in concentrations of calcium from 50 to 250 mg/L, bicarbonate (HCO_3^-) from 150 to 800 mg/L, and TDS from 200 to 1050 mg/L (Drever, 1988, Edmunds *et al.*, 1987).

3) Pyrite oxidation and weathering produce high concentrations of iron and sulfate and acid solutions (Mast *et al.*, 2000, Kelley and Taylor, 1994, Runnells *et al.*, 1992, Everdingen, 1970). Naturally occurring weathering of pyrite has been shown to produce pH values below 3 , iron concentrations greater than 1000 mg/L, and sulfate concentrations greater than 2000 mg/L. This naturally produced acidity in solution can significantly increase the weathering rate of carbonates and other minerals (Skousen *et al.*, 1997, Drever, 1988).

The majority of the chemical constituents that make up the TDS in Callahan Creek are the anions of bicarbonate (HCO_3^-), sulfate (SO_4^{2-}), and chloride (Cl^-) and the cations of calcium (Ca^{2+}), magnesium (Mg^{2+}), and sodium (Na^+).

c. Comparison of Proposed TDS Standard to Natural Waters

Groundwater in the U.S. contains an average of approximately 350 mg/L TDS (Table 8.8, Aqueous Environmental Geochemistry, Langmuir, 1997). Average groundwater compositions in the U.S. would exceed the proposed 334 mg/L standard (White *et al.*, 1963). Practically this means that during low flow periods in over half of the U.S. watersheds, TDS would be above the proposed standard based solely on their natural characteristics.

In his book, Langmuir describes general threshold values of constituent concentrations in ground water associated with specific rock types using 27,000 chemical analyses of ground water

from the U.S. Geological Survey (USGS) WATSTORE data base (Table 8.13). He evaluates the data to determine concentrations that are representative of natural background conditions versus those that are indicative of anthropogenic impact. He describes ground waters which are likely anthropogenic influenced as waters with constituent concentrations above the observed 97.7 percentile level. These 2 sigma values include background and anomalous concentrations of 32 elements, including bicarbonate, sulfate, and specific conductance. Results presented of sedimentary rocks comparable to those found in the Callahan Creek watershed show the following naturally-occurring background concentrations:

Carbonate (values would be geochemically similar to carbonate-rich or carbonate-cemented sandstones)

- bicarbonate (HCO_3^-) – 624 mg/L
- sulfate (SO_4^{2-}) –2,199 mg/L
- calcium (Ca^{2+}) – 10,281 mg/L
- magnesium (Mg^{2+}) – 1,550 mg/L
- TDS (approximated by summing these constituents) – 14,654 mg/L

Sandstone

- bicarbonate (HCO_3^-) – 1,189 mg/L
- sulfate (SO_4^{2-}) –1,237 mg/L
- calcium (Ca^{2+}) – 356 mg/L
- magnesium (Mg^{2+}) – 110 mg/L
- TDS (approximated by summing these constituents) – 2,892 mg/L

Shale

- bicarbonate (HCO_3^-) – 1,274 mg/L
- sulfate (SO_4^{2-}) –2,199 mg/L
- calcium (Ca^{2+}) – 592 mg/L
- magnesium (Mg^{2+}) – 251 mg/L
- TDS (approximated by summing these constituents) – 4,316 mg/L

Ground water compositions and TDS concentrations in the Callahan Creek watershed are below this naturally occurring range of 2,892 to 14,654 mg/L. This range illustrates the potential TDS concentrations that can be generated naturally through rock/water interactions. Although the Callahan Creek data is below this range, the concentrations in Callahan Creek are significant enough that it is apparent that natural background conditions should be considered in evaluating TDS as a stressor and developing an associated TMDL.

d. Natural Background Controls of the Callahan Creek Basin

As noted in the Draft Report, TMDLs consist of waste load allocations (i.e., point sources) and load allocations (i.e., nonpoint sources), including natural background levels. As discussed below, the natural background levels of TDS in the Callahan Creek watershed were not evaluated in the Draft Report, and based on the data included herein exceed the proposed TMDL even without any loads from mining operations.

The water/rock interactions in the watershed produce a natural background component of TDS concentrations in both surface water and groundwater. This natural background component is well documented in the literature and is dependent on numerous factors including soil mineralogy, geology, basin hydrology, and climate (Posey *et al.*, 2000; Anderson *et al.*, 1997; Runnells *et al.*, 1992; Freeze and Cherry, 1979; van Everdinger, 1970). Basin geology contributions from natural weathering reactions can also cause exceedences of water quality

standards and affect biologic integrity of the creek downgradient from the weathering rocks (Jeffree *et al.*, 2000). The natural background component of TDS in the Callahan Creek watershed has not been considered in this TMDL analysis.

The three main sources of TDS solutions in the Callahan Creek watershed are, 1)human discharges into the creek, 2)natural weathering reactions, and 3)accelerated reactions due to mining activities.

Data collected by Cumberland was evaluated to quantify the naturally occurring TDS concentrations produced by water/rock interactions in the Callahan Creek watershed. Representative water quality data was chosen from groundwater wells that had minimal or no effects from present mining activities in the watershed. Measured groundwater TDS concentrations in the basin range from 60 to 1147 mg/L. These concentrations indicate that during low flow periods, when groundwater is the major component of flow in Callahan Creek, the water in the creek will likely exceed 334 mg/L without considering the effects of loads other than groundwater.

The measured groundwater concentrations in the Callahan Creek watershed are consistent with values found in natural groundwaters (average TDS concentrations of 350 mg/L) as described by Langmuir (1997) and discussed in the TDS section of these comments. Langmuir based his analysis on an extensive USGS groundwater database (WATSTORE). Langmuir also calculated groundwater constituent concentrations using statistical analysis of concentrations and interpreted the 2 sigma values as being representative of anthropogenic influences. These 2 sigma TDS values ranged from 2,892 mg/L to 14,654 mg/L depending on the rock type used (carbonate, sandstone, or shale). Observed rock types in the Callahan Creek watershed include carbonate-rich and carbonate-cemented, sandstones, and shales and measured TDS groundwater concentrations are significantly below these TDS concentrations.

The natural background contribution to TDS in Callahan Creek was not considered. If natural background had been considered, the standard would have exceeded the proposed 334 mg/L. As a matter of fact, over half of U.S. groundwater compositions exceed the proposed standard.

e. Remining, Reclamation and Source Control

The Draft Report states that remining will be an important part of the implementation plan, allowing achievement of the load reductions. p. 12-7. Typical best management practices (BMPs) available for surface disturbances associated with coal mining include remedial measures such as regrading, revegetation and liners. Regrading BMP techniques would typically reduce erosion (sediment load) and decrease the amount of surface water runoff. Revegetation BMP would also reduce erosion, decrease surface water runoff and increase the evapotranspiration component of the water balance (Strock, 1998, Earle and Callaghan, 1998).

Even with regrading and revegetation BMPs employed there still will be a water balance component of infiltration into the groundwater system. Infiltration water will continue to react with the naturally occurring soils and rocks and produce constituents in solution, probably above the proposed TDS limit of 334 mg/L, as indicated by the groundwater data discussed above. It may be possible to promote surface water runoff using liners (e.g., HDPE or compacted clay) and limit infiltration and reduce water/rock reactions and overall TDS loading from groundwater to Callahan Creek, but it is not possible to eliminate the groundwater discharge component to Callahan Creek (baseflow). Furthermore, use of such liners would have a negative impact on the ability to establish vegetation, would increase the potential for downstream flooding, and would be cost prohibitive.

Typical best management practices (BMPs) for underground disturbances are similar to those for surface mining with the additional allowance for underground retention and treatment of water prior to pumping or discharge to the surface.

Based on Cumberland's remediation experience in the Callahan Creek watershed, remediation at other mining sites, and documented remediation case studies in the literature (Pierzynski *et al.*, 1994, Johnson *et al.*, 1994) it is highly unlikely that BMPs would significantly affect observed TDS concentrations.

Currently, all of Cumberland's surface mining in the Callahan Creek watershed is remining. The remining process will ultimately result in reclamation of these previously mined areas, leading to a reduced sediment load into the creek. Its long-term effect on TDS will be less significant, and during remining there will be increases in loads of both sediment and TDS. If the 334 mg/L standard is approved, runoff from some areas being remined will likely not meet that standard during the active remining process. If the TDS standard is enforced during remining, it will probably stop all or most remining efforts in the watershed. This would be detrimental to the long-term aquatic health of the watershed, as remining, followed by modern reclamation, improves water quality and benthic health. The ultimate goal in the Callahan Creek watershed should be the successful remining and reclamation (to today's standards) of the previously mined areas. This aspect of land use in the watershed, and the benefits of these activities should be discussed in the report so that remining can continue, instead of being threatened by the currently proposed standards.

Increased sediment load is one of the most important factors in degrading benthic health. In fact, it is listed as the number one source of benthic impairment nationwide on the US Environmental Protection Agency's list of impaired waters (Clean Water Act Section 303(d);

USEPA 2000). Increased sediment fills the interstitial spaces of the stream channel and promotes a more homogeneous and uniform streambed.

Macroinvertebrate response due to increased sediment generally has a greater effect on density metrics and richness measures. Richness reduction, regardless of the metric (EPT, Taxa, or EPT/Chironomidae), is usually 50 percent or more as a result of relatively modest inputs of fine sediments (Zweig and Rabeni 2000). Decreases in density metrics are more severe and, in cases of moderate sediment loading, may prove catastrophic for more intolerant metrics (i.e. EPT density). Remining is a critical component of maintaining and improving the environmental health of the watershed.

The proposed standard could result in Cumberland's losing all or most of the value of its extensive investment in Callahan Creek.

f. Water treatment

TDS above the proposed 334 mg/L limit will occur during dry periods when groundwater discharge is a significant or the sole component of flow in the watershed (baseflow conditions). The only remedy to meet the proposed 334 mg/L TDS standard under those conditions would be water treatment. Water treatment of TDS is very difficult to achieve and very expensive (De Vegt, 1998). This is confirmed by a technical issue paper published by the Society of Environmental Toxicology and Chemistry discussing ion imbalances in fresh water and it is stated, "Unfortunately, cost-effective waste treatment control options for a facility whose effluent is toxic because of TDS or specific ions are scarce, if available at all" (SETAC 2004). This paper also cites a TDS concentration of 1,340 mg/L as the concentration having adverse effects on freshwater organisms, (four times the proposed Callahan Creek TDS standard).

Surface water data has been collected by Cumberland for submittal to DMME from locations throughout the Callahan Creek watershed. TDS concentrations in the Callahan Creek

watershed range from 40 to 1545 mg/L and are typically well-above the proposed standard. Approximately 25% of Cumberland's permitted discharges would be above the proposed TDS standard as noted in the attached report from EMI. The TDS components are predominantly bicarbonate, sulfate, calcium, and magnesium. These constituents are difficult to remove from solution. The water treatment technology would be reverse osmosis. Reverse osmosis water treatment plant size are dependent on flow and are very expensive to build (tens to hundreds of millions of dollars) and very expensive to operate (hundreds of thousands to millions of dollars per year) and the resultant very high TDS waste solution would need to be handled and disposed of as a hazardous waste (Zinck and Griffith, 2000, De Vegt *et al.*, 1998).

Although the Draft Report does not purport to be an implementation plan, the standards it seeks to validate would virtually assure that no implementation plan would succeed.

g. Total Suspended Solids and Sedimentation

The proposed sediment load allocation for Callahan Creek is problematic because, 1) the proposed sediment load targets are inconsistent with well-documented and presently accepted point source discharge standards (70 mg/L maximum, 35 mg/L average) in the basin which are approved by the Virginia Department of Mines, Minerals and Energy (DMME), 2) Middle Creek is highly questionable as a representative reference watershed, and 3) TSS concentrations are of questionable accuracy as a representative measure of sedimentation as an impairment.

Increases in sediment loading to watersheds from anthropogenic influences (e.g., mining) have been well-documented as a potential stressor to freshwater organisms. The DMME and Federal Agencies that regulate mining activities (e.g., Bureau of Land Management, BLM)

currently set TSS limits from mining operations. In the Callahan Creek watershed a 35 mg/L TSS limit is considered protective to the environment as it is currently set by DMLR.[2]

Mining activities in the Callahan Creek watershed include both permitted active mining operations and abandoned mine lands. A well-documented cost-effective solution for decreasing TSS concentrations in watersheds is remining of AML sites using currently accepted Best Management Practices (BMPs). Examples of possible reclamation options for TSS are discussed elsewhere in these comments.

Changes in TSS concentrations in Middle Creek and Callahan Creek occur naturally and natural variations are controlled by flow of the creek and ultimately rainfall events. The percentage of land used for mining in the Middle Creek reference watershed is very different from that in the Callahan Creek watershed (3.1% in Middle Creek compared to 31% in Callahan Creek).

Another drawback to using the Middle Creek watershed is the lack of high-flow TSS data from Middle Creek. TSS data collected only during low-flow conditions of the creek underestimates true suspended solid loading of the reference stream. There is no reliable way to compare TSS in Callahan Creek to TSS in any other reference creek unless the TSS data are collected over a wide range of flow conditions.

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[2] The evaluation of TSS in the Draft Report is confusing. The existing effluent limit approved by DMME of 35 mg/L is greater than the 25 mg/L TSS from the McClure River watershed used to determine whether sediment load was a probable stressor. The target sediment TMDL is 6,392.58 Mg/Yr, as noted on Table 11.5, page 11-9. Attempts to back-calculate from this load to an enforceable concentration were problematic. This load is dependent on both flow and concentration. Based on a yearly flow of 7144 gallons per minute, the corresponding TSS concentration would be approximately 450 mg/L, almost thirteen times the currently allowed 35 mg/L. This illustrates the inaccuracies and uncertainties in the Draft Report, as well as the significant difficulties in independently verifying the results and conclusions presented due to the lack of documentation of procedures and decision-making processes.

The uncertainty associated with using TSS concentrations as representative of sedimentation as an impairment is currently being investigated in numerous watersheds and these limitations are discussed in detail in the Straight Creek TMDL Group's comments. The major problem associated with elevated sediment concentrations for benthic organisms is the loss of habitat due to siltation. Habitat limitations in the Callahan Creek watershed are discussed at length elsewhere within these comments.

h. TMDL Implementation

The Draft Report identifies sediment and TDS as benthic stressors in Callahan Creek. As shown above, habitat impairment is also a stressor. The Draft Report does not suggest how or in what sequence the various stressors will be addressed or how they will affect existing point and non-point discharges.

The proposed TDS standard would significantly affect mining and remining in the basin. Once the TMDL is implemented, the standards would affect present and future VPDES permits in the basin. The cost to meet the proposed standards would limit or prevent future mining or remining in the basin.

i. Reclamation of Middle Creek

The Draft Report supports selection of Middle Creek as the reference stream by noting that mining impacts were remediated there and the biology of the watershed recovered.

In the Middle Creek delisting document, MapTech and DEQ describe decreases in TDS concentrations in Middle Creek as the major reason for the observed biological recovery. Based on preliminary analysis of the Middle Creek reclamation conducted and data provided in the delisting documents, Cumberland does not see how the changes in TDS concentrations before and after remediation support DEQ's conclusions. Figure 3 shows MapTech's TDS data versus time, as well as a line depicting mean TDS concentration from these data. Except for the 1981

TDS value, all TDS data represented in Figure 3 was provided by MapTech. Note that the 1981 value for TDS was calculated (TDS mg/L = specific conductivity umhos/cm x 0.65) from an anecdotal reference to average specific conductivity of 660 umhos/cm in Middle Creek, in the Middle Creek delisting document (page 4-1). High TDS shown in Figure 3 between late-1997 and December 2000 do not correlate with specific conductivity measurements taken in the same station, at the same time (Table 1). Figure 3 shows that TDS concentrations do not exhibit a decreasing trend corresponding to completion of reclamation activities after 2000. Thus, TDS has not significantly changed and therefore has not been a stressor in Middle Creek.

The probable stressor to the Middle Creek watershed was the low pH solutions and the concomitant metals produced by acid rock drainage reactions. The reclamation conducted had dramatic effects on pH values observed in Middle Creek. This interpretation is supported by the large increase in pH of Middle Creek from values below 6 to values of greater than 8 from 1995 to 2003 (e.g., Figures A-32 through 37 and A-40 through A-45, pages A-17 through A-24). Biological impairments from AMD solutions discharging into streams have been well documented as has the recovery of the biota once the acidity and metals have been eliminated from the streams (Earle and Callaghan, 1998; Strock, 1998).

If TDS or the major constituents of TDS in Callahan Creek cause biological impairment, there would be federal (EPA) or state standards set for TDS, bicarbonate, sulfate, calcium or magnesium in streams. In fact, there are none.

V. Miscellaneous.

a. TMDL Standards and Effluent Limits

Cumberland is concerned that the TDS TMDL endpoint of 334 mg/L will be applied to future discharge permits and permit renewals (i.e., VPDES permits) if the TMDL is approved by EPA and adopted by SWCB. During a meeting on March 22, 2005, DEQ and DMME stated that

this would not be the case. It was stated that the 334 mg/L standard would only apply to deep mine discharges, not to permitted discharges from sediment ponds or other permitted, non-deep mine discharges. If this is so, the report should be revised to so state.

The Draft Report includes deep mine discharges, runoff from active mining, and residential discharge from straight-pipes as point sources. Non-point sources include surface runoff, delivery through interflow, delivery through groundwater, and delivery through direct discharge of mine seeps to the stream. The surface runoff portion of the non-point source allocation includes discharges from permitted sedimentation ponds, even though these are typically considered point sources. These discharges are permitted through the VPDES program, which by definition makes them point sources.

As discussed previously, groundwater naturally contains higher levels of TDS than surface water. During dry months and droughts, flow in Callahan Creek consists of a larger percentage of groundwater than surface water. During wet months the opposite is true. This results in a fluctuation of the natural TDS concentration in the creek. Since groundwater in the watershed has natural TDS levels exceeding 334 mg/L, the surface flow in the creek may naturally exceed this standard during times of low flow. The report should address these flow-dependent natural fluctuations in TDS level. Since the TMDL process will require that the load allocations for TDS be met, the report should specify how individual permit limits for TDS will be established.

b. Public Comment Period

The Draft Report does not contain sufficient information to fully evaluate the conclusions within the public comment period allowed, even though it was extended. The raw data was not included in the report, the decision-making procedures were not clearly documented, and therefore it was not possible to critique or verify the findings. The only data included in the

report are scatter graphs, many of which do not include all the data discussed in the text. No data (other than anecdotal data discussed in the text) was included from the two reference watersheds used in the study. Since the data was not included in the Draft Report, a delay was incurred in obtaining the data from DEQ reducing the time available for evaluation.

Furthermore, the data from Dumps Creek and Black Creek TMDLs, though promptly requested from DEQ, was not made available to Cumberland in a reasonable time to permit comparison of the multiple linear regression method used on those watersheds with the reference watershed approach used for Callahan Creek.

The use of two reference watersheds was confusing and introduced additional and unnecessary uncertainty into the process further weakening the conclusions. The rationale for using McClure River data to determine the stressors in Callahan Creek, but using Middle Creek data to set standards was unexplained, and appears unconventional and indefensible. The geology and land use in the McClure River watershed is as different from the Callahan Creek watershed as that of the Middle Creek watershed, thereby introducing numerous additional variables to the study.

c. Economic Impact of TMDL Implementation

As discussed above, Cumberland would be unable to meet the TDS standard of 334 mg/L based on background groundwater and surface water quality alone. Natural levels of TDS in the creek will likely exceed this standard due to the unique geology of the basin and water/rock interactions with our without mining in the watershed. Implementing this TMDL could put Cumberland out of business on Callahan Creek. This would result in the loss of approximately 370 jobs, as well as significant source of tax revenue for Wise County and the State. Cumberland pays $2,000,000 per year to Wise County in severance taxes, not including

property, machinery or payroll taxes. The Draft Report does not address the costs and benefits of implementation.

Virginia law requires that the SWCB give due consideration to the economic and social costs and benefits which can be reasonably expected to result from the adoption of the proposed standard. The Draft Report does not include sufficient information for the SWCB to give such consideration; however, if Cumberland is forced to cease operations, the costs would be locally significant. The benefits of implementing this TMDL are questionable, as discussed above, since the major impairment to the creek appears to be lack of habitat rather than poor water quality. If the water quality improvement goals are met, but habitat is not improved, it is unlikely benthic health will improve.

VI. Incorporation of Comments.

Cumberland incorporates and adopts the comments of the Straight Creek TMDL Group except for comments relying upon data specific to Straight Creek.

Conclusion

For the foregoing reasons, Cumberland requests the following actions be taken with respect to the Draft Report:

1. TDS and sediment be eliminated from the TMDL analysis.

2. The basis for the TMDLs for TDS and sediment be further studied and reconsidered in light of the comments submitted by Cumberland and the Straight Creek TMDL Group.

3. If not eliminated, the TMDLs for TDS and sediment be calculated based on sound scientific principles and properly collected data.

4. In the alternative, that the comment period be extended until August 9, 2005.

Figure 1. TDS versus Precipitation (Sum of recorded precipitation one week before TDS measurement) at Station 0003822

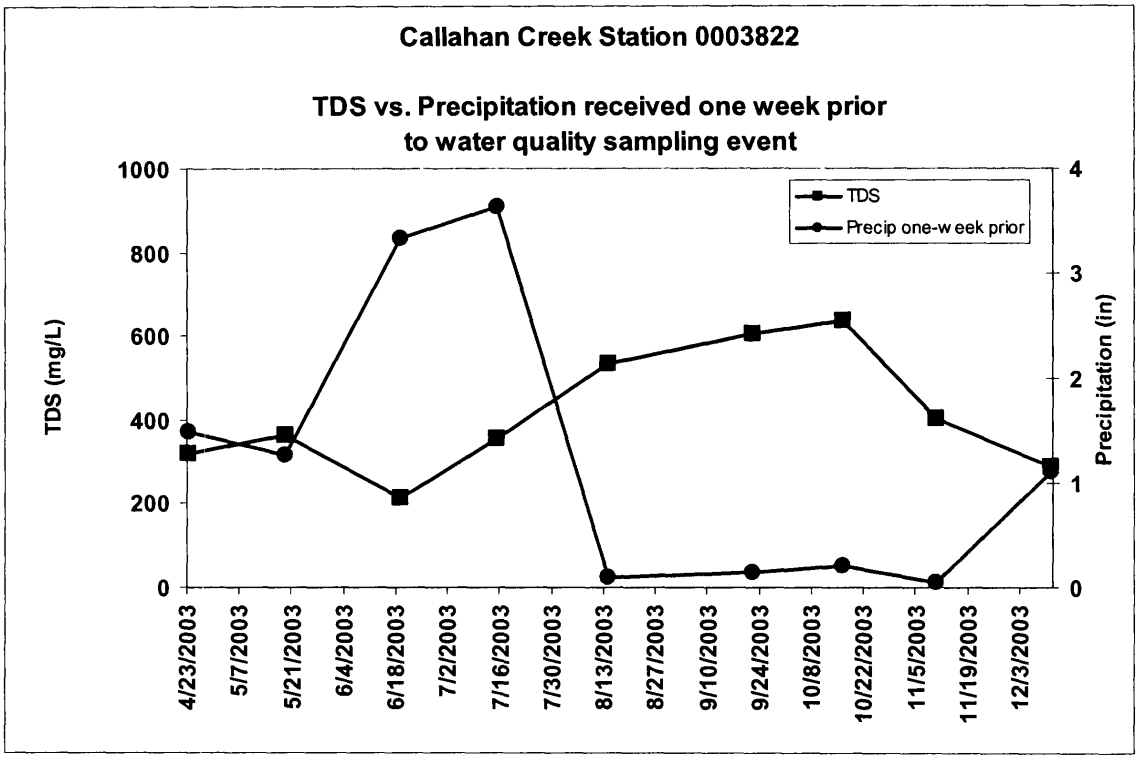

Figure 2. TDS versus Precipitation (Sum of recorded precipitation one week before TDS measurement) at Station 0003823

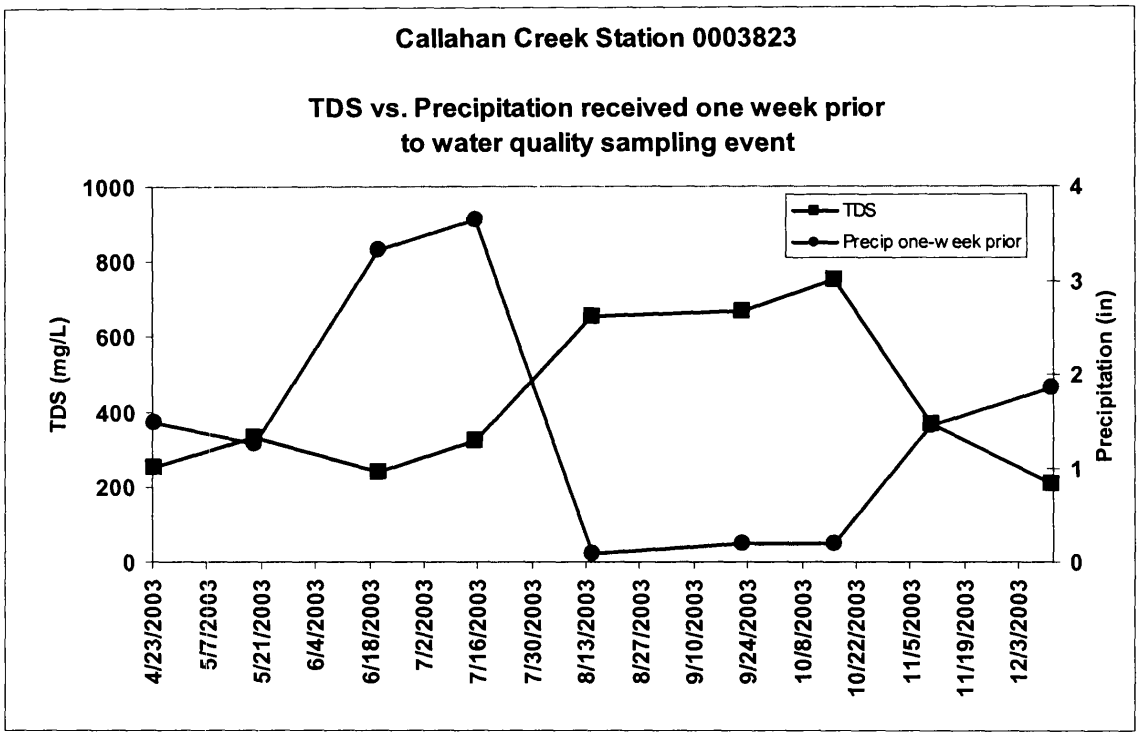

Figure 3. TDS results for Middle Creek. Mean value line calculated from these data. Data provided by MapTech except 1981 TDS value. 1981 value was calculated from anecdotal specific conductivity results referenced in Middle Creek delisting document.

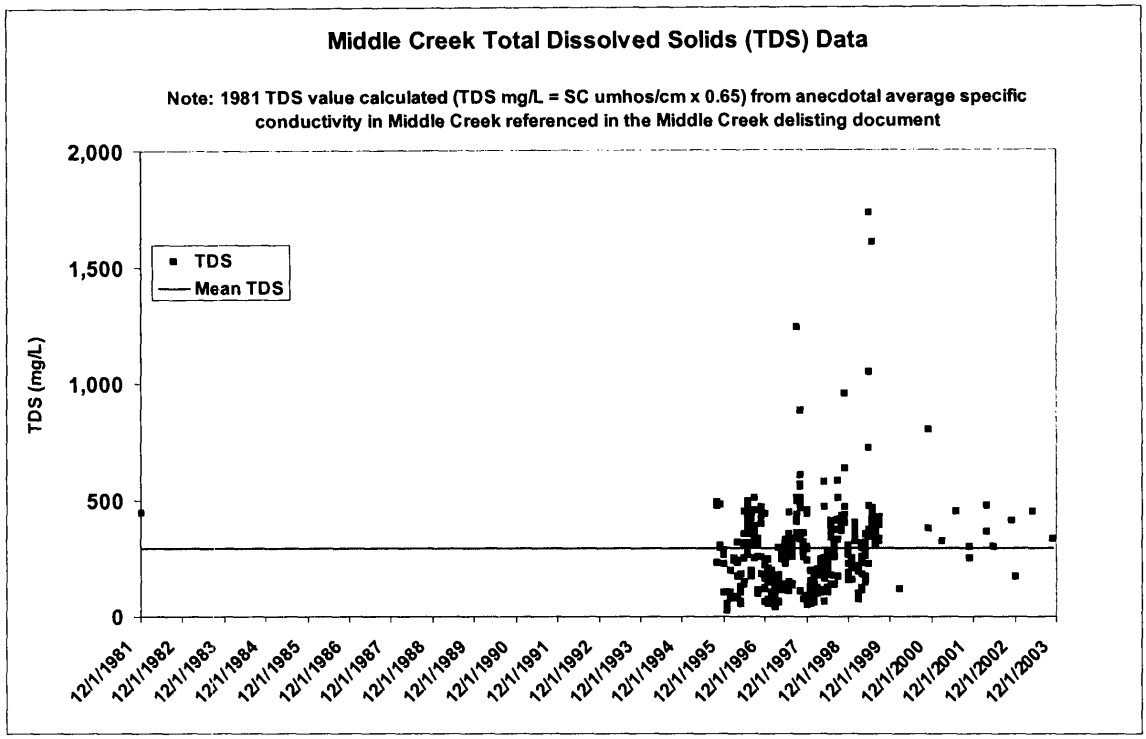

Table 1. Comparison of specific conductivity and TDS for given station and sampling date, when TDS values are notably elevated in Figure 3. Data in Table 1 provided by MapTech.

Year_Month	Station	Cond	TDS
6/1/99	4120011	520	1731
6/1/99	4120011	520	1731
7/1/99	4120011	480	1604
7/1/99	4120011	480	1604
6/1/99	4120018	540	1047
6/1/99	4120018	540	1047
11/1/98	4120012	650	954
11/1/98	4120017	650	954
11/1/00	4120011	480	800
5/1/98	4120018	260	577
6/1/99	4120116	520	721
6/1/99	4120116	520	721
6/1/99	4120204	520	721

Respectfully submitted,

CUMBERLAND RESOURCES CORPORATION

By_____
Marvin Gilliam, Jr.
Vice President

Attachment A to Comments of Cumberland Resources Corporation to TMDL Development for Powell River Basin

Powell River Resources Corporation

Alliance Coal Corporation

Meadow Branch Mining Corporation

Mill Branch Coal Corporation

Nine Mile Spur LLC

Pigeon Creek Processing Corporation

Maggard Branch Coal LLC

Roda Resources LLC

Meadow Branch Coal LLC

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COMMENTS OF CUMBERLAND RESOURCES CORPORAT
TO TMDL DEVELOPMENT FOR THE POWELL RIVER B41M.

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Introduction.

The Virginia Department of Mines, Minerals and Energy ("DMME") and the Virginia Department of Erivirom-nental Quality ("DEQ") published a draft document dated February 7, 2005 entitled "Fecal Bacteria and General Standard Total Maximum Daily Load Development for the Powell River Basin" ("The Draft Report"). The Draft Report was prepared for DMME and DEQ by MapTech, Inc. of Blacksburg, Virginia and is a part of the process mandated by Va. Code
62.1-44.1-9:7 entitled "plans to address impaired waters." The Draft Report purports to support the adoption of Total Maximum Daily Loads ("TMDLs") for fecal coliforin, sediment, and total dissolved solids (TDS) in Callahan Creek in Wise County and Straight Creek in Lee County, both tributaries of Powell River.

Affiliates, of Cumberland Resources Corporation, 152 West Valley Street, Abingdon, Virginia 2421 0 ("CRC") lease coal reserves and operate coal mines and coal preparation and loading facilities, on Callahan Creek and its tributaries. The Cumberland affiliated entities so engaged are listed on Attachment A. These comments are submitted on behalf of CRC and each and all of the Ciimberland affiliates (together "Cumberland").

Cumberland leases over 13,000 acres of land for coal mining within the Callahan Creek watershed. Within that area, it holds 15 CSMO and 15 VPDES permits, each issued by Virginia Division of Miried Land Reclamation ("DMLR"). It currently operates, directly or through independent coiitract mining companies, 12 surface and underground mines, a coal preparation plant and a refuse disposal area within the Callahan Creek watershed. Cumberland and supporting enterprises employ approximately 370 people on Callahan Creek. Cumberland intends to continue its mining operations and expand them in future years.

For the reasons set out below, the Draft Report is insufficient to warrant adoption of the recommended T'MDLs by the State Water Control Board ("SWCB") and should be revised as stated below.

1. The Draft Report does not meet mandatory legal requirements.

The Drall Report is part of a statutory procedure mandating that the SWCB adopt and implement plans to "address impaired waters." Va. Code 62.1-44.19:7. It is a critical part of the process Of fiXing TMDLs which, if approved by SWCB, will constitute a regulation within the Administrative Process Act, Va. Code 2.2-4000 et secl. ("APA"), and the adoption of a water quality stEtndard under Va. Code 62.1-44.15.

TMDLs are not set by federal law. While the SWCB is mandated by 303(d) of the federal CleanW'ater Act ("CWA") to establish TMDLs for impaired waters, there are no federally imposed mandatory limits for total dissolved solids ("TDS") or sediment concentrations, both of which are used to set TMDLs under the Draft Report. Some of the water quality standards which the Draft Report seeks to validate differ materially from federal law and regulation and are more restrictive than federal law. The standards proposed in the Draft Report are state standards, not federal ones.

The process in which the Draft Report is being proposed violates applicable law in the following respects:

a. TDS and sediment are not pollutants identified by the Administrator of EPA under

3 03 (d)(1) and 3 04(a)(2) of the Federal Clean Water Act ("CWA") and therefore are not proper subjects for TMDLs.

b. 'Fhe proposed standards for TMDLs have not been provided to the appropriate committees of both houses of the General Assembly as required by Va. Code 62.1-44.15(3a).

C. The Draft Report gives no basis for the SWCB to give due consideration to the economic and social costs and benefits which can reasonably be expected to occur as a result of the adoption of the proposed standards as required by Va. Code 62.1-44.15(3a).

d. T'he Draft Report gives no basis for the SWCB to deten-nine the associated costs, benefits, and environmental impact of the adoption of the TMDLs recommended therein as is required by Va. Code 62.1-44.19:7.

e. 'I'he Draft Report is, in part, a proposed regulation. As such, it is required to be promulgated in accordance with the APA, including 4007. The draft report and the standards it proposes have not been subjected to the mandatory processes of the APA for promulgation of regulations.

f. I'he Draft Report gives no basis for the SWCB to conclude that the water quality standards proposed in the Draft Report are economically feasible. The SWCB must act reasonably at al I times. Its duty to do includes the duty to assess economic feasibility of its water quality standards.

9. The Draft Report does not distinguish in its analysis of benthic impainnent and fecal bacteria between the discrete segrnents of Callahan Creek as set forth in the official Notice published in the Virginia Reporte , Volume 2 1, Issue I 1, February 7, 2005, page 1419, and as required by Va. Code 62.1-44.19:5(c)(1).

h. 'rhe Draft Report does not "include an assessment ... for the attribution of impain-nent to point and nonpoint sources," as required by Va. Code 62.1-44.18:5(c)(2).

Without an assessment for attribution between point and nonpoint sources, any allocation of TMDLs between point and nonpoint sources will necessarily be arbitrary.

IL Cienerally, the TMDL Process has not been properly applied.

a. Akmong other things, federal regulations require TMDLs to consider the impacts of background riollutant contributions (i.e., natural background water chemistry which is primarily influeiriced by geology), critical stream conditions (e.g., low flow), seasonal variations, and reasonableassurance that the TMDLs can be met. 40 CFR 130.7.

The Draft Report fails to meet the regulatory requirements. First, the standards are set before the causes of impainnent are known or sufficiently evaluated, and before a meaningful evaluation of iniplementation and remediation methodologies and reasonable assurance of achieving the standards is completed.

b. Second, data quality and appropriate monitoring station selection are critical in TMDL development. "Available data" is not necessarily adequate data. The Virginia Water Resources Research Center, Water Quality Advisory Committee (2004) recommends additional sampling to corifirrn benthic impain-nent particularly given the high variability of environmental data. EPA's Sh-essor Identification Guidance Document (EPA 2000), provides that the stressor identification process includes an evaluation of the available data to determine whether it is sufficient to actually identify the cause of impainnent, as well as whether the data is of a sufficient quality to make anything more than a rough estimate of the stressors. As the available data comes froin many sources, collected by different procedures, thorough documentation is critical. Such dlocumentation is lacking in the Draft Report. The documentation presented does not support the conclusions as to the identity of the stressors. Rough estimates are not adequate.

C.]Because of the far-reaching consequences of imposed TMDLs, it is critical that the sound scientific standards be applied in setting them. In many respects the Draft Report

1 If TM'DLs are set now, it would be more appropriate for them to be provisional with adjustments to be made in the future as additional data is collected, data evaluation is completed, and the actual causes of impainnent are known.

reflects an inadequate investigation and analysis of the stated benthic impairment, and the proposed remedies through TMDLs. These deficiencies are well-stated in the Straight Creek TMDL Group's comments under the heading "Process Issues," which are equally applicable to Callahan Creek and are embraced and incorporated by Cumberland. Given the lack of water quality data, flow data and rigorous calibration procedures, the use of a model with its inherent assumptions likely produced inaccurate results.

111. The Draft Report is inadequate to show that TDS and sediment are "stressors" in Callahan Creek.

a. tJse of Available Data

The Draft Report indicates all available data was used to evaluate water quality. In fact there are at least eight additional monitoring stations sampled by Cumberland along the main stem of Callahan Creek. Data from these monitoring stations was submitted to DMME prior to the development of the TMDL and was available for the TMDL study but was not considered. The attached map shows the monitoring stations sampled by Cumberland throughout the Callahan Creek watershed. Locations 98.09/AS- 1, 123. 1 O/AS- 1, 400.06/AS-2, 123.2 1 /SW-3, 123. 1 O/AS-6, 123.2 1 /SW-2, 123. 1 O/AS-7, and 81 1.0 1 /AS-5 are in the main stem and should have been included in the study. These locations are monitored semiannually for both water quality and ben-thic impairinent. The data shows varying TDS and conductivity levels with positive benthic, health indicators. This is consistent with published studies indicating good benthic health Nvith TDS levels up to 1,000 mg/L, with only the most sensitive organisms showing an adv-erse effect up to TDS levels of 2,000 mg/L (Kennedy et al. 2004, Kennedy et al. 2003).

Additioiially, the EPT indices calculated at Cumberland's monitoring stations generally range from 7 to 14 with six data points less than 7 and eleven data points greater than 14.

Similarly, taxa iichness was highest for these data points compared to all sainple points. This indicates the creek's ability to support not only a diverse assemblage of invertebrate fauna but an assemblage coniposed of intolerant fauna as well.

Cumber'land can find no indication in the Draft Report that this significant data was even considered by DEQ before identifying TDS as a probable stressor.

b. Reduction in TDS

According to the Draft Report, TDS concentrations need to be reduced 76% from nonpoint sources and 91 % from direct sources. TDS loading in the basin comes from various sources, including the straight pipe discharges and water/rock reactions.

Remediation of the human component of TDS in the watershed (i.e., straight pipe discharge) is achievable using best management practices (BMPs). Remediation would show immediate reductions in measured TDS concentrations in Callahan Creek and would also decrease or elin-linate the impacts of the observed biological impainnent.

Remediation altemative s of the water/rock interactions producing TDS in the watershed (including significant alterations of mining and reclamation methods as proposed in the Draft Report) would IJe far more difficult and costly to implement, and probably could not achieve the proposed TDSstandard of 334 mg/L. The proposed standard is significantly lower than the EPA secondary dritilcing water standard of 500 ing/L.

C. Effects of Habitat Impain-nent

In general, macroinvertebrates are highly sensitive to modifications in substrate and adjacent terrestrial habitat characteristics. Examples of these modifications include streambed alteration and/or redirection, streambed channelization, homogeneous bank stabilization (i.e. concreted or netted rip rap), and removal of riparian vegetation and/or canopy cover. The resulting streani effects typically include:

0 Decrease in allochthonous inputs paired with increased light penetration. The increase in solar radiation increases mean seasonal water temperatures and Eitimulates autotrophic production by attached algae.

0 Increased dissolved nutrient concentrations, especially nitrates and phosphates, (lue to increased runoff reaching the stream. This, combined with increases in light penetration and temperature, promote algal production.

0 Overall change in allochthonous input quality due to terrestrial vegetation change J@om mature to successional species.

0 Loss of large woody debris dams decrease channel complexity, channel stability, and retention of coarse and fine particulate organic matter (CPOM and FPOM). 'Fhis ultimately leads to a shift in the composition of trophic relational communities (i.e. loss of macroinvertebrates with a shredder trophic habit).

Increase in sediment inputs as a result of increased runoff. Sediment transport effects may continue for many years after the disturbance and may be further increased due to the lack of debris dams.

Coal has been mined in the Callahan Creek watershed since the late I gth century. The attached historical photographs illustrate that the creek was at the center of a major industrial complex. The creek was rerouted as necessary to accommodate mining operations. The attached recent photographs demonstrate that habitat degradation is likely the primary cause of the apparent impairment. The photographs illustrate eroded banks, lack of vegetation, manicured lawns continuiiig up to the creek bank, rip rap, gabions, bridge abutments, etc. The majority of sediment load produced in the basin is from pre-law mining and abandoned mined lands. Callahan Creek has not been in its "natural state" for I 00 years. To expect that water quality changes will restore such a state appears unreasonable given the limits of available habitat.

Cause aiid effect relationships are difficult to establish among individual habitat assessment criteria and changes in invertebrate fauna. Likewise, specific water quality parameters such as TDS and conductivity are often unreliable indicators of benthic impairment. In fact, studies indicate that increases in conductivity support an increase in percent Ephemeroptera for levels under 2000 @&cm (Kennedy et al. 2004). This trend is also noted for both conductivity and TDS in macroinvertebrate samples collected from Callahan Creek by Appalachian Technical Services, Inc. from December 2001-2004, but habitat assessment scores for Callahan Creek tend to fall in the suboptimal quality range.

Numerous studies have compared benthic macroinvertebrate community responses to a known stressor. However, few studies have compared the relative benthic macroinvertebrate metric response: of stressors (e.g., TDS, conductivity) to their coexisting habitat conditions (i.e., habitat assessment scores). Such a study conducted by the EPA demonstrated that plecoptera and ephemerop-tera richness (EPT metrics), proportional abundance of tolerant taxa, and tolerant taxa richness were sensitive indicators of habitat degradation rather than water quality (Yuan and Norton 2003). Of the seven metrics calculated for Callahan Creek, the lowest scoring metrics were taxa richness, % dominant taxa, EPT index, and community loss index. The similarities in richness and tolerance measures of the Callahan Creek metrics adds to the likelihood that benthic impairment originates from habitat degradation rather than TDS.

d. Chronic Toxicity Testing

EPA completed a chronic toxicity study using fathead minnows (Pimephales promelas) and Ceriodaphnia dubia on an ambient water sample collected from Callahan Creek at station number 6BCAI-000.03. According to the report, the tests were completed "to deterrnine if water column toxicity is stressing the benthic community." The test results, dated February 23, 2005, show that watei- quality is not stressing the benthic community. This conclusion is consistent

with Merricks' thesis, cited in the Draft Report, which does not support a strong coffelation between benthic impairment and elevated conductivity. A master's thesis which has not undergone peer review, should not be relied upon as the sole scientific evidence of such a coffelation, pairl-licularly where no strong coffelation is stated by the author and the coffelation is not supported by qualified scientists. See Dr. Peter De Lisle's comments, attached.

Conductivity of the water during the test ranged from 476 @tmhos to 625 gmhos; this coffesponds to approximate TDS concentrations of 319 mg/L to 419 mg/L. Five of the seven conductivity measurements exceeded the 334 mg/L standard proposed in the TMDL. This supports the previous discussion regarding the effect of TDS concentrations on aquatic life. It is not surprising that a TDS level of approximately 419 mg/L had no stressing effect on the fathead minnows or Cefiodaphnia, since the published literature indicates that levels in excess of 1,000 mg/L have no effect (Lasier et al., 2004, Kennedy et al. 2004, Kennedy et al. 2003, Lasier et al., 2002, ChapmarL et al., 2000, Gas Research Institute, 1994, Prosser, 1973).

This result, conclusions reached from other studies discussed above, and Cumberland's evaluation of the Draft Report indicate that TDS is not a stressor in Callahan Creek. In order to further evaluate: our conclusion, we solicited the opinion of Dr. De Lisle, President of Coastal Bioanalytics, Iric., and an expert in toxicity testing. Therefore Cumberland requests that TDS be deleted as a probable stressor in Callahan Creek.

IV. 'Fhe Draft Rgport is inadequate to support the TDS and Sediment TMDLs.

a. Reference Watershed Selection

The Reference Watershed Candidate Comparisons table prepared by MapTech dated October 18, 2004 (attached) which was used to evaluate potential reference watersheds and to select Middle C'reek as the reference watershed, contains incoffect percentages for land use categories in Callahan Creek. Page 9-4 of the Draft Report. For example, the watershed is listed

as 95% forested[in the table whereas the report states it is 68% forested, and the table lists mining occupying 3. 1 % of the land area, whereas the report notes 3 1 %. The percentages in the table are used to support Middle Creek as a reference watershed. The land use category percentages in the Draft Report however point out its significant shortcomings as a reference watershed. The report notes Callahan is 68% forested versus 97% in Middle Creek, 3 1 % pennitted minirig in Callahan Creek versus 0% in Middle Creek; agricultural land use in Callahan Creek occupies 0.6% versus 1.3% in Middle Creek.

The soil types in the two watersheds are different, even when considering the grossly generalized soils categories used by STATSGO. The soils categories presented there are so generalized as to be meaningless at a watershed scale. As noted in the STATSGO Data Base Data Use Infonnation publication (USDA, 1995), "STATSGO data are not detailed enough to make interpretations at a county level." Therefore, they are certainly inappropriate for decision-making at the level of detail necessary for evaluating a watershed the size of Callahan Creek.

The geology of'the two basins is not evaluated as noted above. Additionally the overall morphology of the watersheds is significantly different, leading to different characteristics in stream morphollogy and habitat. A comparison between such differing watersheds is inappropriate for use as the basis for establishing water quality standards.

Page 9-1 of the Draft Report states, the reference watershed should have a similar area, itnot to exceed double or less than half that of the impaired watershed." Table IO. I I of the Draft Report shows that Middle Creek is less than half the size of Callahan Creek.

A reference watershed should be chosen based on its comparability to the watershed under evaluation. Based on the Draft Report and the Reference Watershed Candidate Comparison table, the criteria for evaluation included size, stream order, land use, soils, hydrologic groiip, slope, and erodibility. Geology has a major influence on the characteristics of

a watershed, including the geomorphology as well as the water chemistry as noted below in the discussion on natural background levels of TDS. Geology was not considered in the selection of a reference watershed. As a result, the conclusions based on a comparison between the Callahan Creek watershetJ and Middle Creek or McClure River watersheds are not justified.

The Call[ahan Creek watershed is underlain by Pennsylvanian-age rocks of the Lee Conglomerate, the Norton Fonnation, the Gladeville Sandstone, the Wise Formation, and the Harlan Sandstoi-le. The Wise Formation includes the coal-bearing strata as well as siltstones, sandstones, and shales. The strata adjacent to the coal seams are unusually alkaline as noted on the attached Acid-Base Account Sheets. Based on the presence of brackish water and marine fossils and lithologic characteristics, these strata were likely deposited in a back-barrier depositional environment. This environment would have produced the carbonaceous sands, silts and shales present in this watershed. These alkaline strata are unique to the Callahan Creek watershed and two adjacent watersheds, Roaring Fork and Looney Creek.

The Middle Creek watershed is underlain by Mississippian-age limestones, shales, and sandstones. The coal seams are located in the Price Fonnation between sandstones and shales. These sandstones and shales are not the carbonaceous alkaline variety found in the Callahan Creek watershed. Therefore, as the rocks and minerals from these strata weather (particularly oxidation of pyrite in the shales) acid mine drainage (AMD) is formed and is not naturally buffered as it is in the Callahan Creek watershed. The documented benthic impairment in Middle Creek vvas caused by this AMD and associated water chemistry. The elevated pH measurements in the Middle Creek Delisting Report are likely due to treatment of mine discharges required to elevate the acidic pH prior to discharge. The reclamation efforts in Middle Creek vvere aimed at addressing the impairrnent resulting from this lower pH mining environment. This is very different from the Callahan Creek watershed where the naturally

alkaline strata surrounding the coal seams buffers discharge associated with the mining activities as evidenced by the differences in pH data between Callahan Creek and Middle Creek. Therefore, although both watersheds were mined, the differing geology in the two watersheds results in very different characteristics of mine discharges and very different potential surface water in-lpacts based on the different weathering of alkaline versus non-alkaline strata. The mining impacts causing the biological impacts to Middle Creek were easy to identify and mitigate compa:red to the impact of TDS on Callahan Creek.

DEQ has remarked that stakeholders were given the opportunity to provide input into the selection of the reference watershed at a previous public meeting during the Summer of 2004. As the public rrieeting to which DEQ refers was held before its detennination of the potential stressors in Cal'lahan and Straight Creeks, stakeholders had no practical ability to give such input. Selection of a reference watershed should take into account the proposed stressors, so that those specific stressoirs can be evaluated in a healthy watershed. By doing so, natural background can be more objectively evaluated.

One of the candidate reference watersheds, McClure River, does not meet the proposed TDS standard of 334 mg/L, supporting the conclusion that the proposed standard is unjustifiably low and should be withdrawn.

b. Nature of Total Dissolved Solids

Geologic, chemical, hydrologic, and biologic controls of total dissolved solids concentrations (TDS) in the Callahan Creek watershed have not been thoroughly investigated and evaluated, and the proposed standard for the watershed of 334 mg/L is not defensible or realistic. As ncited in the attached comments from Dr. De Lisle, TDS composition as well as exposure magnitude, frequency and duration are critical components in detennining toxicity of

TDS which were not evaluated. Problems with the TDS analysis in the Callahan Creek TMDL include the following.

Changes in TDS concentrations in Callahan Creek occur naturally based on groundwater versus surface viater inputs to the watershed. Groundwater generally has higher concentrations of TDS than surface water. The details of naturally occurring and site specific groundwater are further discussed in the natural background section of these comments. This natural variation was not considered when developing a TDS standard for the Callahan Creek Basin. Figures I and 2 show datzL from stations 3822 and 3823 where the TDS exceedences were observed and show the correlation between TDS values and rainfall events. These figures show that TDS values in Callahan Creek increase when little or no rainfall occurs one week prior to sampling (inclusive of sai-npling date).

The natiiral component of TDS concentrations due to water/rock interactions and the corresponding Aveathering reactions in the watershed need to be deten-nined for both the groundwater and surface water. The most important of the sedimentary components that weather to produce a portion of the observed TDS in Callahan Creek are the sandstones, shales, calcareous sand-stones, and coal in the watershed. Minerals within these sedimentary units which weather the fastest and produce the majority of the constituents of TDS in the Callahan Creek watershed include; calcite (CaCOA dolomite (CaMg(CO3)2), siderite (FeCOA gypSUM (CaSO42H20), and pyrite (FeS2) (Rose, 1979; Drever, 1988; Lerman, 1990; Langinuir, 1997; Kowalewski, 2003).

Example equilibrium concentrations of dissolved constituents from naturally occurring mineral weathering reactions in groundwater are:

1) Gypsiim weathering releases calcium concentrations ranging from 300 to 450 mg/L, sulfate ranging from 800 to 1500 mg/L, and TDS would range from I I 00 to 2000 mg/L (Drever, 1988).
2) Calcite constituent concentrations are dependent on whether the solution is open to the atmosphere (sur-face water) versus closed to the atmosphere (groundwater) but will range in concentrations of calcium from 50 to 250 mg/L, bicarbonate (HC03-) from 150 to 800 mg/L, and TDS from 200 to 1050 mg/L (Drever, 1988, Edmunds et al., 1987).
3) Pyrite oxidation and weathering produce high concentrations of iron and sulfate and acid solutions (Mast et al., 2000, Kelley and Taylor, 1994, Runnells et al., 1992, Everdingen, 1970). Naturally occurring weathering of pyrite has been shown to produce pH values below 3 , iron concentrations greater than I 000 mg/L, and sulfate concentrations greater than 2000 mg/L. This naturally produced acidity in solution can significantly increase the weathering rate of carbonates and other minerals (Skousen et al., 1997, Drever, 1988).
The majority of the chemical constituents that make up the TDS in Callahan Creek are the anions of bicarbonate (HC03-), sulfate (SO4 2-) , and chloride (CF) and the cations of calcium (Ca2+), magnesium (Mg2+) , and sodium (Na+).
C. Comparison of Proposed TDS Standard to Natural Waters
Groundivater in the U.S. contains an average of approximately 350 mg/L TDS (Table 8.8, Aqueous Enviromnental Geochemistry, Langrnuir, 1997). Average groundwater compositions in the U.S. would exceed the proposed 334 mg/L standard (White et al., 1963). Practically this means that during low flow periods in over half of the U.S. watersheds, TDS would be above the proposed standard based solely on their natural characteristics.
In his book, Langmuir describes general threshold values of constituent concentrations in ground water associated with specific rock types using 27,000 chemical analyses of ground water

from the U.S. Geological Survey (USGS) WATSTORE data base (Table 8.13). He evaluates the data to determine concentrations that are representative of natural background conditions versus those that are indicative of anthropogenic impact. He describes ground waters which are likely anthropogenic iirifluenced as waters with constituent concentrations above the observed 97.7 percentile level. These 2 sigma values include background and anomalous concentrations of 32 elements, inclu(ling bicarbonate, sulfate, and specific conductance. Results presented of sedimentary rocks comparable to those found in the Callahan Creek watershed show the following naturally-occurring background concentrations:

Carbonate (vallues would be geochemically similar to carbonate-rich or carbonate-cemented sandstones)

• bicarboilate (HC03-) - 624 mg/L
• sulfate (SO4 2-) -2,199 mg/L
• calcium (Ca@+) - 10,281 mg/L
2+
• magnesium (Mg) - 1,550 mg/L
• TDS (approximated by summing these constituents) - 14,654 mg/L

Sandstone

• bicarboi-late (HC03-) - 1,189 mg/L
• sulfate (S04 2-) -1,237 mg/L
• calcium (Ca2) - 356 mg/L
• magnesium (Mg2+) - I IO mg/L
• TDS (approximated by summing these constituents) - 2,892 mg/L

Shale

- bicarbonate (HC03-) - 1,274 mg/L
- sulfate (S04 2-) -2,199 mg/L
- calcium (Ca2+) - 592 mg/L
- magnesium (Mg2+) - 251 mg/L
- TDS (approximated by summing these constituents) - 4,316 mg/L

Ground water compositions and TDS concentrations in the Callahan Creek watershed are below this naturally occurring range of 2,892 to 14,654 mg/L. This range illustrates the potential TDS concentrations that can be generated naturally through rock/water interactions. Although the Callahan Creek data is below this range, the concentrations in Callahan Creek are significant enough that it is apparent that natural background conditions should be considered in evaluating TDS as a stress-Dr and developing an associated TMDL.

d. Natural Background Controls of the Callahan Creek Basin

As note-i in the Draft Report, TMDLs consist of waste load allocations (i.e., point sources) and load allocations (i.e., nonpoint sources), including natural background levels. As discussed beloNv, the natural background levels of TDS in the Callahan Creek watershed were not evaluated in the Draft Report, and based on the data included herein exceed the proposed TMDL even without any loads from mining operations.

The water/rock interactions in the watershed produce a natural background component of TDS concentrations in both surface water and groundwater. This natural background component is well documented in the literature and is dependent on numerous factors including soil mineralogy, geology, basin hydrology, and climate (Posey et al., 2000; Anderson et al., 1997; Runnells et al., 1992; Freeze and Cherry, 1979; van Everdinger, 1970). Basin geology contributions fi-om natural weathering reactions can also cause exceedences of water quality

standards and aff6ct biologic integrity of the creek downgradient from the weathering rocks (Jeffree et al., 2000). The natural background component of TDS in the Callahan Creek watershed has not been considered in this TMDL analysis.

The threc: main sources of TDS solutions in the Callahan Creek watershed are, I)human discharges into ti-le creek, 2)natural weathering reactions, and 3)accelerated reactions due to mining activities.

Data collected by Cumberland was evaluated to quantify the naturally occurring TDS concentrations produced by water/rock interactions in the Callahan Creek watershed. Representative vvater quality data was chosen from groundwater wells that had minimal or no effects from present mining activities in the watershed. Measured groundwater TDS concentrations iirl the basin range from 60 to 1 147 mg/L. These concentrations indicate that during low flow periods, when groundwater is the major component of flow in Callahan Creek, the water in the creek will likely exceed 334 mg/L without considering the effects of loads other than groundwater.

The measured groundwater concentrations in the Callahan Creek watershed are consistent with values foui-id in natural groundwaters (average TDS concentrations of 350 mg/L) as described by Langmuir (1997) and discussed in the TDS section of these comments. Langmuir based his analysis on an extensive USGS groundwater database (WATSTORE). Langmuir also calculated grouirldwater constituent concentrations using statistical analysis of concentrations and interpreted the 2 sigma values as being representative of anthropogenic influences. These 2 sigma TDS valiies ranged from 2,892 mg/L to 14,654 mg/L depending on the rock type used (carbonate, sanfistone, or shale). Observed rock types in the Callahan Creek watershed include carbonate-rich and carbonate-cemented, sandstones, and shales and measured TDS groundwater concentrations are significantly below these TDS concentrations.

The natural background contribution to TDS in Callahan Creek was not considered. If natural backgroiind had been considered, the standard would have exceeded the proposed 334 mg/L. As a matter of fact, over half of U.S. groundwater compositions exceed the proposed standard.

e. F"emining, Reclamation and Source Control

The Dra-ft Report states that remining will be an important part of the implementation plan, allowing achievement of the load reductions. p. 12-7. Typical best management practices (BMPs) available for surface disturbances associated with coal mining include remedial measures such Eis regrading, revegetation and liners. Regrading BMP techniques would typically reduce erosion (sediment load) and decrease the amount of surface water runoff. Revegetation BMP would also reduce erosion, decrease surface water runoff and increase the evapotranspirat-ion component of the water balance (Strock, 1998, Earle and Callaghan, 1998). Even with regrading and revegetation BMPs employed there still will be a water balance component of ii-ifiltration into the groundwater system. Infiltration water will continue to react with the naturally occurring soils and rocks and produce constituents in solution, probably above the proposed T13S limit of 334 mg/L, as indicated by the groundwater data discussed above. It may be possible to promote surface water runoff using liners (e.g., HDPE or compacted clay) - and limit infiltration and reduce water/rock reactions and overall TDS loading from groundwater to Callahan Creek, but it is not possible to eliminate the groundwater discharge component to Callahan Creek. (baseflow). Furtherrnore, use of such liners would have a negative impact on the ability to establish vegetation, would increase the potential for downstream flooding, and would be cost prohibitive.

Typical best management practices (BMPs) for underground disturbances are similar to those for surface mining with the additional allowance for underground retention and treatment of water prior to pumping or discharge to the surface.

Based oti Cumberland's remediation experience in the Callahan Creek watershed, remediation at other mining sites, and documented remediation case studies in the literature (Pierzynski et al., 1994, Johnson et al., 1994) it is highly unlikely that BMPs would significantly affect observed TDS concentrations.

Currently, all of Cumberland's surface mining in the Callahan Creek watershed is remining. The i-emining process will ultimately result in reclamation of these previously mined areas, leading to a reduced sediment load into the creek. Its long-term effect on TDS will be less significant, and during remining there will be increases in loads of both sediment and TDS. If the 334 mg/L standard is approved, runoff from some areas being remined will likely not meet that standard d-uiring the active remining process. If the TDS standard is enforced during remining, it will probably stop all or most remining efforts in the watershed. This would be detrimental to the long-term aquatic health of the watershed, as remining, followed by modem reclamation, improves water quality and benthic health. The ultimate goal in the Callahan Creek watershed should be the successful remining and reclamation (to today's standards) of the previously mined areas. This aspect of land use in the watershed, and the benefits of these activities shoulti be discussed in the report so that remining can continue, instead of being threatened by the currently proposed standards.

Increased sediment load is one of the most important factors in degrading benthic health. In fact, it is listed as the number one source of benthic impairynent nationwide on the US Enviromnental Protection Agency's list of impaired waters (Clean Water Act Section 303(d);

USEPA 2000). Increased sediment fills the interstitial spaces of the stream channel and promotes a more homogeneous and unifonn streambed.

Macroinvertebrate response due to increased sediment generally has a greater effect on density metrics and richness measures. Richness reduction, regardless of the metric (EPT, Taxa, or EPT/Chironoinidae), is usually 50 percent or more as a result of relatively modest inputs of fine sediments (Z'weig and Rabeni 2000). Decreases in density metrics are more severe and, in cases of moderalle sediment loading, may prove catastrophic for more intolerant metrics (i.e. EPT density). Remining is a critical component of maintaining and improving the environmental health of the watershed.

The proposed standard could result in Cumberland's losing all or most of the value of its extensive investment in Callahan Creek.

f. NVater treatment

TDS abcive the proposed 334 mg/L limit will occur during dry periods when groundwater discharge is a significant or the sole component of flow in the watershed (baseflow conditions). The only remedy to meet the proposed 334 mg/L TDS standard under those conditions would be water treatment. Water treatment of TDS is very difficult to achieve and very expensive (De Vegt, 1998). TI-iis is confirmed by a technical issue paper published by the Society of Envirom-nental'Toxicology and Chemistry discussing ion imbalances in fresh water and it is stated, "UnfortLinately, cost-effective waste treatment control options for a facility whose effluent is toxic: because of TDS or specific ions are scarce, if available at all" (SETAC 2004). This paper also cites a TDS concentration of 1,340 mg/L as the concentration having adverse effects on freshwater organisms, (four times the proposed Callahan Creek TDS standard).

Surface water data has been collected by Cumberland for submittal to DMME from locations throu,-,@hout the Callahan Creek watershed. TDS concentrations in the Callahan Creek

watershed range from 40 to 1545 mg/L and are typically well-above the proposed standard. Approximately' 25% of Cumberland's perinitted discharges would be above the proposed TDS standard as noted in the attached report from EMI. The TDS components are predominantly bicarbonate, sul-Fate, calcium, and magnesium. These constituents are difficult to remove from solution. The water treatment technology would be reverse osmosis. Reverse osmosis water treatment plant size are dependent on flow and are very expensive to build (tens to hundreds of millions of dollars) and very expensive to operate (hundreds of thousands to millions of dollars per year) and the resultant very high TDS waste solution would need to be handled and disposed of as a hazardotis waste (Zinck and Griffith, 2000, De Vegt et al., 1998).

Althoug'h the Draft Report does not purport to be an implementation plan, the standards it seeks to validate would virtually assure that no implementation plan would succeed.

9. Total Suspended Solids and Sedimentation

The proposed sediment load allocation for Callahan Creek is problematic because, 1) the proposed sediment load targets are inconsistent with well-documented and presently accepted point source discharge standards (70 mg/L maximum, 35 mg/L average) in the basin which are approved by the Virginia Department of Mines, Minerals and Energy (DMME), 2) Middle Creek is highly questiOnable as a representative reference watershed, and 3) TSS concentrations are of questionable accuracy as a representative measure of sedimentation as an impain-nent.

Increases in sediment loading to watersheds from anthropogenic influences (e.g., mining) have been well-documented as a potential stressor to freshwater organisms. The DMME and Federal Agencies that regulate mining activities (e.g., Bureau of Land Management, BLM)

currently set TS',") limits from mining operations. In the Callahan Creek watershed a 35 mg/L TSS limit is considered protective to the enviromnent as it is currently set by DMLR.'

Mining activities in the Callahan Creek watershed include both perrnitted active mining operations and a'bandoned mine lands. A well-documented cost-effective solution for decreasing TSS concentrations in watersheds is remining of AML sites using currently accepted Best Management Practices (BMPs). Examples of possible reclamation options for TSS are discussed elsewhere in these comments.

Changes in TSS concentrations in Middle Creek and Callahan Creek occur naturally and natural variatioris are controlled by flow of the creek and ultimately rainfall events. The percentage of land used for mining in the Middle Creek reference watershed is very different from that in the Callahan Creek watershed (3. 1 % in Middle Creek compared to 3 1 % in Callahan Creek).

Another drawback to using the Middle Creek watershed is the lack of high-flow TSS data from Middle Creek. TSS data collected only during low-flow conditions of the creek underestimates -true suspended solid loading of the reference stream. There is no reliable way to compare TSS iri Callahan Creek to TSS in any other reference creek unless the TSS data are collected over a. wide range of flow conditions.

2The evaluation of TSS in the Draft Report is confusing. The existing effluent limit approved by DMME of 35 mg/L is greater than the 25 mg/L TSS from the McClure River watershed used to determine whether sediment load was a probable stressor. The target sediment TMDL is 6,392.58 Mg/Yr, as noted on Table 11.5, page 11-9. Attempts to back-calculate from this load to an enforceable concentration were problematic. This load is dependent on both flow and concentration. Based on a yearly flow of 7144 gallons per minute, the corresponding TSS concentration viould be approximately 450 mg/L, almost thirteen times the currently allowed 35 mg/L. This ill-Listrates the inaccuracies and uncertainties in the Draft Report, as well as the significant difficulties in independently verifying the results and conclusions presented due to the lack of documentation of procedures and decision-making processes.

The uncei-tainty associated with using TSS concentrations as representative of sedimentation as an impairment is currently being investigated in numerous watersheds and these limitations are discussed in detail in the Straight Creek TMDL Group's comments. The major problem associated with elevated sediment concentrations for benthic organisms is the loss of habitat due to siltation. Habitat limitations in the Callahan Creek watershed are discussed at length elsewhere: within these comments.

h. TMDL Implementation

The Drafl Report identifies sediment and TDS as benthic stressors in Callahan Creek. As shown above, habitat impairinent is also a stressor. The Draft Report does not suggest how or in what sequence tlie various stressors will be addressed or how they will affect existing point and non-point discharges.

The proposed TDS standard would significantly affect mining and remining in the basin. Once the TMDI, is implemented, the standards would affect present and future VPDES permits in the basin. The cost to meet the proposed standards would limit or prevent future mining or remining in the basin.

i. Reclamation of Middle Creek

The Draft Report supports selection of Middle Creek as the reference stream by noting that mining imriacts were remediated there and the biology of the watershed recovered. In the N/liddle Creek delisting document, MapTech and DEQ describe decreases in TDS concentrations in Middle Creek as the major reason for the observed biological recovery. Based on preliminary analysis of the Middle Creek reclamation conducted and data provided in the delisting docunients, Cumberland does not see how the changes in TDS concentrations before and after remedliation support DEQ's conclusions. Figure 3 shows MapTech's TDS data versus time, as well as a line depicting mean TDS concentration from these data. Except for the 1981

TDS value, all TDS data represented in Figure 3 was provided by MapTech. Note that the 1981 value for TDS was calculated (TDS mg/L = specific conductivity umhos/cm x 0.65) from an anecdotal referejice to average specific conductivity of 660 umhos/cm in Middle Creek, in the Middle Creek delisting document (page 4-1). High TDS shown in Figure 3 between late-1997 and December 2000 do not correlate with specific conductivity measurements taken in the same station, at the same time (Table 1). Figure 3 shows that TDS concentrations do not exhibit a decreasing trend, corresponding to completion of reclamation activities after 2000. Thus, TDS has not significaLntly changed and therefore has not been a stressor in Middle Creek.

The probable stressor to the Middle Creek watershed was the low pH solutions and the concomitant metals produced by acid rock drainage reactions. The reclamation conducted had dramatic effects on pH values observed in Middle Creek. This interpretation is supported by the large increase iri pH of Middle Creek from values below 6 to values of greater than 8 from 1995 to 2003 (e.g., Figures A-32 through 37 and A-40 through A-45, pages A-17 through A-24

Biological impairments from AMD solutions discharging into streams have been well documented as'has the recovery of the biota once the acidity and metals have been eliminated from the streams (Earle and Callaghan, 1998; Strock, 1998).

If TDS or the major constituents of TDS in Callahan Creek cause biological impainnent, there would be federal (EPA) or state standards set for TDS, bicarbonate, sulfate, calcium or magnesium in -streams. In fact, there are none.

V. Iqiscellaneous.

a. 'FMDL Standards and Effluent Limits

Cumbei-land is concemed that the TDS TMDL endpoint of 334 mg/L will be applied to future discharge permits and permit renewals (i.e., VPDES pen-nits) if the TMDL is approved by EPA and adopted by SWCB. During a meeting on March 22, 2005, DEQ and DMME stated that

this would not be the case. It was stated that the 334 mg/L standard would only apply to deep mine discharges, not to permitted discharges from sediment ponds or other pennitted, non-deep mine discharges. If this is so, the report should be revised to so state.

The Draft Report includes deep mine discharges, runoff from active mining, and residential discharge from straight-pipes as point sources. Non-point sources include surface runoff, delivery through interflow, delivery through groundwater, and delivery through direct discharge of mine seeps to the stream. The surface runoff portion of the non-point source allocation includes discharges from permitted sedimentation ponds, even though these are typically considered point sources. These discharges are permitted through the VPDES program, which by definition makes them point sources.

As discussed previously, groundwater naturally contains higher levels of TDS than surface water. During dry months and droughts, flow in Callahan Creek consists of a larger percentage of groundwater than surface water. During wet months the opposite is true. This results in a fluctuation of the natural TDS concentration in the creek. Since groundwater in the watershed has natural TDS levels exceeding 334 mg/L, the surface flow in the creek may naturally excee(i this standard during times of low flow. The report should address these flow-dependent natur-al fluctuations in TDS level. Since the TMDL process will require that the load allocations for TDS be met, the report should specify how individual permit limits for TDS will be established.

b. llublic Comment Period

The Draft Report does not contain sufficient information to fully evaluate the conclusions within the publiic comment period allowed, even though it was extended. The raw data was not included in the report, the decision-making procedures were not clearly documented, and therefore it was not possible to critique or verify the findings. The only data included in the

report are scatter- graphs, many of which do not include all the data discussed in the text. No data (other than anec(lotal data discussed in the text) was included from the two reference watersheds used in the study. Since the data was not included in the Draft Report, a delay was incurred in obtaining the data from DEQ reducing the time available for evaluation.

Furthen-nore, the data from Dumps Creek and Black Creek TMDLs, though promptly requested from DEQ, was not made available to Cumberland in a reasonable time to pennit comparison of the multiple linear regression method used on those watersheds with the reference watershed approach used for Callahan Creek.

The use of two reference watersheds was confusing and introduced additional and unnecessary uncertainty into the process further weakening the conclusions. The rationale for using McClure River data to deten-nine the stressors in Callahan Creek, but using Middle Creek data to set standards was unexplained, and appears unconventional and indefensible. The geology and land use in the McClure River watershed is as different from the Callahan Creek watershed as that of the Middle Creek watershed, thereby introducing numerous additional variables to the study.

C. F-conomic Impact of TMDL Implementation

As disciissed above, Cumberland would be unable to meet the TDS standard of 334 mg/L based on background groundwater and surface water quality alone. Natural levels of TDS in the creek will likely exceed this standard due to the unique geology of the basin and water/rock interactions with our without mining in the watershed. Implementing this TMDL could put Cumberland out of business on Callahan Creek. This would result in the loss of approximately 370 jobs, as well as significant source of tax revenue for Wise County and the State. Cumberland pays $2,000,000 per year to Wise County in severance taxes, not including

property, machir[ery or payroll taxes. The Draft Report does not address the costs and benefits of implementation.

Virginia law requires that the SWCB give due consideration to the economic and social costs and benefits which can be reasonably expected to result from the adoption of the proposed standard. The Draft Report does not include sufficient information for the SWCB to give such consideration; however, if Cumberland is forced to cease operations, the costs would be locally significant. The benefits of implementing this TMDL are questionable, as discussed above, since the major impaii-rnent to the creek appears to be lack of habitat rather than poor water quality. If the water quality improvement goals are met, but habitat is not improved, it is unlikely benthic health will improve.

VI. liricorporation of Comments.

Cumber] and incorporates and adopts the comments of the Straight Creek TMDL Group except for cominients relying upon data specific to Straight Creek.

Conclusion

For the lbregoing reasons, Cumberland requests the following actions be taken with respect to the Draft Report:

I . TDS and sediment be eliminated from the TMDL analysis.

2. The basis for the TMDLs for TDS and sediment be further studied and reconsidered in light of the comments submitted by Cumberland and the Straight Creek TMDL Group.

3. If not eliminated, the TMDLs for TDS and sediment be calculated based on sound scientific principles and properly collected data.

4. I'n the altemative, that the comment period be extended until August 9, 2005.

Figure 1. TDS versus Precipitation (Sum of recorded precipitation one week before TDS measurement) at Station 0003822

Callahan Creek Station 0003822

TDS vs. Precipitation received one week prior
to water quality sampling event
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Figure 2. TDS versus Precipitation (Sum of recorded precipitation one week before TDS measurement) at Station 0003823

Callahan Creek Station 0003823

TDS vs. Precipitation received one week prior
to water quality sampling event

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Figure 3. TDS results for Middle Creek. Mean value line calculated from these data. Data provided by MapTech except 1981 TDS value. 1981 value was calculated from anecdotal specific conductivity results referenced in Middle Creek delisting document.

Middle Creek Total Dissolved Solids (TDS) Data

Note: 1981 TDS value calculated (TDS mg/L = SC umhoskm x 0.65) from anecdotal average specific conductivtty In Middle Creek referenced in the Middle Creek delisting document
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Table 1. Compa:rison of specific conductivity and TDS for given station and sampling date, when TDS values are notably elevated in Figure 3. Data in Table I provided by MapTech.

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6/1/99 4.120011 520 1731
7/1/99 4 1 2001 1 480 1604
7/1/99 4 1 2001 1 480 1604
6/1/99 41 20018 540 1047
6/1/99 zll 20018 540 1047
11/1/98 41 20012 650 954
11/1/98 41 20017 650 954
11/1/00 4120011 480 800
5/1/98 41 20018 260 577
6/1/99 41 20116 520 721
6/1/99 4120116 520 721
6/1/99 4120204 520 721

Respectfully submitted,

CUMBERLAND RESOURCES CORPORATION

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Marvin Gilliam, Jr. L/
Vice President

Attachment A to Comments of Cumberland Resources Corporation
to TMDL Development for Powell River Basin

Powell River Resources Corporation

Alliance Coal Corporation

Nleadow Branch Mining Corporation

Nlill Branch Coal Corporation

Nine Mile Spur LLC

P'igeon Creek Processing Corporation

Maggard Branch Coal LLC

KI oda Resources LLC

Meadow Branch Coal LLC

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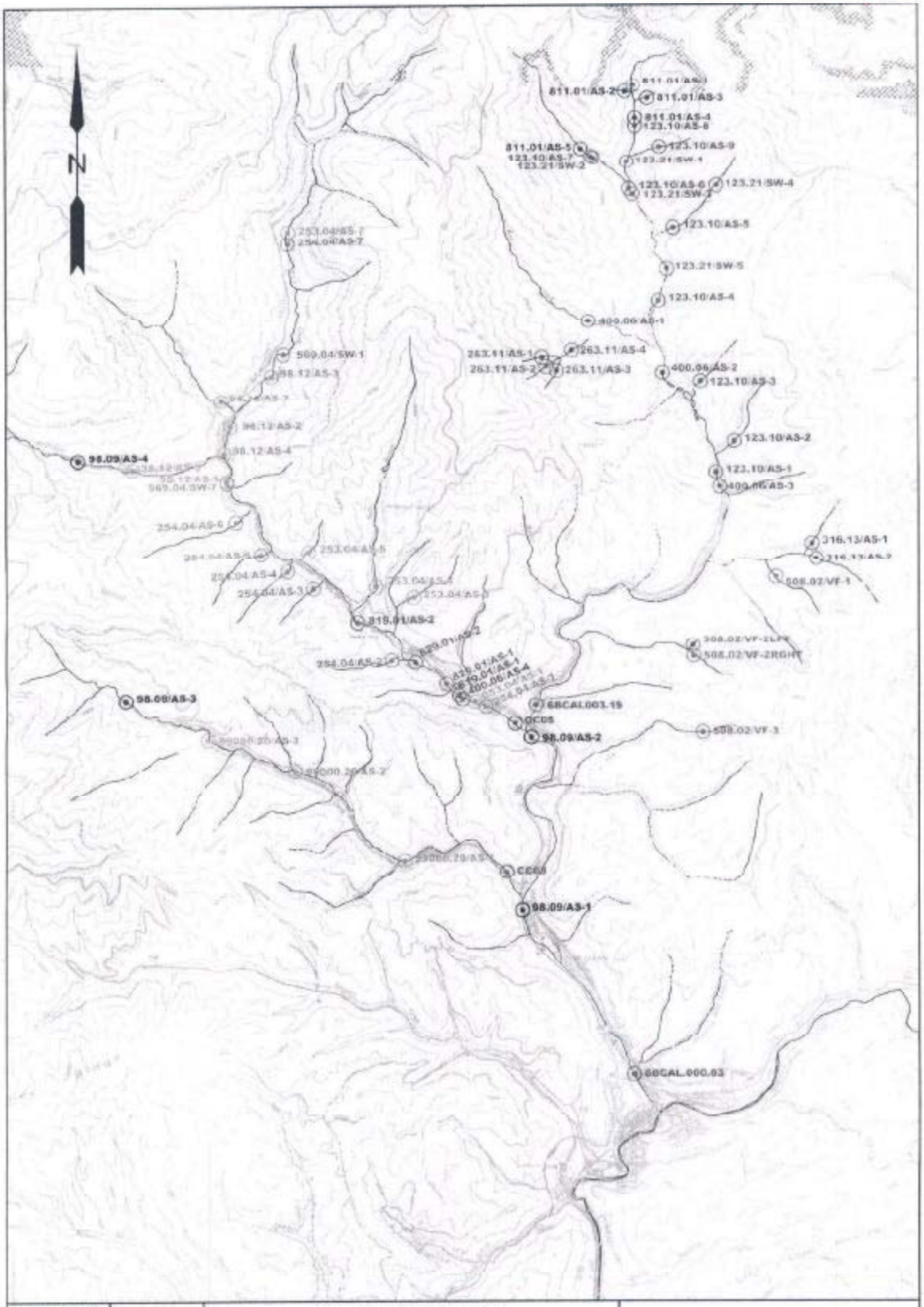
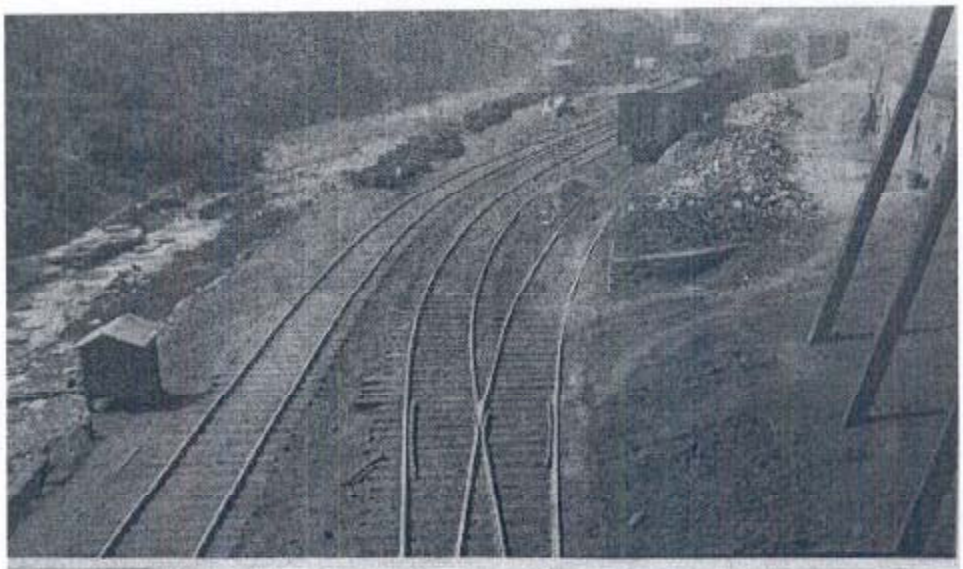


Scale: 1"=3000'	Project No. 67.44	FIGURE 1. LOCATION MAP AQUATIC SAMPLING SITES LOCATED WITHIN THE CALLAHAN CREEK WATERSHED WISE COUNTY, VIRGINIA	ATS® Appalachian Technical Services, Inc. Wise, Virginia
Drawn: CLJ			
Checked: TBC			
Date: 03/05		APPALACHIA AND WHITESBURG U.S.G.S. QUADRANGLES	

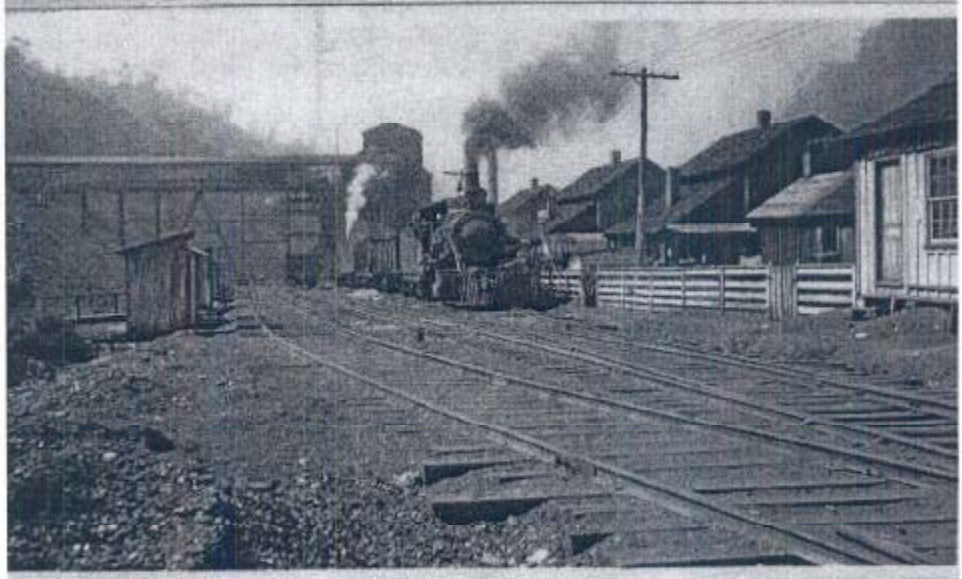
Andover: Showing Embankment thrown up to protect Coal Storage.

Arno: Doctor's Office.

From 1915 SCC Company Report



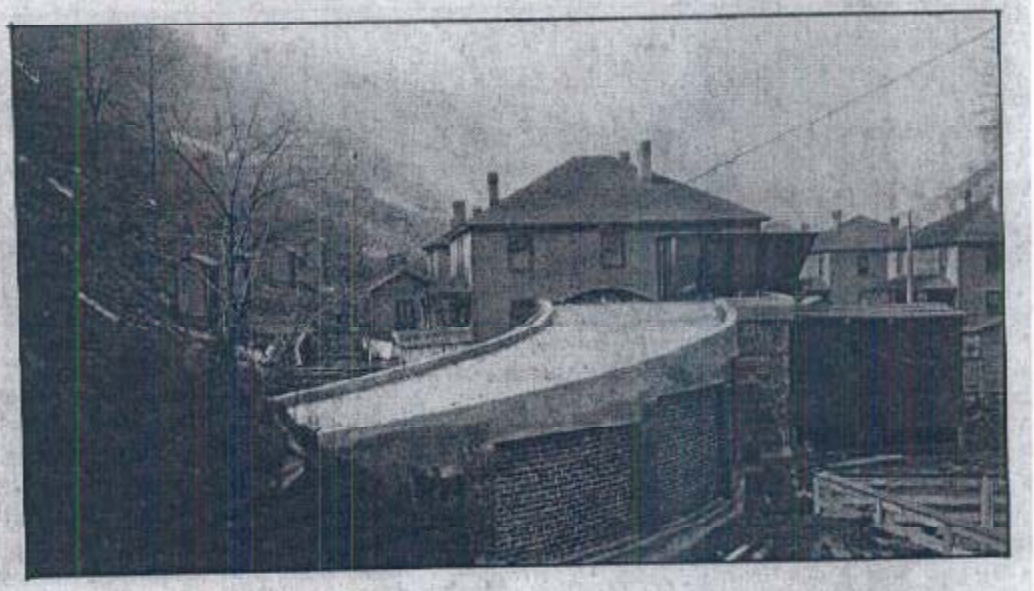
REARRANGEMENT OF TRACKS BELOW STONEGA NO. 3 TIPPLE



REARRANGEMENT OF TRACKS ABOVE STONEGA NO. 3 TIPPLE.

From 1915 SCC Company Report

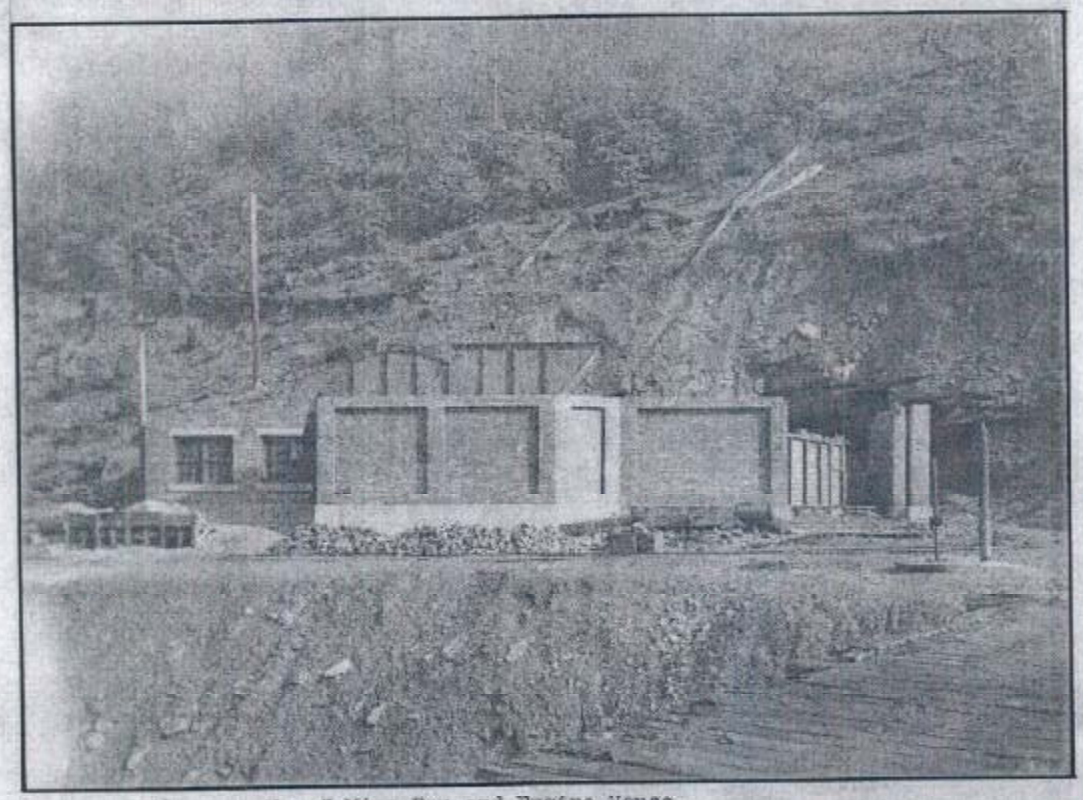
Arno: Motor Barn, near Drain Headings.



Arno: Goosenack leading to new fan.

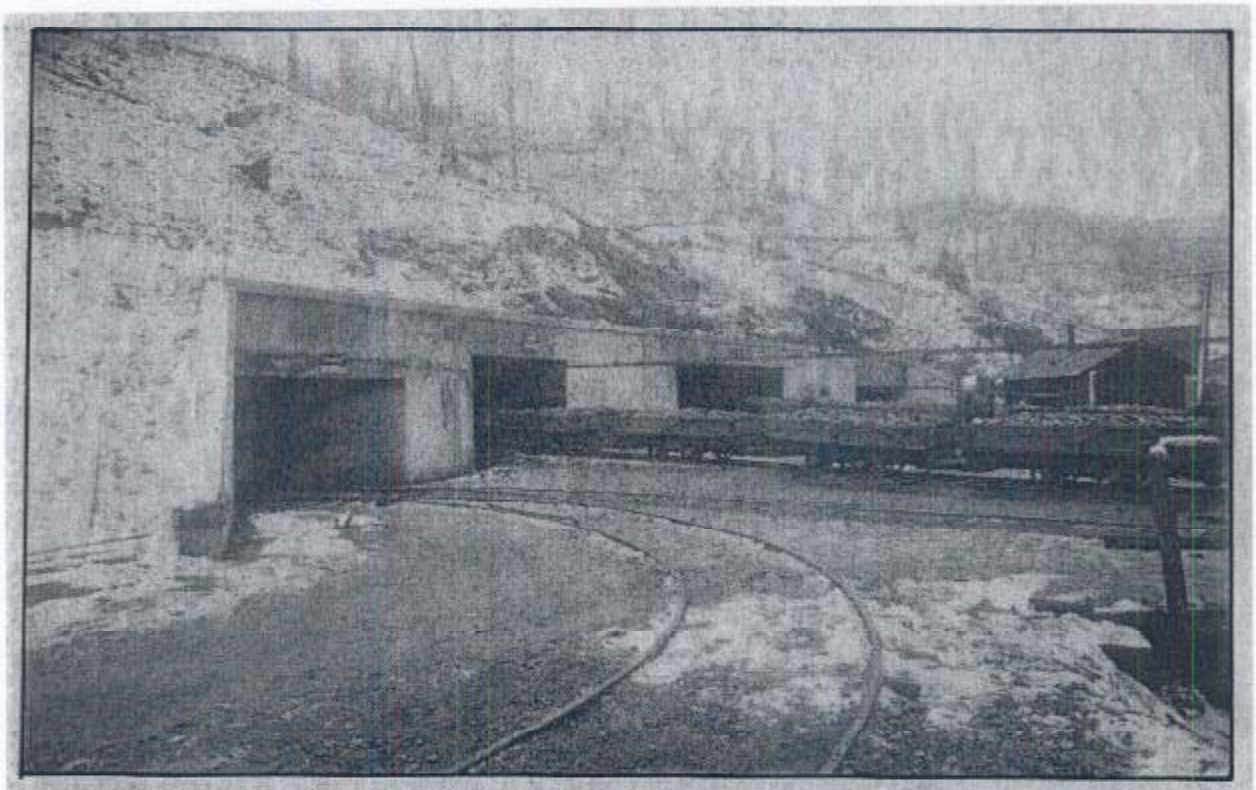
From 1915 SCC Company Report

Stonega Colliery: Electric installation on Coke Ovens.



Stonega Colliery: No. 3 Mine Fan and Engine House.

From 1919 SCC Company Report



Stonega Colliery: New Concrete Approach into the Mine.

Stonega Colliery: Slate dumping machine.

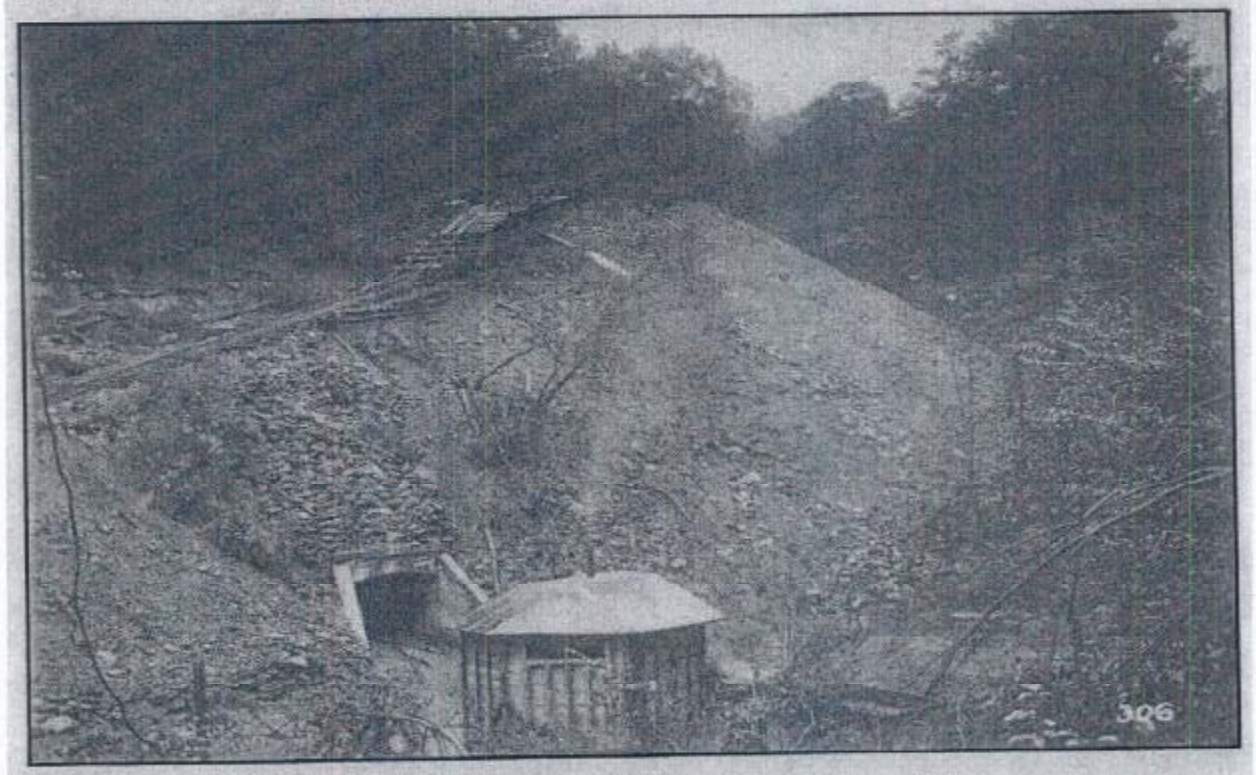
From 1920 SCC Company Report

Stonega Colliery: Slate dumping machine.

Stonega Colliery: Filling recently completed on top of Coke Ovens.

From 1920 SCC Company Report

Arno Colliery: Slate dump.



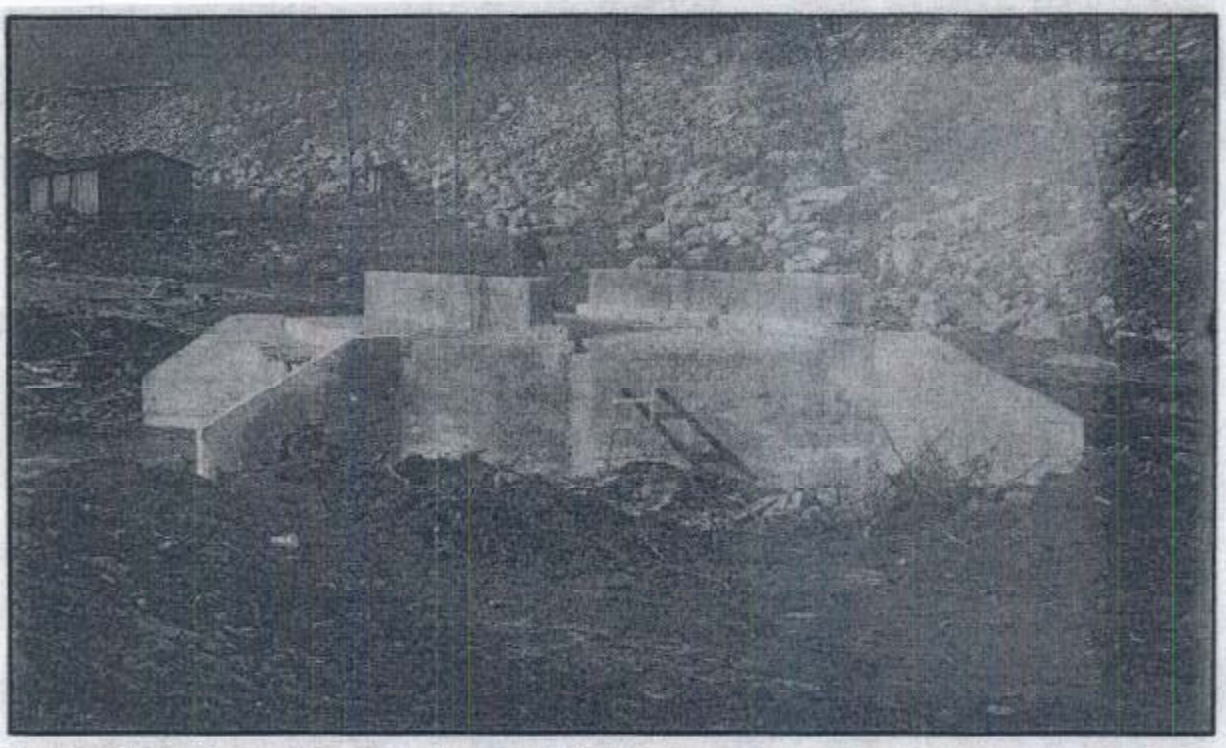
Stonega Colliery: Slate dump.

From 1921 SCC Company Report

Derby Colliery: First foundations placed for dwellings, Nov. 23, 1922.

Derby Colliery: Grading for townsite, August 16, 1922.

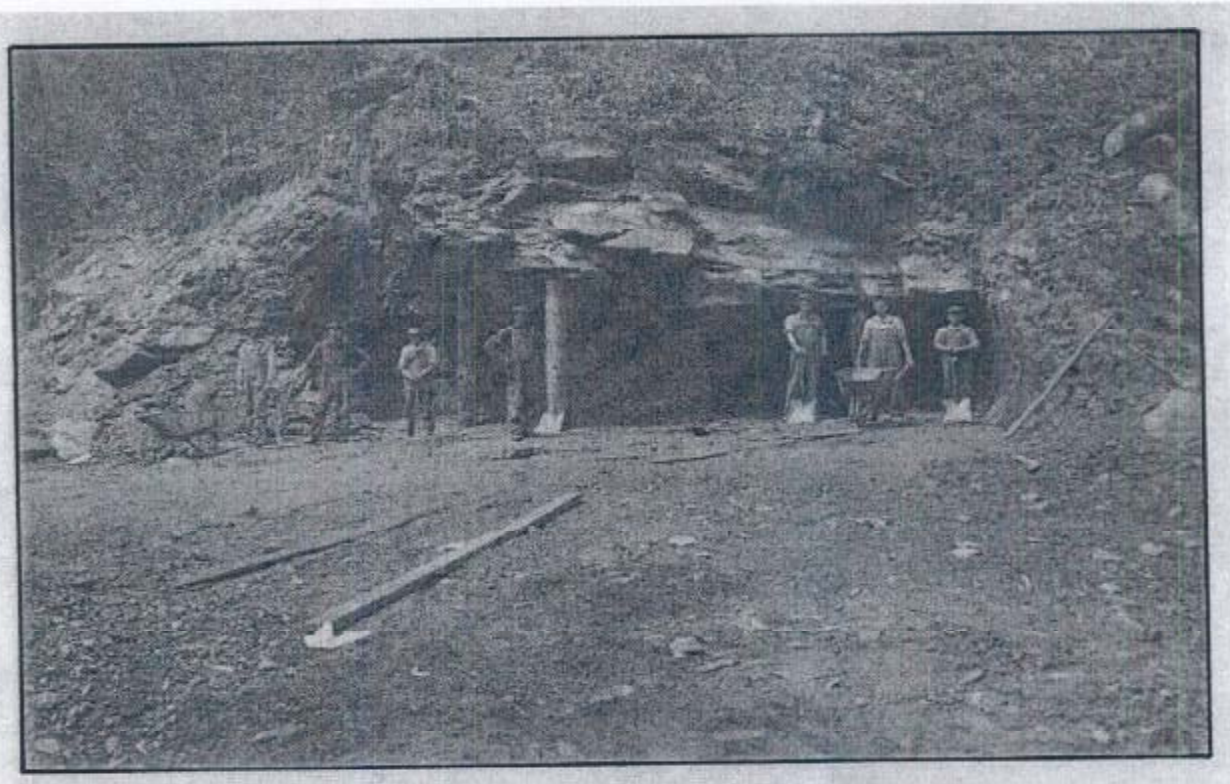
From 1922 SCC Company Report



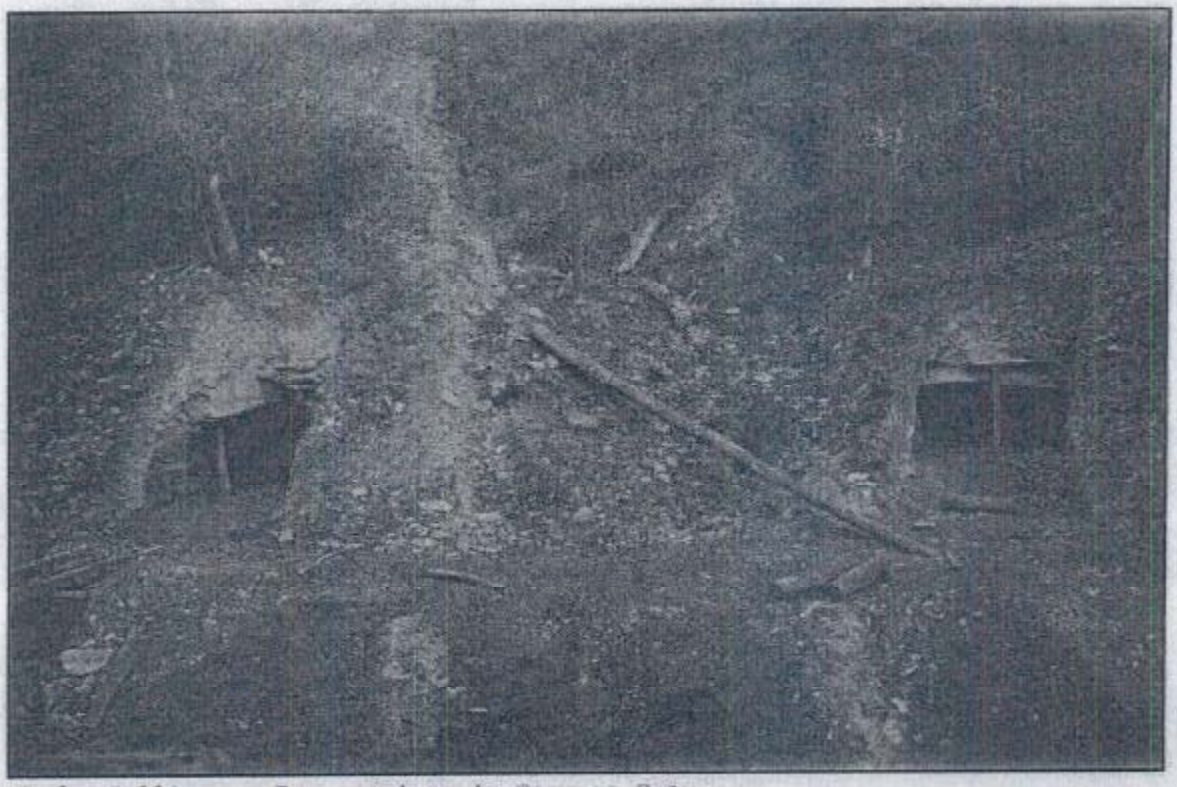
Derby Colliery: Reinforced concrete highway bridge.

Derby Colliery: Grading for Taggart Tramroad. November 1, 1922.

From 1922 SCC Company Report

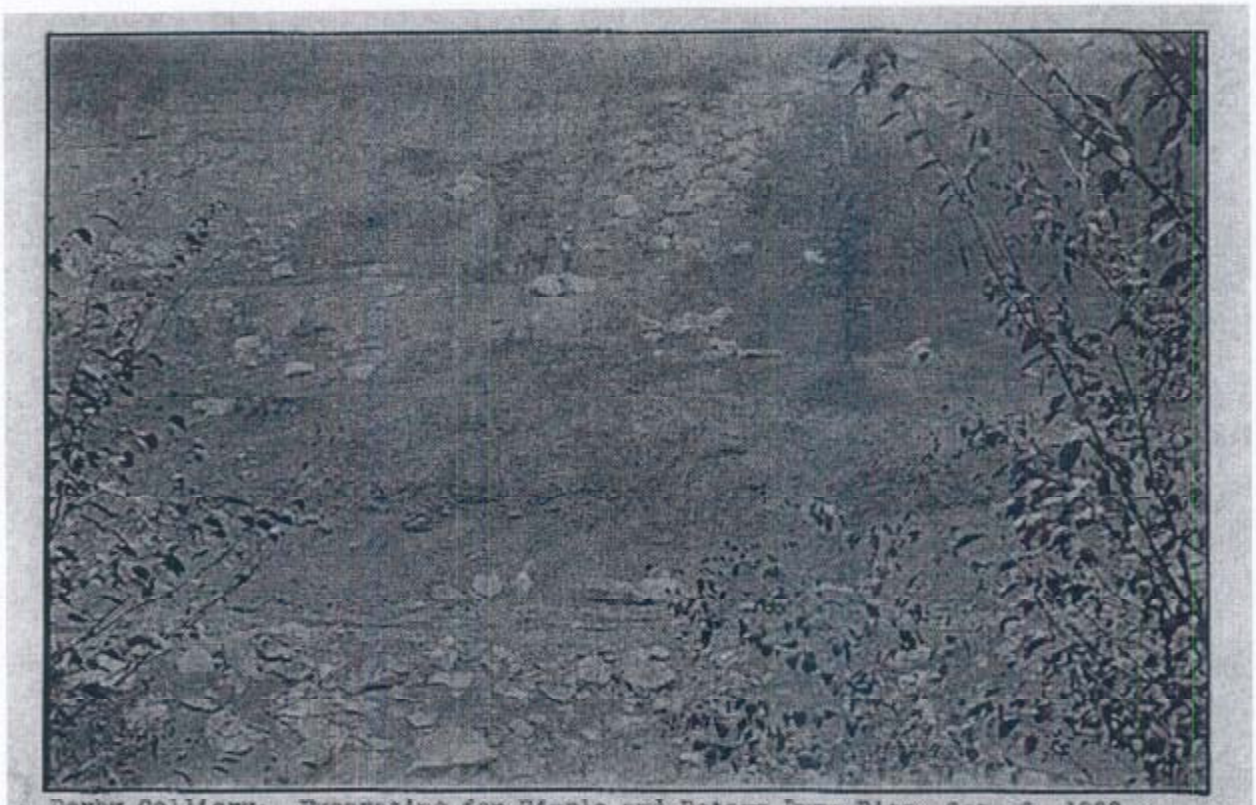


Derby Colliery: Main haulage openings, Taggart Seam.



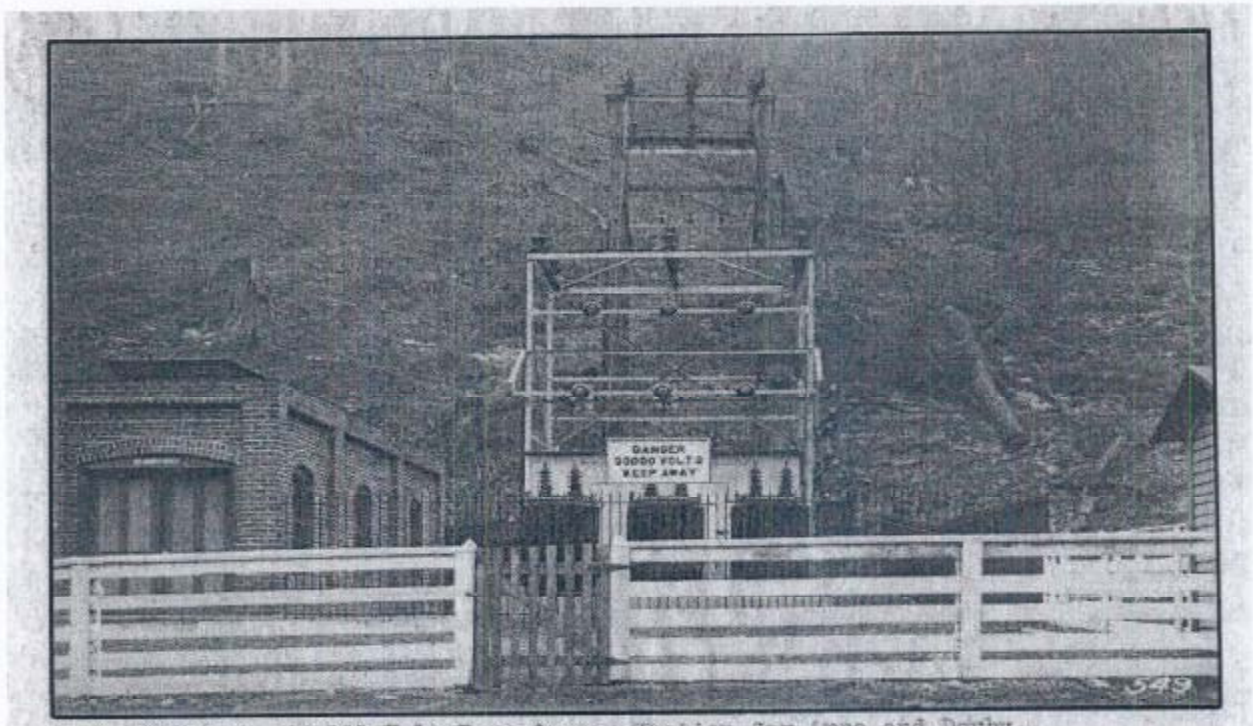
Derby Colliery: Two openings in Taggart Seam.

From 1922 SCC Company Report



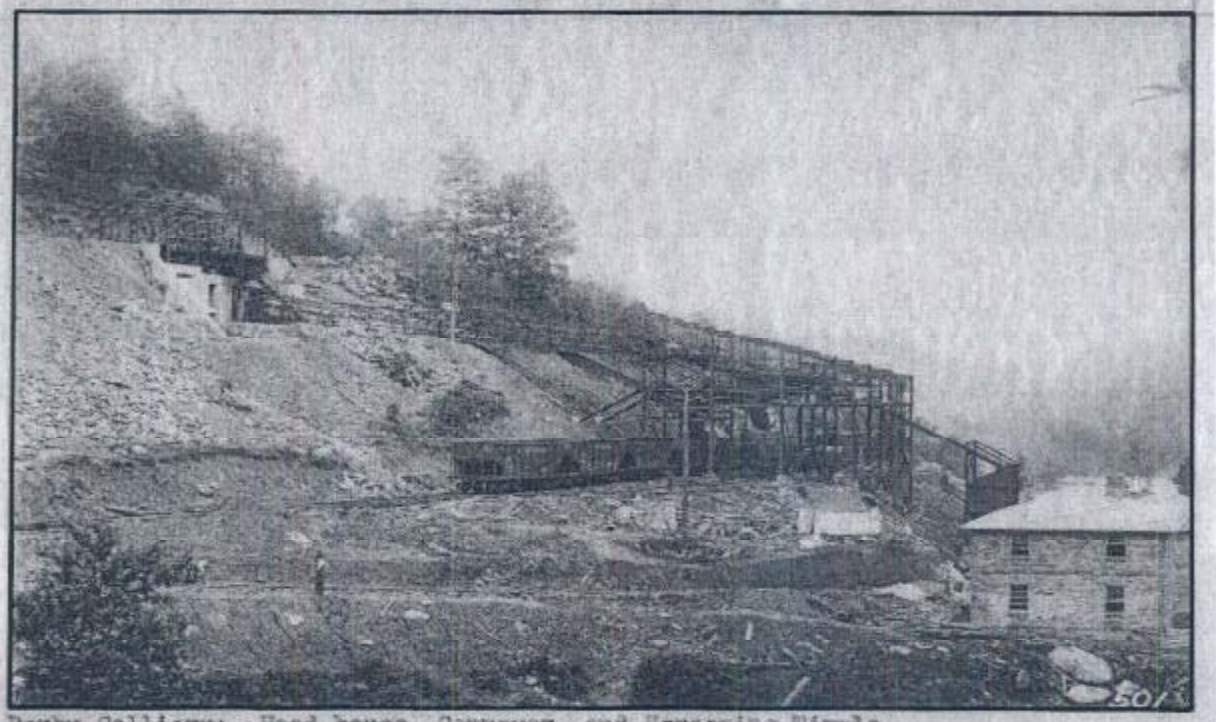
Derby Colliery: Excavating for Tipple and Rotary Dump Pits, Oct. 6, 1922.

From 1922 SCC Company Report

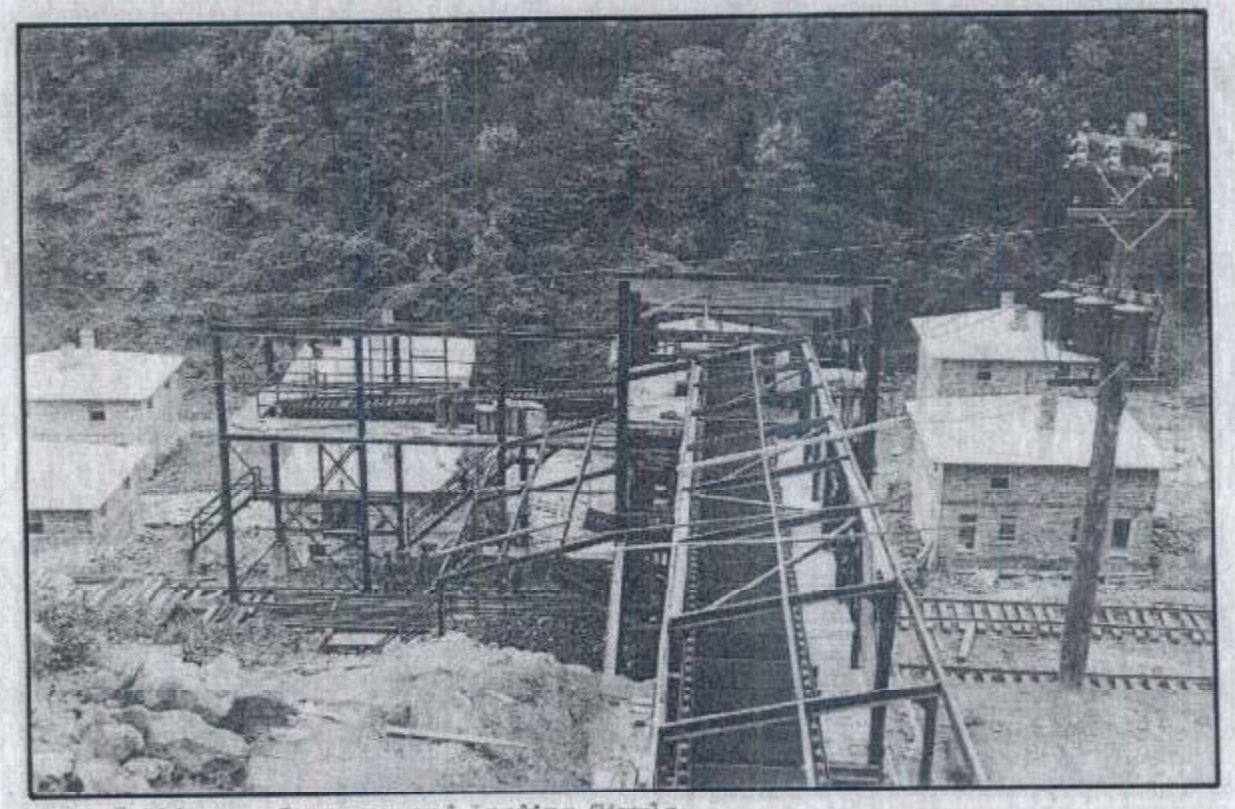


Arno Colliery: 33,000-Volt Transformer Station for Arno and Derby.

From 1923 SCC Company Report

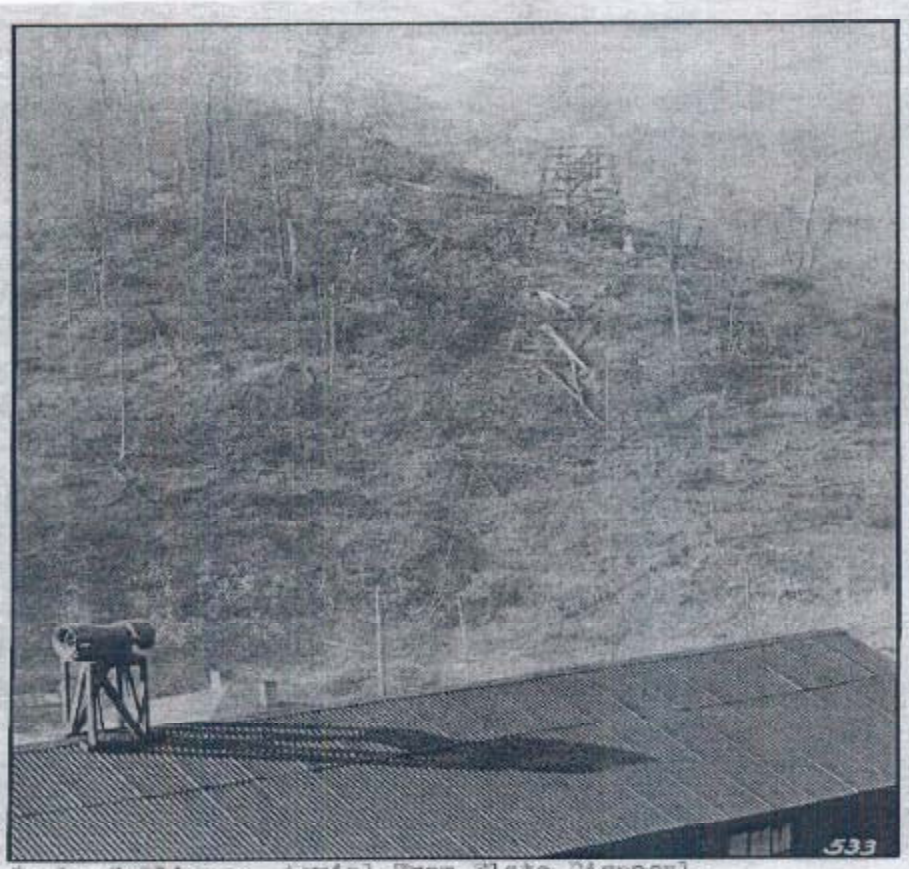


Derby Colliery: Head-house, Conveyor, and Screening Tipple.

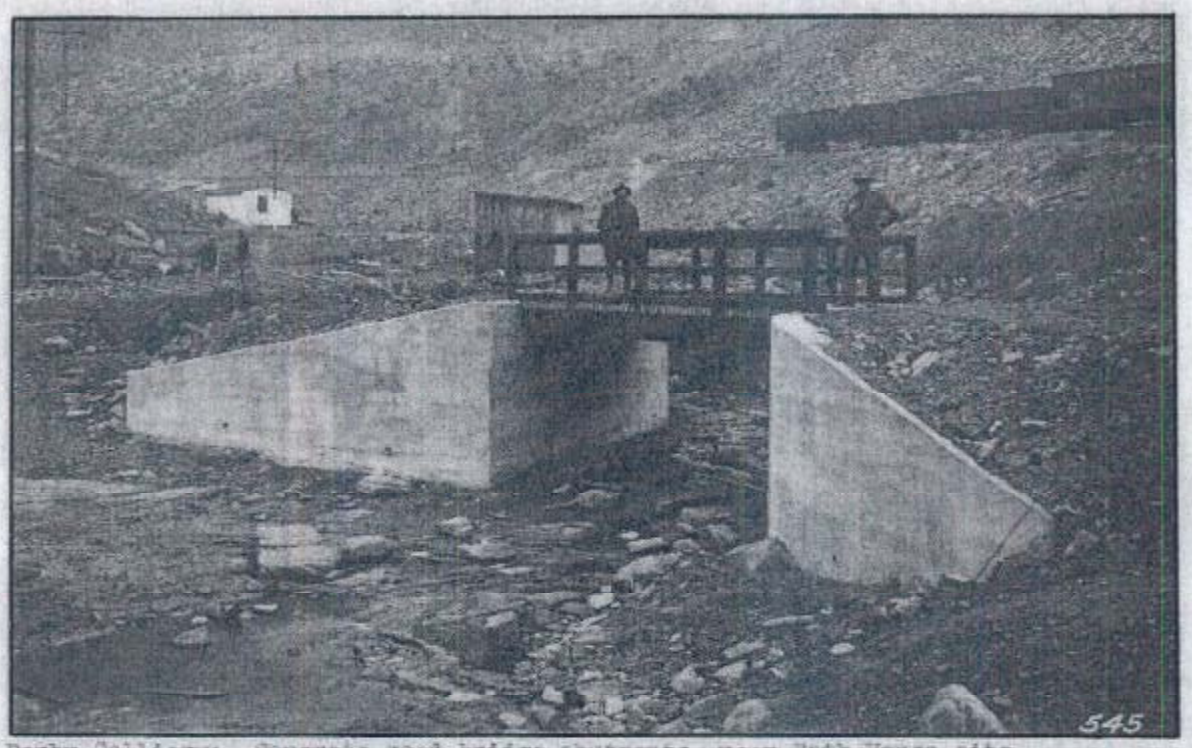


Derby Colliery: Conveyor and Loading Tipple.

From 1923 SCC Company Report

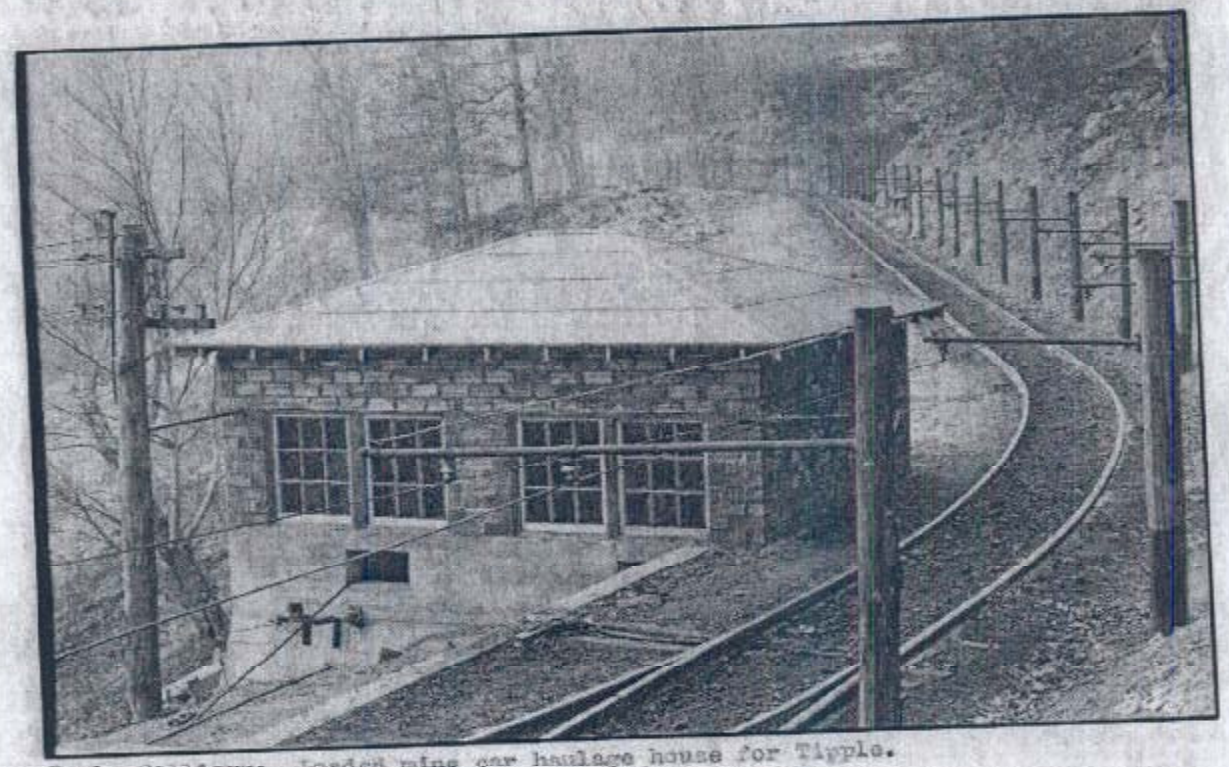


Derby Colliery: Aerial Tram Slate Disposal.

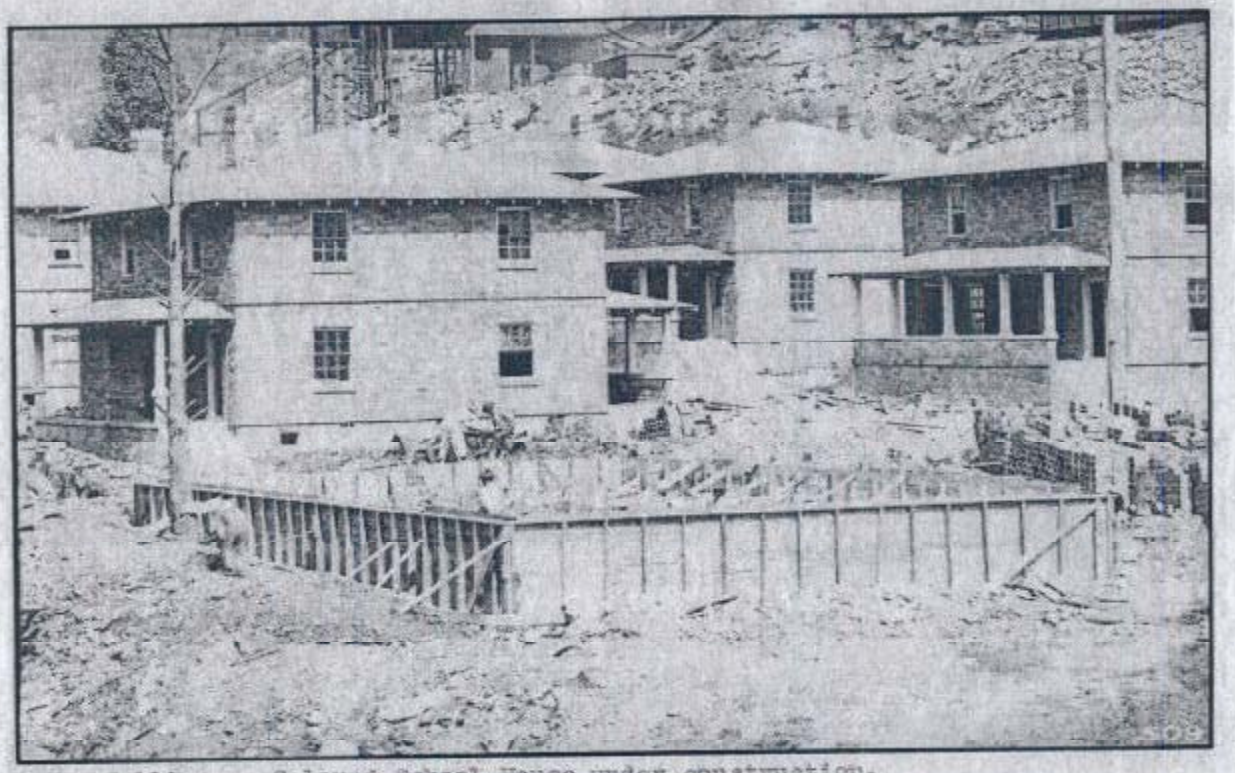


Derby Colliery: Concrete road bridge abutments, near Bath House site.

From 1923 SCC Company Report



Derby Colliery: Loaded mine car haulage house for Tipple.



Derby Colliery: Colored School House under construction.

From 1923 SCC Company Report

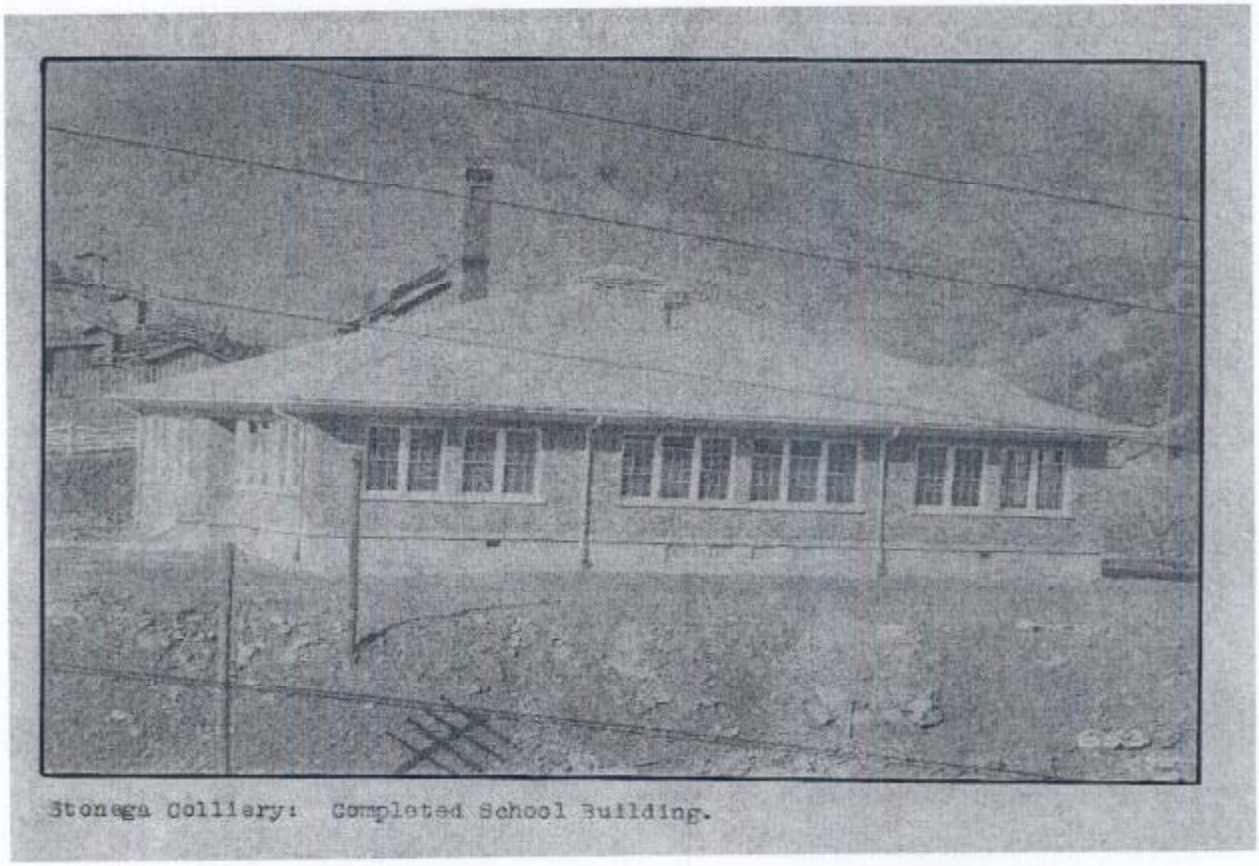
Derby Colliery: Amusement Hall, under construction.

Derby Colliery: 8-Room Tile dwellings below the Tipple, under construction.

From 1923 SCC Company Store

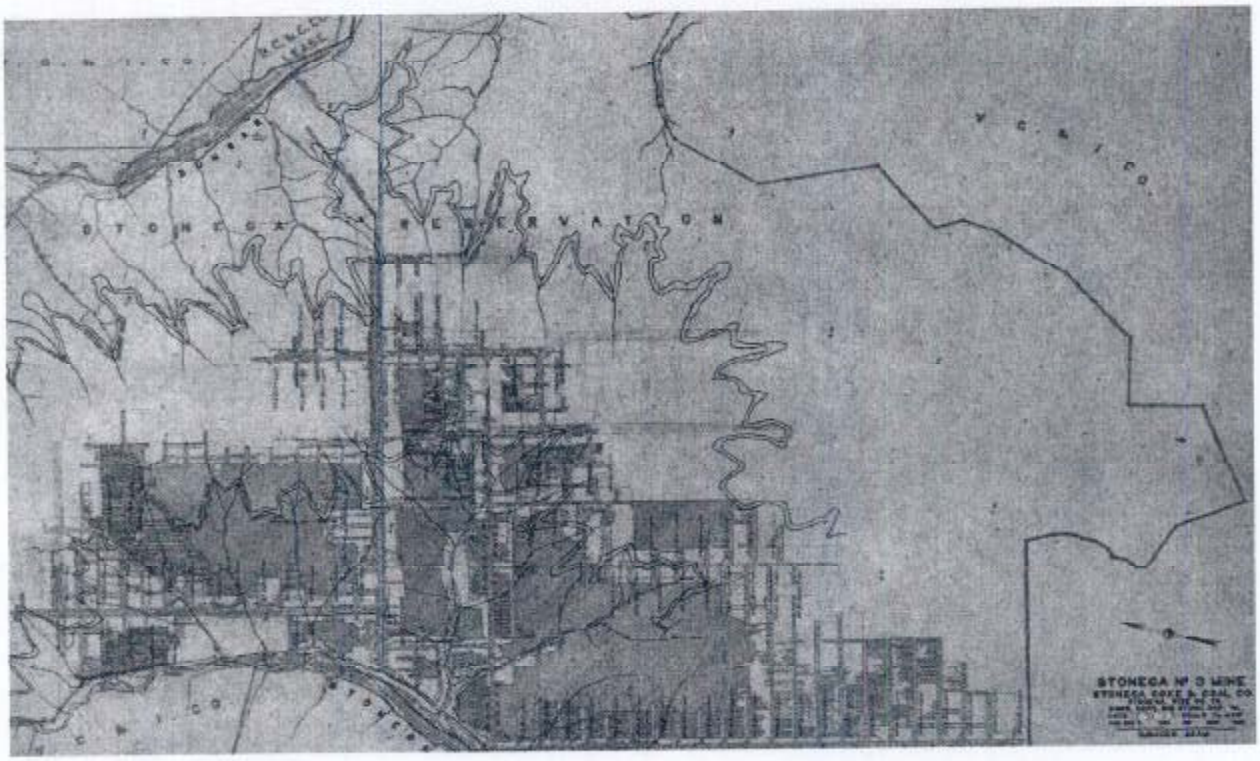
Derby Colliery: Looking toward Arno.

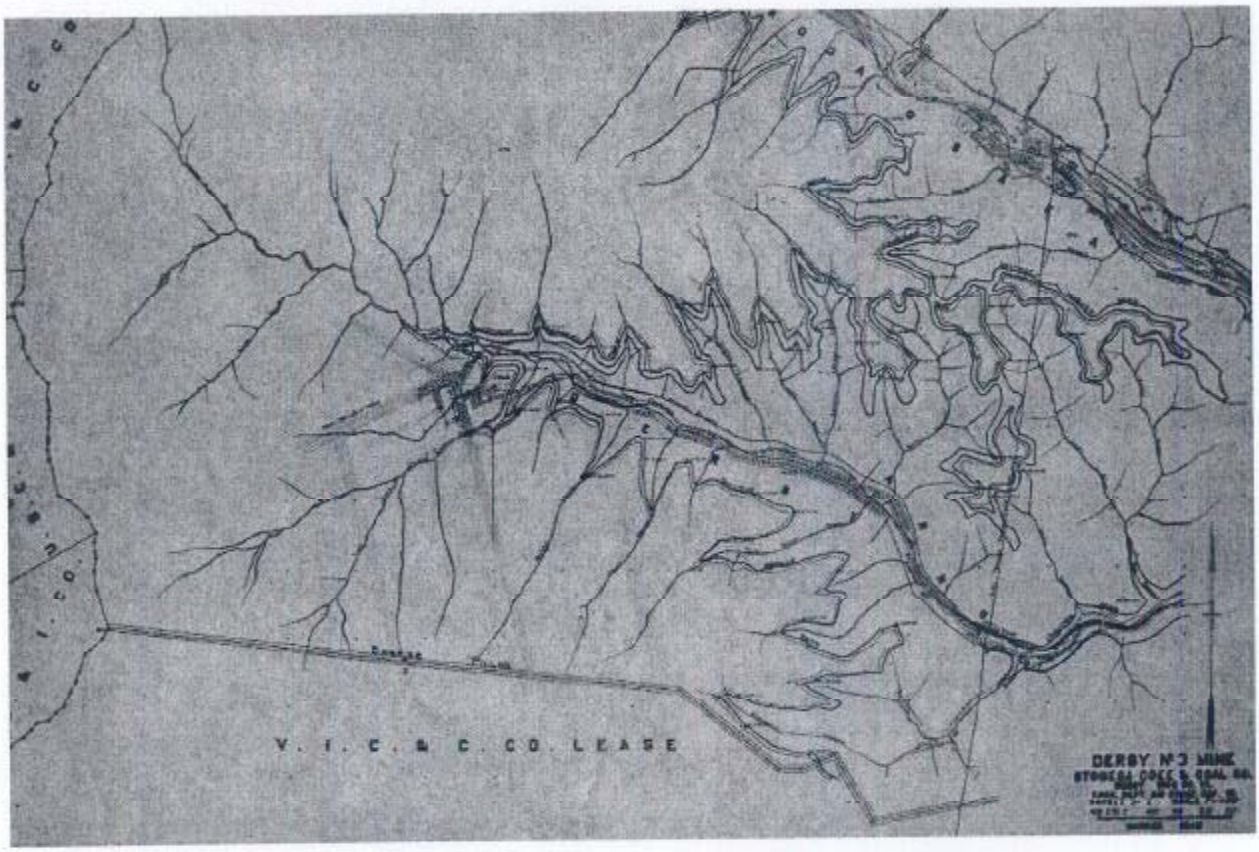
From 1923 SCC Company Report



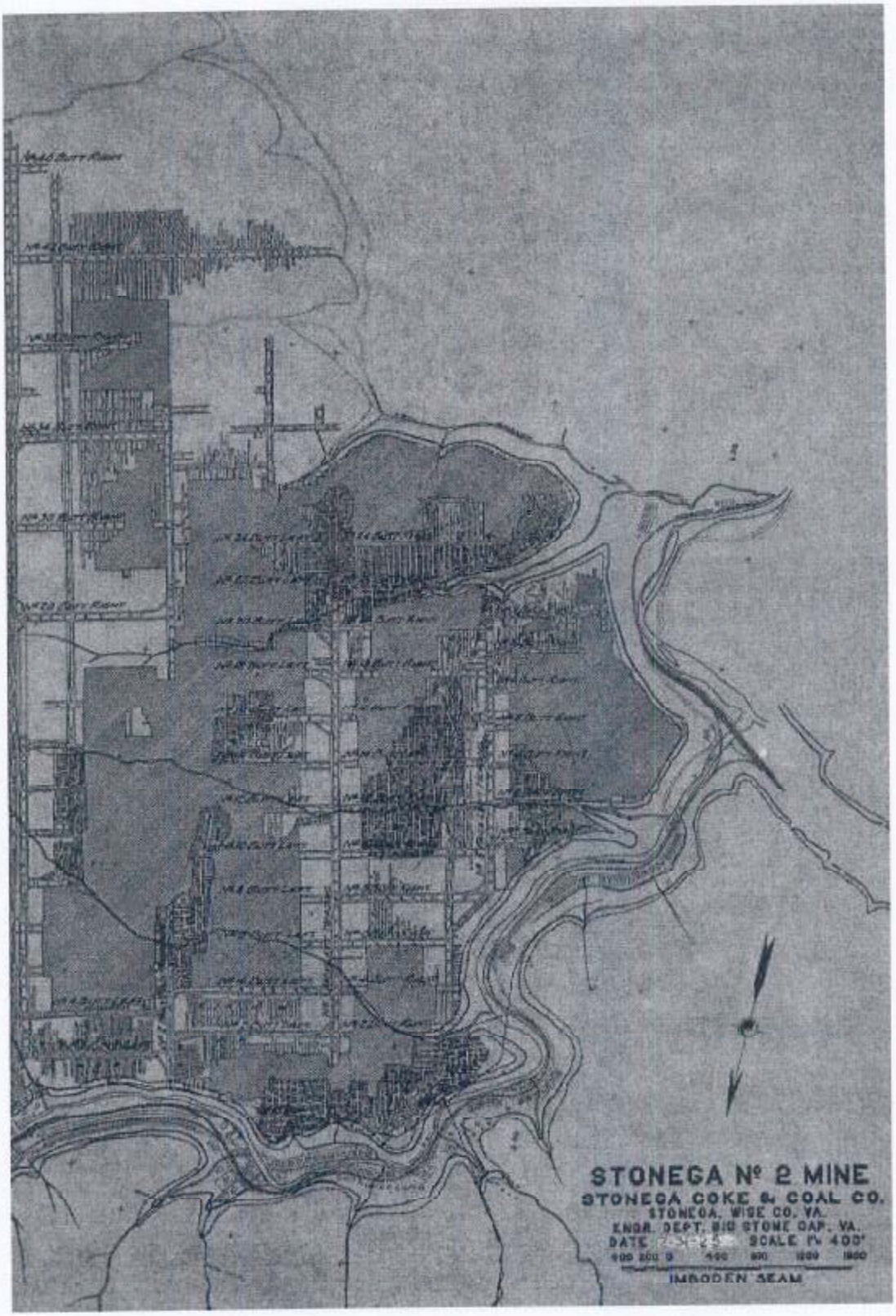
Stonega Colliery: Completed School Building.

From 1925 SCC Company Report

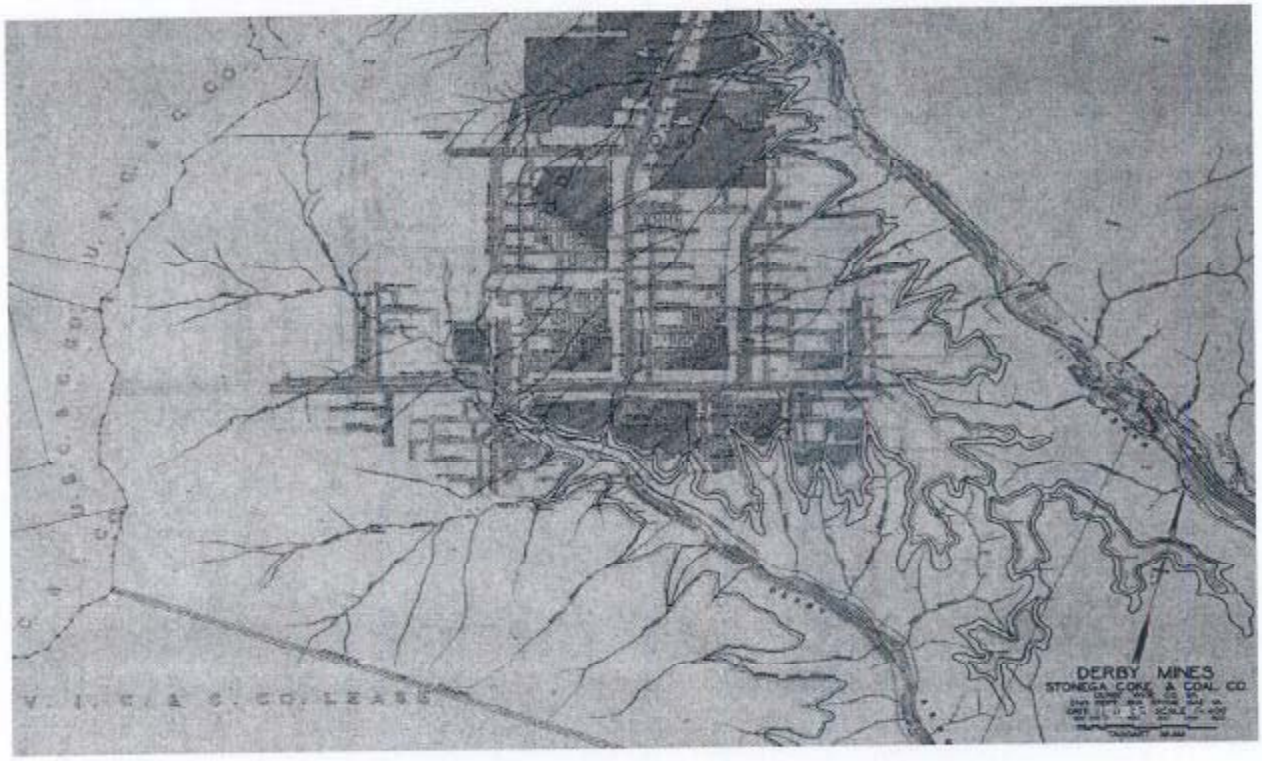




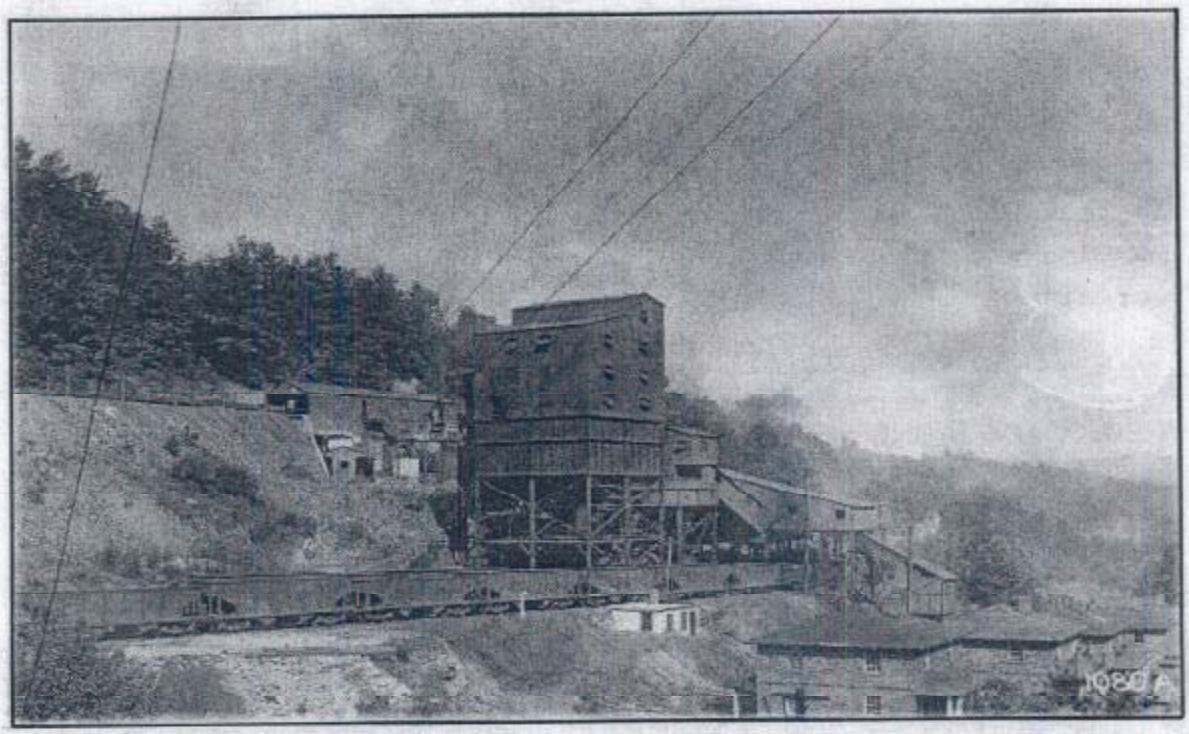
From 1925 SCC Company Report



From 1925 SCC Company Report

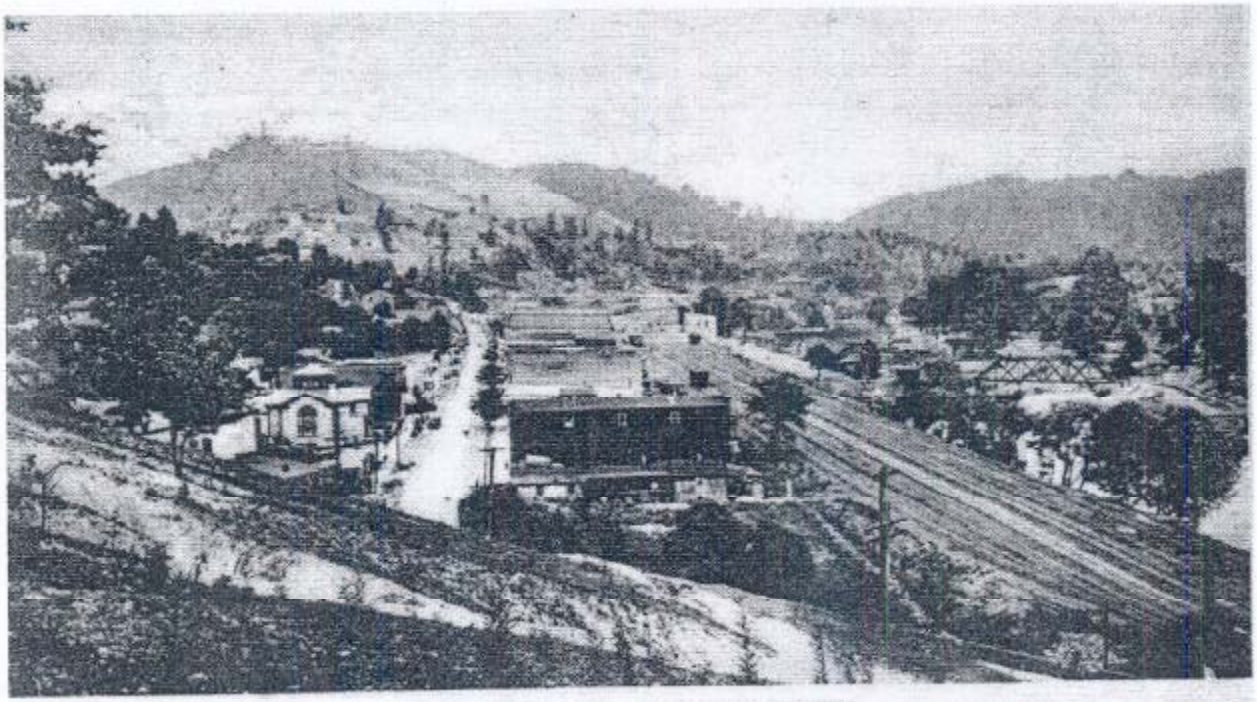


From 1925 SCC Company Report



Derby Colliery - Tipple.

From 1939 SCC Company Report



APPALACHIA, VA., LOOKING NORTH.

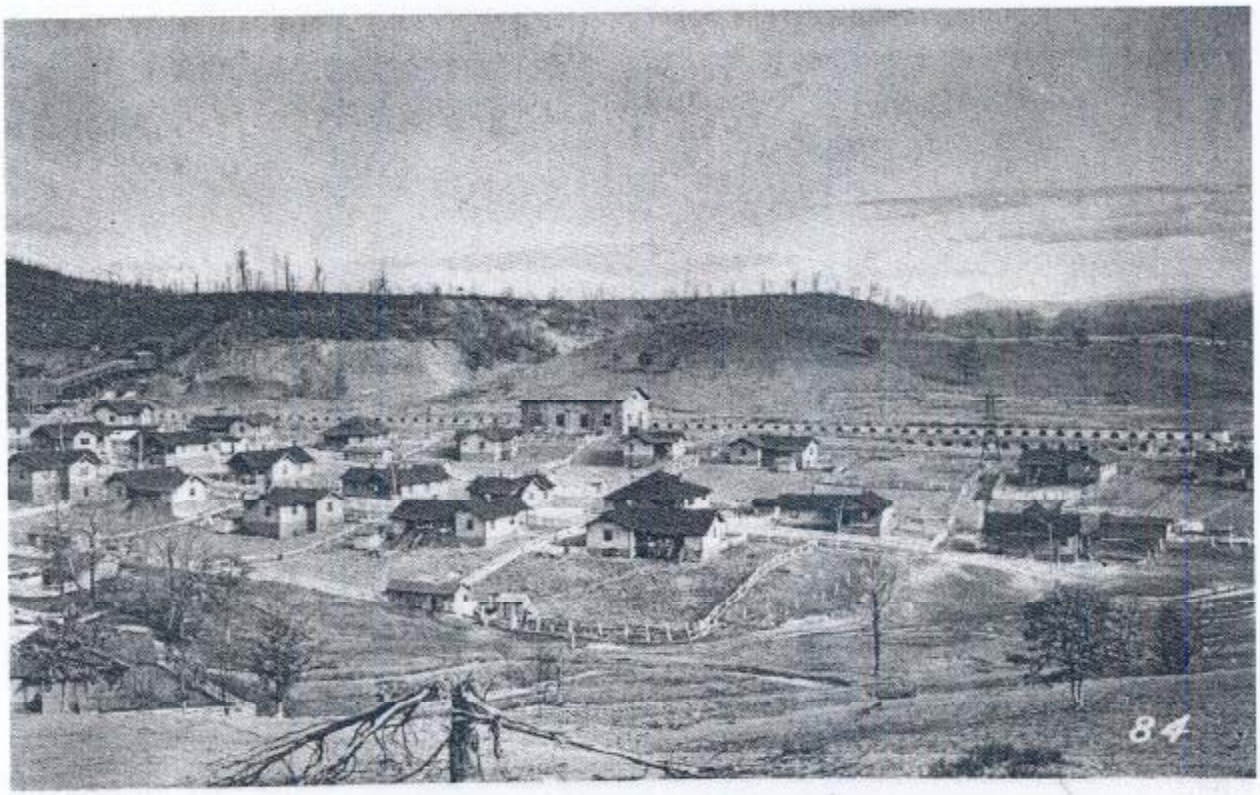
Arno Tipple was shut down in 1940. Picture furnished by Cecil Stacey

From Collins 1983

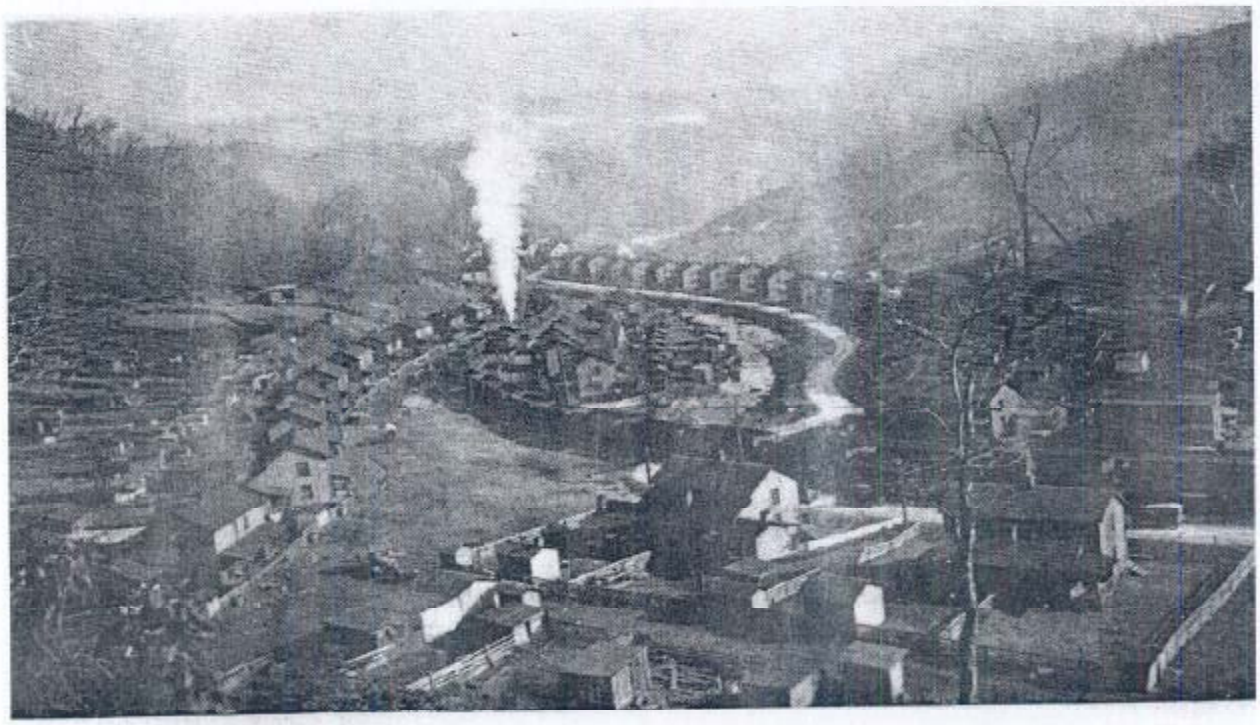
Derby, Va. in 1920's.

Derby, Virginia

From Collins 1983



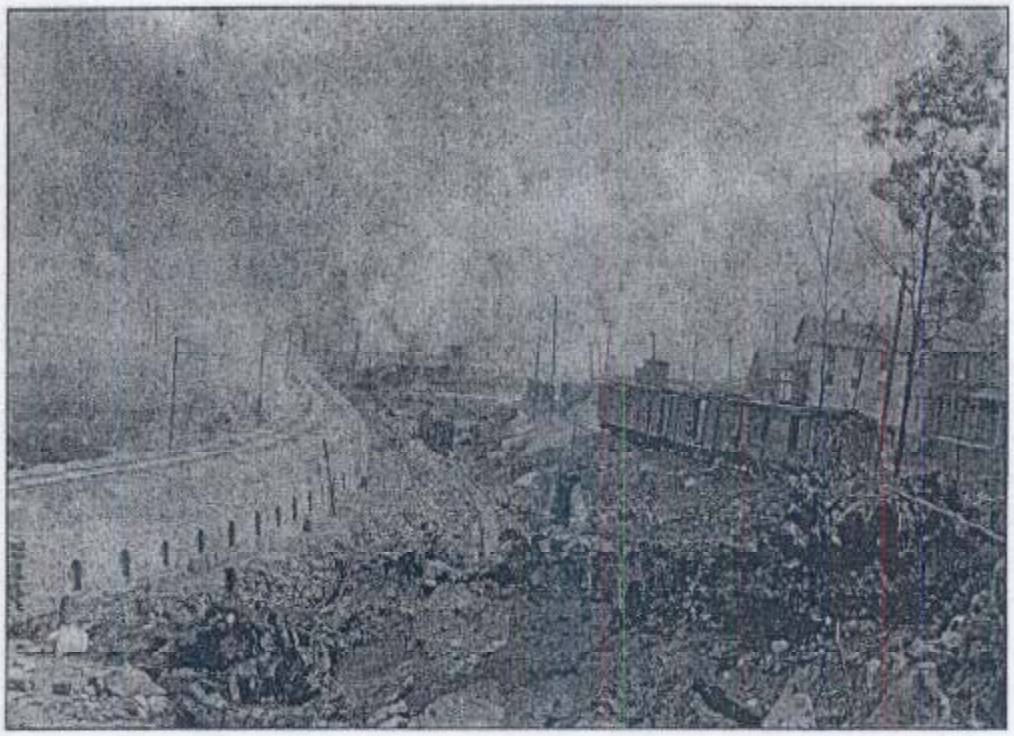
Old Keokee mining Camp showing tipple and coke ovens.
Picture from the collection of Mrs. John Joyce.

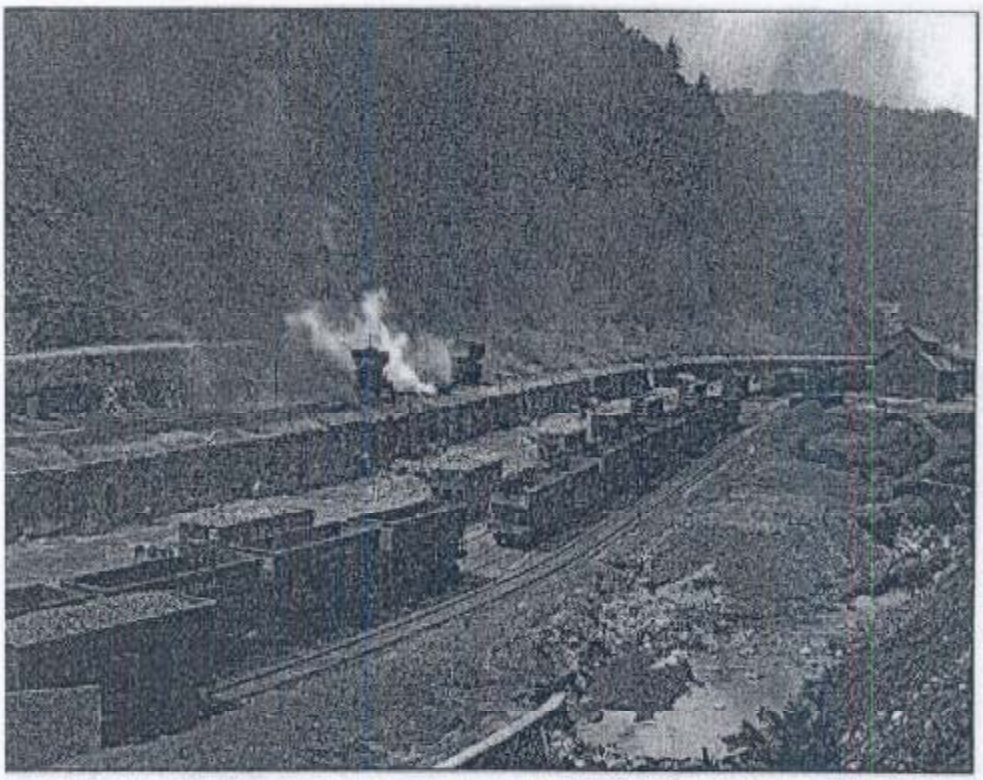


Stonega, Va. about 1919.

From Collins 1983

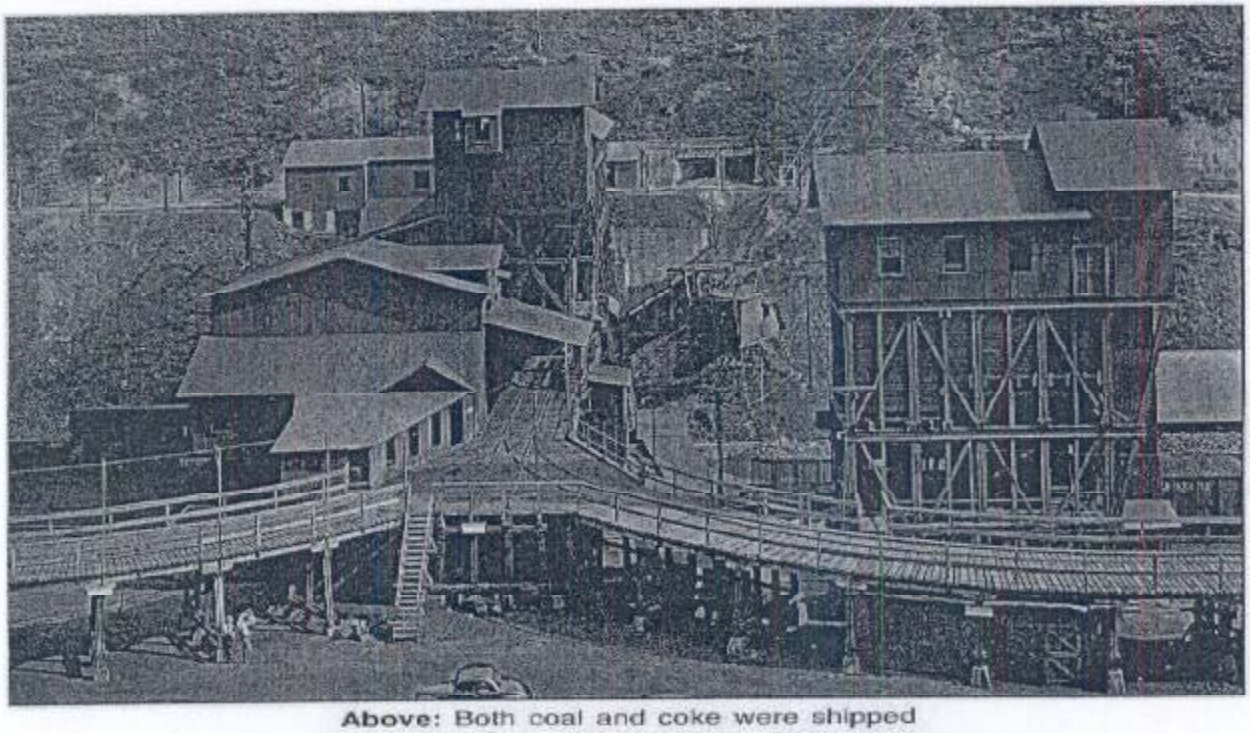
Right: By 1910, more than 4,400 coke ovens had been constructed in Wise County. With all of the dense, foul smoke created by these ovens, the residents of upper Stonega, shown in this view, or any other colliery containing ovens hardly knew if it was day or night. (K. Fannon Collection)



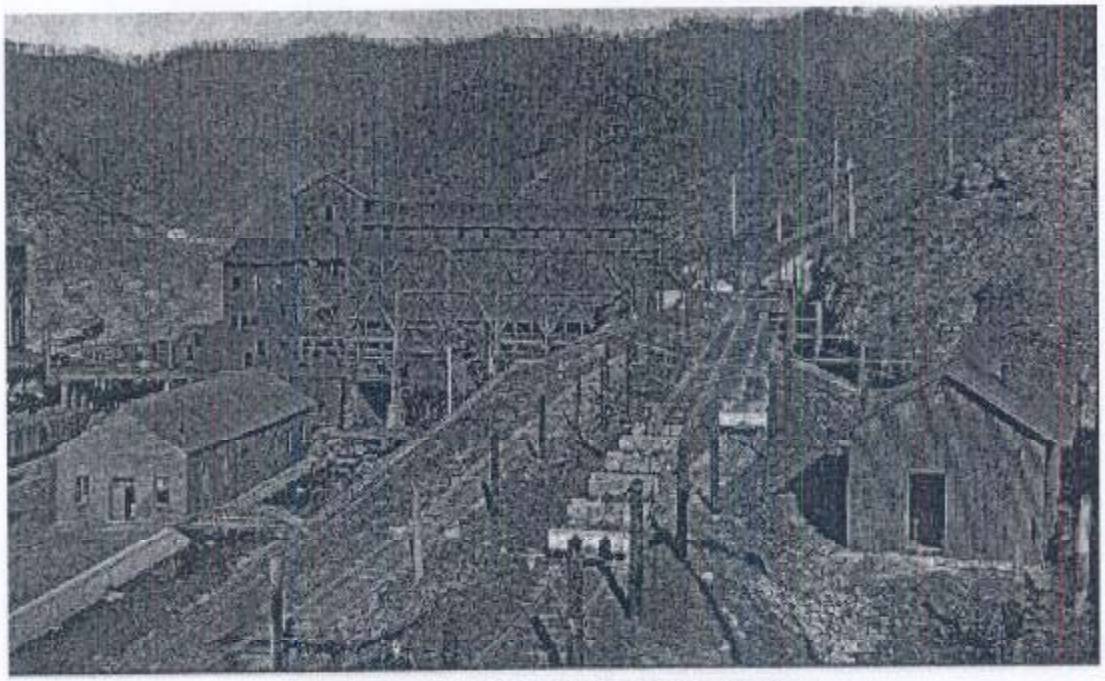


Left: The Stonega coke yards continually belched smoke. The smoke was often so thick and close to the ground that Hugh could hardly see the engineer to give him a signal and was surprised when the engineer responded. (Hagley Museum and Library, Westmoreland Collection)

From Wolfe 1994

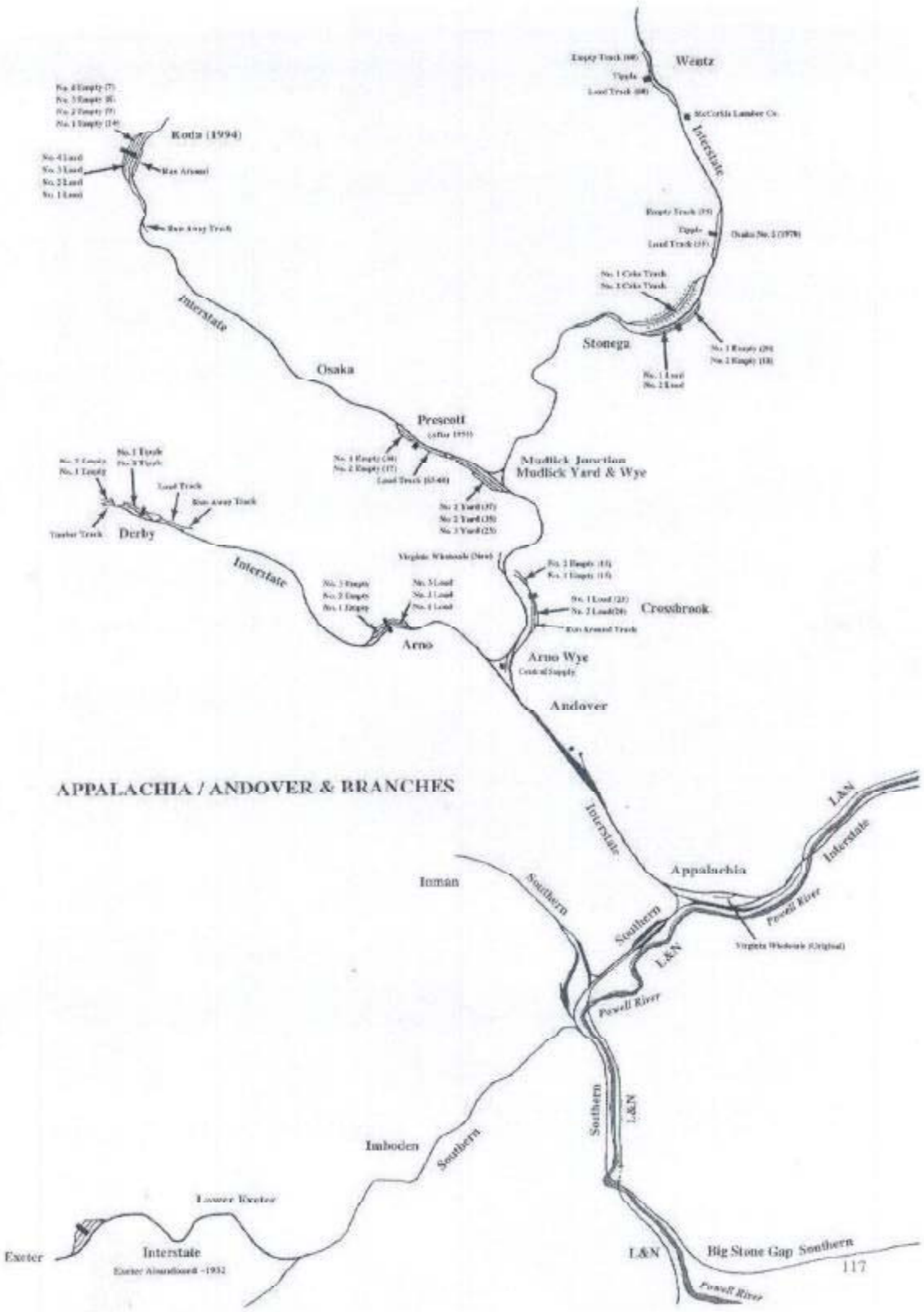


Above: Both coal and coke were shipped from the Stonega operation. This view shows the Stonega tipple and larry trestle on September 20, 1938. (Hagley Museum and Library; Westmoreland Collection)

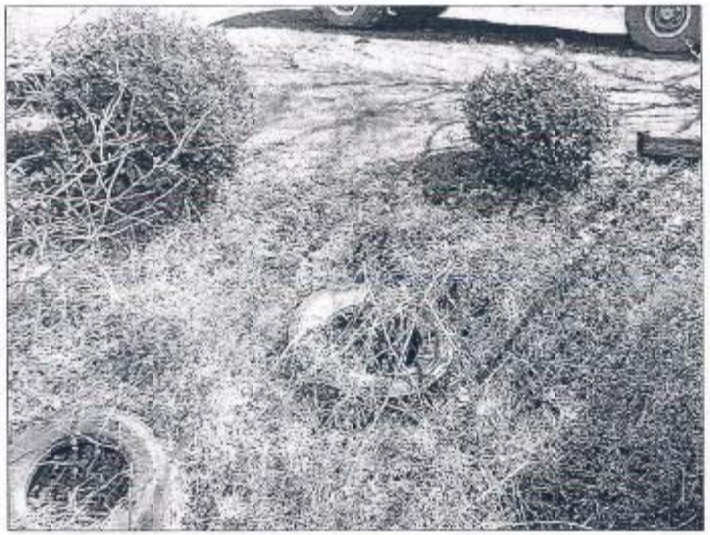


A view of the Stonega complex showing the tipple, supply buildings and the tracks leading to and from the mine operations. A portion of a coke oven battery is visible in the background. (Hagley Museum and Library, Westmoreland Collection)

From Wolfe 1994



From Wolfe 1994



CC48B Drainage Pipe

CC49A Drainage Way

CC49B Gabion Baskets and Retaining Wall

CC49C Pipe

Coastal Bioanalysts, Inc.

April 11, 2005

Phil Mullins
Senior Mining Engineer
Cumberland Resources Corporation
P.O. Box 2560
Wise, VA 24293

Dear Phil,

I have reviewed the draft document for TMDL development for Callahan and Straight Creeks. In summary, I disagree with the TDS standard of 334 mg/l. The value was derived from very limited correlational data collected before and after reclamation of Middle Creek. Also, the study failed to recognize that TDS toxicity is dependent on the relative concentrations of anions and cations comprising the overall TDS value, as well as exposure duration and frequency. Toxicity data reported in the literature concerning TDS were essentially ignored in the development of the standard.

Attached you will find my review of the TMDL development document. Please let me know if you have any questions or need additional information.

Sincerely,

Peter F. De Lisle, Ph.D.
President

6400 Enterprise Court, Gloucester, VA 23061
Phone 804-694-8285 Fax 804-695-1129
www.coastalbio.com

There is no valid scientific basis for the selection of a TDS standard of 334 mg/l for the Powell River basin. The value is significantly lower than TDS standards developed by other states (Table 1). The unusually low value arises from several problems in the development of the standard:

1. **Use of Middle Creek TDS data for the development of the standard.**

The TDS standard (334 mg/l) was selected based on the maximum value measured since the delisting of Middle Creek. Notwithstanding issues regarding whether Middle Creek is an appropriate reference stream for Callahan and Straight Creeks, it was not demonstrated that this value represents a maximum safe level above which benthic impairment is to be expected.

It was concluded (MapTech, 2004) that the primary stressor responsible for historical benthic impairment in Middle Creek was TDS. This conclusion was based on correlational data relating decreased TDS (from 600 μmhos/cm (~404 mg/l) in 1981 to 263 μmhos/cm (~177 mg/l) present) with improved benthic health at a single monitoring station. While correlational relationships are useful for inferences (i.e. selection of "possible stressors" as opposed to "probable stressors"), cause-effect relationships cannot be concluded from such data; examples of nonsense, statistically significant correlations abound (Sokal and Rohlf, 1981). Correlation of TDS changes with benthic community structure at multiple stations, where other possibly confounding factors may also vary, would provide a better "weight of evidence" for TDS toxicity but still would not be conclusive.

Other correlated variables, which may not have been measured, may actually be responsible for the impact on the benthic community. For example, sediment pore water ammonia was not measured in any of the monitoring programs (MapTech, 2004, 2005). Ammonia accumulates in sediments as the result of the natural breakdown of nitrogenous organic compounds, nutrient runoff and point sources such as municipal wastewater treatments plants (EPA, 2001b). Indeed, the effects of urbanization and resulting ammonia buildup in sediments have spurred recent studies regarding the toxicity of ammonia to freshwater mussels to help explain population declines (e.g. Bartsch *et al.*, 2001; T. Newton, personal communication). Reclamation of Middle Creek would likely result in reduced sediment ammonia concentrations and TDS.

2. **Lack of understanding of the mode of action in TDS toxicity.**

The authors repeatedly state that "Large swings in TDS concentrations can be harmful to aquatic organisms because the density of the water determines the flow of water into and out of the cells of aquatic organisms." This is a gross oversimplification of ion balance in aquatic organisms and the citation for the statement is a website designed for teaching secondary school students and volunteers about stream monitoring. If density alone determined flow of water between the organism and the external media then fish and aquatic invertebrates would be able to live in solutions consisting of any dissolved

material (e.g. sucrose) so long as the media osmolality were correct. It is well known that ionic and osmotic regulation is controlled through 1) active transport of ions, 2) excretion and 3) control of membrane permeability. Active transport of ions across biological membranes is dependent on the external ion composition as well as overall concentration. Additionally, all aquatic fish and invertebrates, including the mollusks and sponges which are relatively poor osmoregulators, are hyperosmotic to media with TDS as high as 1500 mg/l (e.g. see discussion in Prosser, 1973). Consequently any TDS toxicity in the concentration ranges typical of Callahan and Straight Creeks is likely more dependent on ionic composition than ionic strength (see discussion below).

Regarding "swings in TDS" the authors also cite a Society of Environmental Toxicology and Chemistry (SETAC, 2004) white paper as stating that sudden spikes in TDS may be fatal. The objective of the white paper is to provide a broad overview of the TDS toxicity issue for non-scientists. The SETAC paper provides guidance for interpretation of WET tests in which toxicity is observed following standard exposure periods from 48 hr to 7 days, suggesting that 1340 mg/l TDS (~2000 μmhos/cm) be used as a flag value for possible TDS toxicity. The authors then (incorrectly) conclude that based on instantaneous field measurements (i.e. unknown exposure duration) of TDS exceeding this value that "There seems to be little doubt that the extremely high TDS concentrations often present in Straight Creek are responsible for depressing the sensitive benthic community" (p 8-42). As emphasized in the review of Goodfellow and coworkers (2000), TDS composition as well as exposure magnitude, frequency and duration ultimately determine whether exposure to high TDS waters is toxic.

3. Disregard for scientific literature on TDS toxicity

Although many studies regarding TDS toxicity have centered on wastewaters with high TDS (e.g. produced waters), which may also contain other unknown toxicants, sufficient data exist from studies with prepared test solutions to draw some conclusions regarding toxic levels of TDS. Generally, high TDS waters enriched with potassium are most toxic to freshwater organisms and those enriched with sulfate are least toxic (Mount et al., 1997). In testing of over 2,900 ion-enriched solutions these investigators found the following ions (in order of decreasing toxicity) to significantly ($p=0.05$) affect acute survival of *C. dubia, D. magna* and *P. promelas:* $K^+ > HCO_3 = Mg^{2+} > Cl^- > SO_4^{2-}$. Although Ca^{2+} and Na^+ were not significant, toxicity of salts of these cations was probably associated with the corresponding anions. Validation of these findings can be found in the close agreement between toxicity predicted with the GRI-FW STR program (developed from these data) and toxicity test results with real world samples (Gas Research Institute, 1994). We have also used this program in our laboratory with numerous high TDS samples and similarly obtained good agreement between predicted and measured toxicity.

The relatively high acute toxicity of TDS samples predominated by K^+ is also apparent in data from other sources (Table 2) and in chronic exposures (Table 3). In addition, chronic studies with *C. dubia* support the notion of the following relative toxicities:

$HCO_3 > Cl^- > SO_4^{2-}$ (Lasier *et al.*, 2002; Lasier *et al.* 2005). Another trend that is apparent in the data is that toxicity appears to be greater in soft waters. Based on these findings, TDS toxicity is expected to be minimal in hard waters with relatively high sulfate concentration.

When used in effluent toxicity testing, *Ceriodaphnia* tests are more likely to indicate effluent toxicity even when there is no impact to the downstream benthic community (Diamond and Daily, 2000). Consequently, results of TDS toxicity tests with this species can be considered a conservative estimate of instream effects. Additionally, the consensus of a team of reviewers representing EPA, state agencies, industry and academia was that TDS toxicity does not require the conservative safety factors traditionally applied to conventional pollutants (Goodfellow *et al.*, 2000).

Because sulfate is the primary component of TDS in Straight and Callahan Creeks, and these waters are typically >150 mg/l hardness, it is clear from the data in Tables 2 and 3 that a standard of no less than 1000 mg/l TDS would be appropriate. Additionally, because TDS composition (rather than bulk value) determines toxic effect, excursions above 1000 mg/l should not be *de facto* violations of the standard. Site-specific assessment of high TDS should evaluate potential for toxicity using values for specific TDS components and appropriate models and/or toxicity tests with an appropriate species (e.g. *C. dubia*), in a manner similar to that used in the Iowa standard.

Table 1. State TDS Standards

State	Standard	Reference
Alaska	1000 mg/l TDS[1]	Chapman *et al.* 2000
Illinois	1500 mg/l TDS	Iowa DNR, 2003
Iowa	1000 mg/l[2]	Iowa DNR, 2004
Ohio	1500 mg/l	MapTech, 2005
Mississippi	1000 μmhos/cm Conductivity	MapTech, 2005

[1]Site-specific criterion for mine drainages

[2]Standard provides for site-specific evaluation of TDS. If instream TDS is > 1000 mg/l additional testing (ion analysis and/or WET tests) is used to determine if water quality impaired.

Table 2. TDS Acute Toxicity.

Species	48-h EC50 (mg/l)	TDS Composition	Reference
C. dubia	516	KCl in moderately hard SW[1]	EPA, 2001
P. promelas	1057		
C. dubia	2148-2748	NaCl in soft RW[2]	EPA, 1991a
	3180	NaCl in very hard RW	
P. promelas	4948-7948	NaCl in soft RW	
	5580	NaCl in very hard RW	
C. dubia	390->5610	50 salt combinations in RW enriched with K, HCO_3, Mg, Cl, Na, Ca and SO_4	Mount *et al.* 1997
D. magna	630->6470		
P. promelas	720->7960		
C. dubia	860->5610	Same data set with K enriched combinations excluded	
D. magna	1330->6470		
P. promelas	2500->7960		

[1]SW = Synthetic freshwater (TDS = 207.4 mg/l). Total TDS is sum of SW TDS plus added salt.
[2]RW = Reconstituted freshwater (TDS = 48 mg/l for soft, 95 mg/l for moderately hard, 190 mg/l for hard and 380 mg/l for very hard). Total TDS is sum of RW TDS plus added salt.

Table 3. Chronic TDS Toxicity.

Species	IC25 (mg/l)	EC50 (mg/l)	NOEC (mg/l)	TDS Composition	Reference
C. dubia	440	474	477	KCl in moderately hard SW[1]	EPA, 2001a
P. promelas	853	1002	817		
C. dubia	978	1348	678	NaCl in soft RW[2]	EPA, 1991b
	1395	1695	1095	NaCl in mod hard RW	
	1390	1690	1190	NaCl in hard RW	
	1380	1780	1380	NaCl in very hard RW	
P. promelas	718-978	888-1348	548-678	NaCl in soft RW	
	1295	1595	1095	NaCl in mod hard RW	
	2490	3390	2190	NaCl in hard RW	
	3580	4880	2380	NaCl in very hard RW	
C. dubia	787	1184	----	Chloride, bicarbonate, sulfate mix in soft RW	Lasier *et al.* 2004
O. mykiss embryo			>2000	Mock mine effluents rich in sulfates and Calcium	Chapman *et al.* 2000
O. mykiss fry			>2000		
C. tentans			1100		
S. capricornutum			>2000		

[1]SW = Synthetic freshwater (TDS = 207.4 mg/l). Total TDS is sum of SW TDS plus added salt.
[2]RW = Reconstituted freshwater (TDS = 48 mg/l for soft, 95 mg/l for moderately hard, 190 mg/l for hard

and 380 mg/l for very hard). Total TDS is sum of RW TDS plus added salt.

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2.4 **CHEMICAL ANALYSES OF STRATA** - (Utilize the following Acid-Base (AB) Account sheet(s) or equivalent formatted information. If equivalent formatted information is used and included in the application package, identify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

AB Location No.	ALL-08-96		Surface Elevation	2796.2
Borehole (**B**); Crop (**C**); Exposure (**E**); Other (**O**)		**B**	**UNDERLINE MAXIMUM POTENTIAL ACIDITY(IES) (MPA) BASED ON PYRITIC SULFUR ANALYSES.**	

Unit No.	Lab. ID. No.	Lithologic Type	PH *	Total Sulfur **	Pyritic Sulfur **	MPA **	NP **	Excess Acid (-) or NP (+) **
3		Shale	9.0	0.14		4.38	30.66	26.29
4		Coal –Low Splint A		3.48				
5		Shale	7.7		0.52	16.25	4.86	-11.39
6A		Sandstone	7.9	0.10		3.13	10.32	7.20
6B		Sandstone	8.2	0.05		1.56	4.92	3.36
6C		Sandstone	8.6	0.00		0.00	32.43	32.43
6D		Sandstone	8.4	0.03		0.94	52.57	51.64
7		Coal – Low Splint B						
8		Sandy Shale	8.6	0.09		2.81	62.38	59.56
9		Sandstone	8.1	0.12		3.75	15.08	11.33
10		Shale	7.5		1.48	46.25	6.48	-39.78
11		Coal – Low Splint C/D						
12		Shale	8.4	0.15		4.69	7.55	2.86
13		Coal – Low Splint C/D						
14		Sandstone	8.8	0.10		3.13	2.71	-0.41
15		Coal – Low Splint C/D						
16		Shale	8.9	0.00		0.00	3.25	3.25
17		Sandstone	8.8	0.08		2.50	61.84	59.34
18		Shale	7.3		1.64	51.25	4.86	-43.39
19		Coal – Low Splint E		4.19				
20		Shale	9.3	0.27		8.44	8.62	0.19
21		Coal – Low Splint E						
22		Shale	9.6	0.11		3.44	36.58	33.14
23		Sandstone	9.5	0.10		3.13	45.18	42.05
24		Shale	9.6	0.11		3.44	63.99	60.55
25		Sandstone	9.2	0.13		4.06	24.72	20.66
26		Sandy Shale	9.7	0.16		5.00	33.89	28.89
27		Shale	9.7	0.10		3.13	38.73	36.60
28		Coal – Taggart A-1						
29		Shale	8.0		0.14	4.38	3.84	-0.54
30		Sandstone	9.7	0.22		6.88	60.76	53.89
31		Shale	9.0	0.19		5.94	61.54	55.60
32		Coal – Taggart A-2						

33		Shale	9.7	0.00		0.00	12.39	12.39
34		Sandstone	9.6	0.00		0.00	6.48	6.48
35		Shale	9.2	0.10		3.13	54.31	51.19
36		Coal – Taggart						
37		Shale	8.9	0.10		3.13	11.85	8.72
38		Sandstone	8.5	0.16		5.00	28.57	23.57
39		Shale	8.9	0.19		5.94	43.56	37.63
40		Coal – Taggart Marker		0.84				
41		Shale	9.4	0.17		5.31	5.40	0.09

* Report to nearest tenth NP = Neutralization Potential

** Report to nearest hundredth

2.4 **CHEMICAL ANALYSES OF STRATA** - (Utilize the following Acid-Base (AB) Account sheet(s) or equivalent formatted information. If equivalent formatted information is used and included in the application package, identify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

AB Location No.	ALL-06-96		Surface Elevation	2611.9
Borehole (B); Crop (C); Exposure (E); Other (O)		B	**UNDERLINE MAXIMUM POTENTIAL ACIDITY(IES) (MPA) BASED ON PYRITIC SULFUR ANALYSES.**	

Unit No.	Lab. ID. No.	Lithologic Type	PH *	Total Sulfur **	Pyritic Sulfur **	MPA **	NP **	Excess Acid (-) or NP (+) **
11		Sandy Shale	9.5	0.15		4.69	41.35	36.66
12		Sandstone	9.1	0.12		3.75	45.94	42.19
13		Sandy Shale	9.5	0.10		3.13	44.10	40.98
14		Sandstone	9.3	0.08		2.50	51.04	48.54
15		Shale	9.5		0.79	24.69	8.62	-16.06
16		Coal – Taggart A						
17		Shale	9.8	0.26		8.13	32.81	24.69
18		Sandstone	9.7	0.00		0.00	10.64	10.64
19		Shale	9.5	0.10		3.13	36.25	33.13
20		Coal – Taggart		0.63				
21		Shale	9.2	0.17		5.31	1.64	-3.68
22		Sandy Shale	9.4	0.11		3.44	41.41	37.98
23		Shale	9.0	0.12		3.75	25.82	22.07
24		Coal - Taggart Marker		0.85				
25		Shale	9.5	0.12		3.75	0.56	-3.19

* Report to nearest tenth NP = Neutralization Potential

** Report to nearest hundredth

2.4 **CHEMICAL ANALYSES OF STRATA** - (Utilize the following Acid-Base (AB) Account sheet(s) or equivalent formatted information. If equivalent formatted information is used and included in the application package, identify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

AB Location No.	ALL-01-96		Surface Elevation	3115.8
Borehole (B); Crop (C); Exposure (E); Other (O)		B	**UNDERLINE MAXIMUM POTENTIAL ACIDITY(IES) (MPA) BASED ON PYRITIC SULFUR ANALYSES.**	

Unit No.	Lab. ID. No.	Lithologic Type	PH *	Total Sulfur **	Pyritic Sulfur **	MPA **	NP **	Excess Acid (-) or NP (+) **
44	14732	Shale	9.8	0.23		7.19	60.23	53.04
45		Coal – Low Splint A		4.82				
46	14727	Sandstone	9.7	0.00		0.00	22.60	22.60
47		Coal – Low Splint B						
48	14728	Shale	8.6	0.06		1.88	61.84	59.96
49		Coal – Low Splint C/D						
50	14719	Shale	9.1	0.15		4.69	54.31	49.63
51	14726	Sandstone	9.6	0.00		0.00	4.86	4.86
52	14731	Shale	9.5	0.17		5.31	9.16	3.85
53		Coal – Low Splint E		3.85				
54	14729	Shale	9.6	0.12		3.75	50.55	46.80

* Report to nearest tenth NP = Neutralization Potential
** Report to nearest hundredth

2.4 **CHEMICAL ANALYSES OF STRATA** - (Utilize the following Acid-Base (AB) Account sheet(s) or equivalent formatted information. If equivalent formatted information is used and included in the application package, identify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

AB Location No.	LS-97-4		Surface Elevation	2689.9
Borehole (B); Crop (C); Exposure (E); Other (O)		B	**UNDERLINE MAXIMUM POTENTIAL ACIDITY(IES) (MPA) BASED ON PYRITIC SULFUR ANALYSES.**	

Unit No.	Lab. ID. No.	Lithologic Type	PH *	Total Sulfur **	Pyritic Sulfur **	MPA **	NP **	Excess Acid (-) or NP (+) **
18	35649	Sandy Shale	8.4	0.06		2.50	3.55	1.05
19	35650	Sandstone	8.2	0.07		2.19	20.11	17.92
20A	46865	Shale	8.9	0.74		23.13	32.43	9.31
20B	46866	Shale	9.1	0.37		11.56	36.85	25.29
20C	46867	Shale	9.2	0.43		13.44	36.36	22.92
20D	46868	Shale	9.2	0.44		13.75	36.36	22.61
20E	46869	Shale	9.0	0.42		13.13	41.27	28.15
20F	46870	Shale	8.9	0.45		14.06	40.29	26.23
20G	46871	Sandstone	6.8	1.63		50.94	52.08	1.15
20H	46872	Shale	9.0	0.65		20.31	60.93	40.61
20I	46873	Shale	9.2	0.02		0.63	169.75	169.13
20J	46874	Shale	9.2	0.70		21.88	54.05	32.17
20K	46875	Shale	9.0	0.77		24.06	38.82	14.76
20L	46876	Shale	6.1		3.63	113.44	9.83	-103.61
20M	46877	Shale	5.5		3.48	108.75	14.25	-94.50
21		Coal – Low Splint A Rid.	-	6.63	2.64			
22	35652	Shale	8.8	0.18		5.63	17.42	11.80
23		Coal – Low Splint A	-	1.07	0.47			
24	35653	Shale	8.8	0.18		5.63	7.13	1.51
25		Coal – Low Splint B						
26	35654	Shale	8.9	0.08		2.50	3.10	0.60
27	35655	Sandstone	9.1	0.00		0.00	7.68	7.68
28		Coal – Low Splint C/D	-	1.46	0.43			
29	35656	Shale	9.0	0.18		5.63	2.21	-3.42
30	35657	Sandstone	9.3	0.06		1.88	8.92	7.05
31	35658	Shale	9.1	0.15		4.69	3.55	-1.14
32		Coal – Low Splint E	-	6.07	2.06			
33	35659	Sandy Shale	9.1		0.59	18.44	5.34	-13.10
34A	46878	Sandstone	9.3	0.31		9.69	33.41	23.73
34B	46879	Sandstone	9.5	0.22		6.88	30.47	23.59
34C	46880	Sandstone	9.7	0.00		0.00	23.10	23.10

34D	46881	Sandy Shale	9.3	0.07		2.19	42.75	40.56
34E	46882	Sandstone	9.5	0.15		4.69	44.71	40.03
35	35661	Sandy Shale	9.2	0.13		4.06	16.08	12.02
36	35662	Sandstone	9.5	0.00		0.00	22.79	22.79
37		Coal – Taggart A1	-	1.40	0.48			
38	35663	Shale	9.0		0.24	7.50	4.89	-2.61
39		Coal – Taggart A2	-	1.29	0.37			
40	35664	Sandy Shale	9.0	0.10		3.13	3.55	0.42
41	35665	Sandstone	9.3	0.16		5.00	53.67	48.67
42	35666	Sandy Shale	9.3	0.07		2.19	23.24	21.05
43		Coal – Taggart	-	0.59	0.20			
44	35667	Sandy Shale	9.2	0.04		1.25	20.11	18.86
45	35668	Sandstone	9.4	0.00		0.00	29.06	29.06
46	35669	Shale	9.1	0.11		3.44	9.37	5.93
47		Coal – Taggart Marker	-	0.67	0.00			
48	35670	Shale	9.0	0.09		2.81	3.10	0.29

* Report to nearest tenth NP = Neutralization Potential

** Report to nearest hundredth

2.5	LOCATION OF ACID-BASE SAMPLING POINTS							
ACID-BASE SAMPLING POINTS							Total Number:	4
Loc. No.	Elevation	Latitude	Longitude		Loc. No.	Elevation	Latitude	Longitude
ALL-08-96	2796.2	36°58'28"	82°45'49"		ALL-06-98	2611.9	36°58'56"	82°46'15"
ALL-01-96	3115.8	36°59'13	82°46'45"		LS-97-4	2689.9	36°59'35"	82°47'12"

GROUND WATER HYDROLOGY

2.6 WATER SUPPLY INVENTORY INFORMATION - (Use form WSI-034D. Reference the location of the information as Attachment 2.6.)

N/A – There are no developed water resources within a one-half mile radius of the proposed permit area or within the potential impact area of the proposed underground mining.

2.7 GROUND WATER BASELINE MONITORING PROGRAM

Three sampling points have been established for the collection of premining data to reflect seasonal variations in groundwater quantity and quality for representative aquifers in the general vicinity of the proposed operations. The monitoring point locations are indicated on the *Geology Map*. GW-1 is a Taggart Marker seam mine discharge located in a downdip area near the middle of the permit. This point provides representative monitoring of perched groundwaters associated with the Taggart Marker seam, the lowest mining horizon. GW-2 and GW-3 are existing monitoring wells located on P.N. 1401567. These monitoring points are representative of the alluvial system and base flow of Callahan Creek. A well construction data sheet for the alluvial wells are included as Attachment 2.19.

Monitoring at GW-1 was conducted from March 1997 through July 1997 with six (6) samples collected on a 21-day cycle. Monitoring at GW-2 was conducted from February 1995 through July 1997 with samples collected on a monthly basis. Monitoring at GW-3 was conducted from July 1996 through January 1998. The baseline data collected is included for all monitoring locations in Attachment 2.8.

2.8 GROUND WATER BASELINE AND WELL CONSTRUCTION DATA - (Use forms GWB-034D, GDM-034D, and WCD-034D. Reference the location of the information as Attachment 2.8.)

See Attachment 2.8

ENVIRONMENTAL MONITORING, INCORPORATED
ENVIRONMENTAL CONSULTANTS ▲ ANALYTICAL LABORATORIES
P.O. BOX 1190 ▲ NORTON, VIRGINIA 24273 ▲ 276/679-6544

April 4, 2005

Mr. Phil Mullins, P.E.
Cumberland Resources, Inc.
P.O. Box 2560
Wise, VA 24293

RE: Review of Total Dissolved Solids Concentrations
Permitted Outfalls – Cumberland Resources
EMI Project No. 2073.7

Dear Mr. Mullins:

You requested Environmental Monitoring, Inc. (EMI) to collect water samples from permitted sediment control structures utilized by Cumberland Resources. The samples were collected from the top of the water near the permitted discharge location on structures containing water. Samples were collected from the top of each structure even if there was no discharge from the outfall. Three structures were observed to be dry. A total of 30 samples were collected for analysis. No samples were collected from the actual permitted outfalls. Samples were analyzed for Specific Conductivity and Total Dissolved Solids (TDS) by the EMI laboratory.

The results of laboratory analysis are attached in summary for your review. The summary compares the TDS results to the potential effluent limitation value of 334 mg/l value you provided. Based on this comparison 23% of the sites were considered to be immediately problematic or expected to exceed the 334 mg/l limitation if imposed. An additional 17% of the sites were considered marginal or within 25% of the 334 mg/l limit. It is the opinion of the consultant as many as 1/3 of the sites evaluated could be expected to exceed the anticipated effluent limitation of 334 mg/l on a regular basis. Compliance with the proposed effluent limitation for TDS would be extremely difficult for the permit holder. Methods for effluent treatment currently utilized by the coal mining industry will not be effective for TDS reduction.

TDS values were compared to Specific Conductivity in an effort to determine if a relationship could be established. A regression analysis was performed on the data set providing a r^2 value of 0.9792. The function describing the relationship is TDS = Specific Conductivity x 0.6733 – 27.171. A typical ratio for TDS to Conductivity is 2/3. Only one data point was observed to be outside 2.5

Standard Deviations from the mean. The function provided above was not significantly impacted by removing the potential outlier and a decision was made to continue to consider the subject point within the calculations.

If you should have any further questions regarding this evaluation, please feel free to contact me at our Norton, Virginia office (276) 679-6544.

Respectfully submitted,

ENVIRONMENTAL MONITORING, INC.

R. J. Porter, Chemist
Project Manager

Attachments

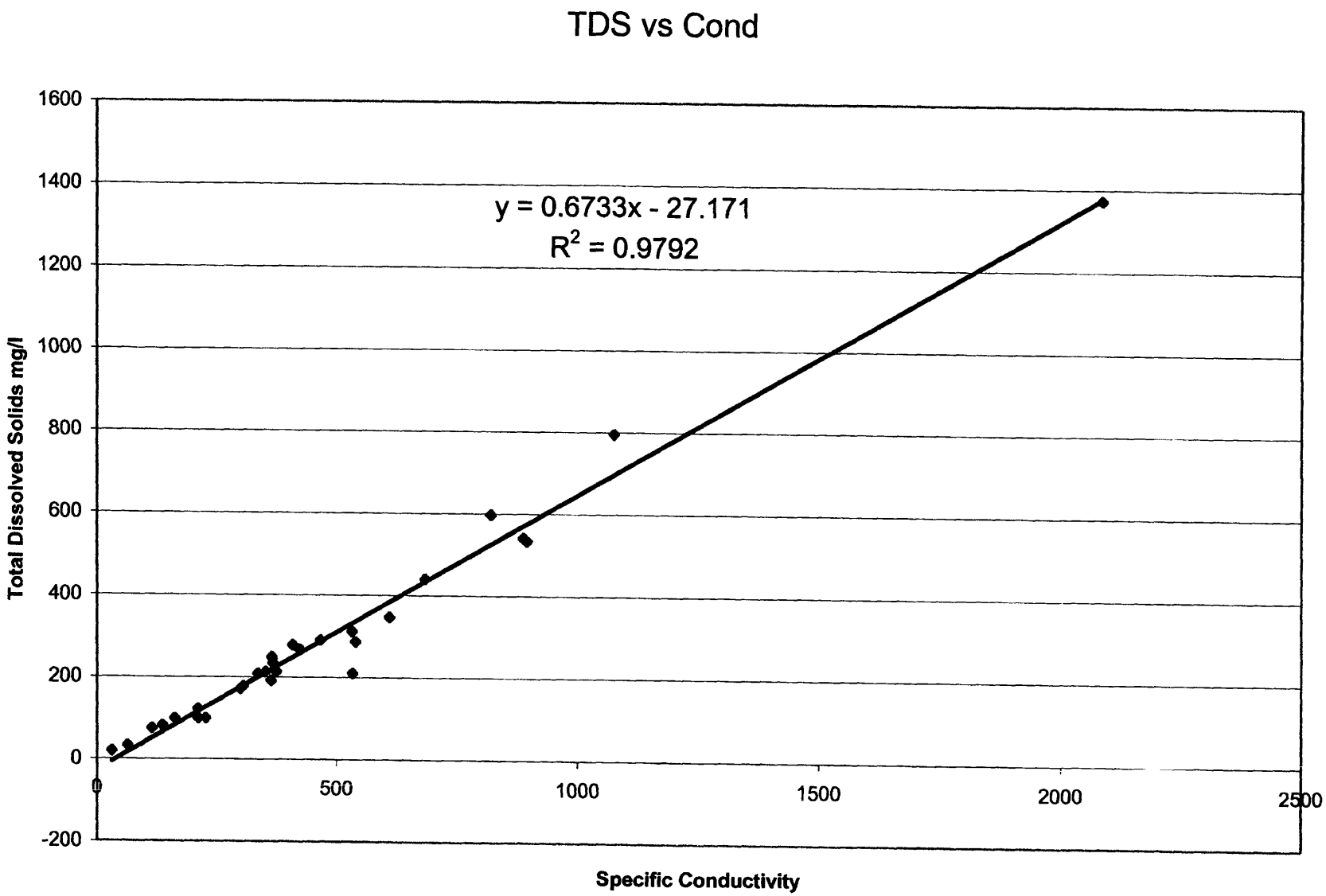
Cumberland Resources - Total Dissolved Solids Evaluation

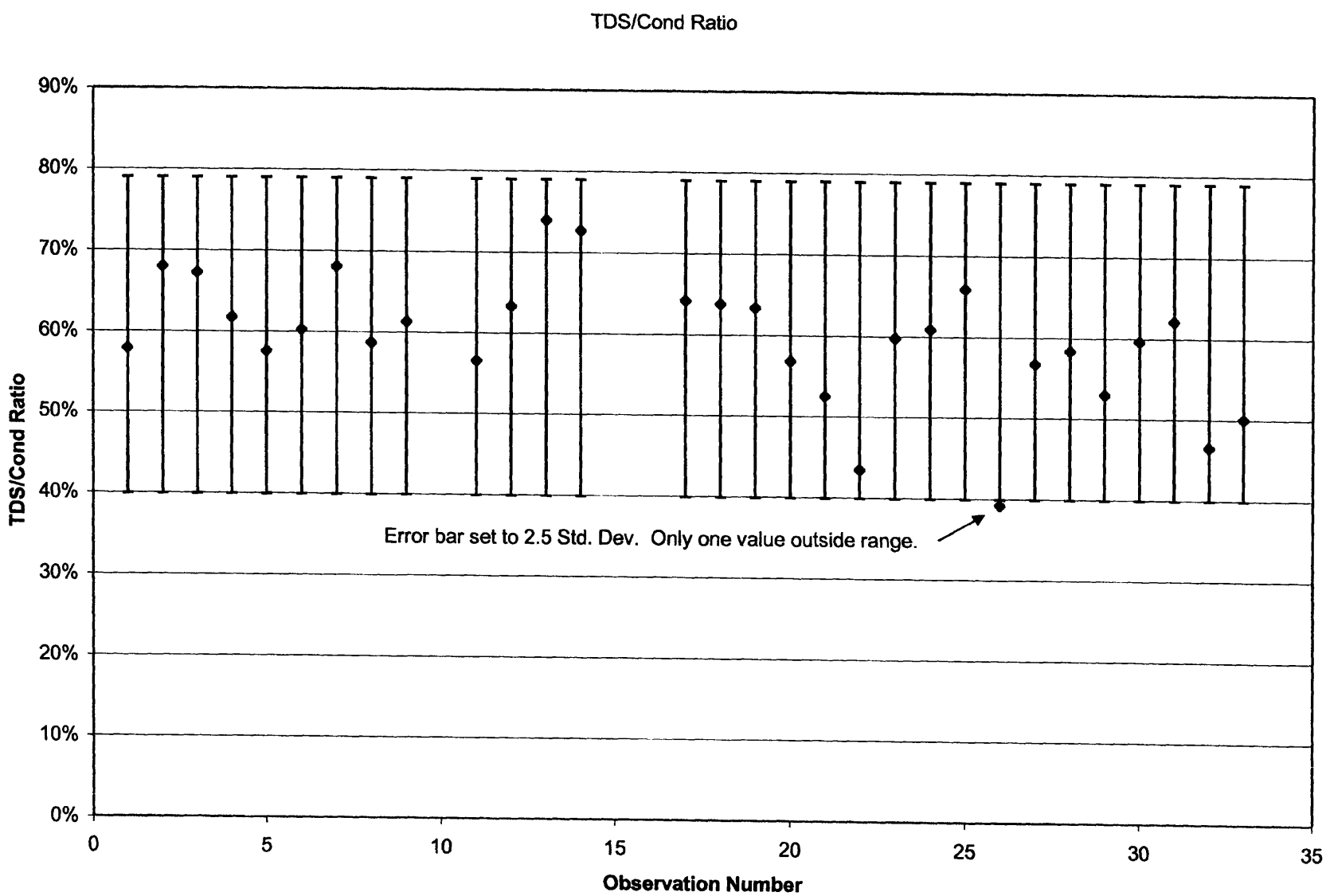
2073.7

Samples were collected by grab from top of each pond.

Where no sample was collected the pond was dry.

Site Identification	Date Collected	Sample No	Current Flow gpm	Spec. Cond	TDS mg/l	Problematic	>334 Marginal	>250<334 Acceptable	<250 TDS/Cond Ratio
1601656 004	3/29/2005	674893	500	306	177	0	0	1	58%
1601656 003	3/29/2005	674894	0	409	278	0	1	0	68%
1601656 002	3/29/2005	674895	25	366	246	0	0	1	67%
1601656 001	3/29/2005	674896	75	337	208	0	0	1	62%
1201805 002	3/29/2005	674897	50	212	122	0	0	1	58%
1601876 001	3/29/2005	674898	75	352	212	0	0	1	60%
1601876 002	3/29/2005	674899	0	366	249	0	0	1	68%
1601876 003	3/29/2005	674900	0	138	81	0	0	1	59%
1601876 005	3/29/2005	674901	0	31	19	0	0	1	61%
1601738 002	3/29/2005	674902	0			0	0	1	
1501773 005	3/29/2005	674903	0	375	212	0	0	1	57%
1501773 007	3/29/2005	674904	0	368	233	0	0	1	63%
1601738 006	3/29/2005	674905	75	1075	795	1	0	0	74%
1601738 08T	3/29/2005	674906	0	820	596	1	0	0	73%
1601738 004	3/29/2005	674907	0						
1601738 003	3/29/2005	674908	0						
1601738 009	3/29/2005	674909	250	684	439	1	0	0	64%
1601738 15T	3/29/2005	674910	10	116	74	0	0	1	64%
1201612 001	3/29/2005	674911	100	423	268	0	1	0	63%
1601738 017	3/29/2005	674912	50	301	171	0	0	1	57%
1501773 001	3/29/2005	674913	50	364	191	0	0	1	52%
1601738 007	3/29/2005	674914	3000	228	99	0	0	1	43%
1501773 010	3/29/2005	674915	75	164	98	0	0	1	60%
1301769 003	3/29/2005	674916	0	887	540	1	0	0	61%
1301769 001	3/29/2005	674917	40	2085	1373	1	0	0	66%
1501773 002	3/29/2005	674918	10	534	209	0	0	1	39%
1501773 003	3/29/2005	674919	0	610	346	1	0	0	57%
1501773 008	3/29/2005	674920	0	533	311	0	1	0	58%
1501773 009	3/29/2005	674921	0	540	286	0	1	0	53%
1201828 A	3/29/2005	674922	0	894	533	1	0	0	60%
1201890 001	3/29/2005	674923	0	467	290	0	1	0	62%
1201921 001	3/29/2005	674924	0	213	99	0	0	1	46%
1201921 002	3/29/2005	674925	0	64	32	0	0	1	50%
						Count	Problematic	Marginal	Acceptable
						30	7	5	19
							23%	17%	63%


TDS vs Cond
y = 0.6733x - 27.171
R2 = 0.9792
Total Dissolved Solids mg/l
Specific Conductivity
1600
1400
1200
1000
800
600
400
200
0
-200
0
500
1000
1500
2000
2500


TDS/Cond Ratio
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
TDS/Cond Ratio
0
5
10
15
20
25
30
35
Observation Number
Error bar set to 2.5 Std. Dev. Only one value outside range.

GEO. E. PENN (1895-1931)
WM. A. STUART (1922-1976)

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STEPHEN M. HODGES
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WADE W. MASSIE [III, IV]
DANIEL H. CALDWELL
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April 13, 2005

HAND-CARRIED

Nancy T. Norton, P.E.
Department of Environmental Quality
P.O. Box 1688
Abingdon, VA 24212-1688

Re: Cumberland Resources Corporation's Comments to Callahan Creek Draft TMDL Report

Dear Ms. Norton:

On behalf of Cumberland Resources Corporation, I enclose comments to the draft Total Maximum Daily Load (TMDL) study for Callahan Creek in Wise County.

That Cumberland requests that it be notified of all future proceedings at DEQ or SWCB pertaining to any of the issues addressed in the Draft Report, the finalization of the Draft Report, or its submission to EPA, SWCB or any other governmental entity, and that Cumberland be provided a copy of comments by all other parties on the Draft Report.

Communications to Cumberland should be directed to me and to:

Phillip Mullins, P.E.
Cumberland Resources Corporation
P.O. Box 2560
Wise, VA 24293
Phone: 276/679-0804
Fax: 276/679-1541
E-mail: pmullins@crcva.com

If you have any questions, comments or concerns, please feel free to call me.

Sincerely yours,

STEPHEN M. HODGES

ERT/mdh
Enclosure

cc: Mr. Phil Mullins
Mr. Michael D. Lawless, CPG
Mr. C. E. Bolton, Jr.

Apn'l 11, 2005

Phil Mullins
Senior Mining L,ngineer
Cumberland Resources Corporation
P.O. Box 2560
Wise, VA 24293

Dear Phil,

I have reviewed the draft document for TMDL development for Callahan and Straight Creeks. In summary, I disagree with the TDS standard of 334 mg/l. The value was den'ved from very limited correlational data collected before and after reclamation of Middle Creek. Also, the study failed to recognize that TDS toxicity is dependent on the relative concentrations of anions and cations comprisiirig the overall TDS value, as well as exposure duration and frequency. Toxicity data reported in the literature conceming TDS were essentially ignored in the developnient of the standard.

Attached you will find my review of the TMDL development document. Please let me know if you have any quc-stions or need additional infonnation.

Sincerely,

Peter F. De Lisle, Ph.D.
President

6400 Enterprise Court, Gloucester, VA 23061
Phone 804-694-8285 Fax 804-695-1129
www.coastalbio.com

There is no valid scientific basis for the selection of a TDS standard of 334 mg/l for the Powell River basin. The value is significantly lower than TDS standards developed by other states (Table 1). The unusually low value arises from several problems in the developmerit of the standard:

1. Use of Middle Creek TDS data for the development of the standard.

The TDS standard (334 mg/1) was selected based on the maximum valtie measLired since the delisting of Middle Creek. Notwithstaiidinc, issues regarding whether Middle Creek is an appropriate reference stream for Callahan and Straight Creeks, it was not demonstrated that this value represents a maximum safe level above which benthic impairment is to be expected.

It was concliaded (MapTech, 2004) that the primary stressor responsible for historical benthic impairment in Middle Creek was TDS. This conclusion was based on correlational data relating decreased TDS (from 600 @tmhos/cm. (-404 mg/1) in 1981 to 263 @tmhos/cm. (-177 mg/1) present) with improved benthic health at a singl monitoring station. While correlational relationships are useftil for inferences (i.e. selection of ,,.possible stressors" as opposed to "probable stressors"), cause-effect relatioilships caiuiot be concludecl from such data; examples of nonsense, statistically significaiit correlations abound (Sokal and Rohlf, 1981). Correlation of TDS changes with benthic comniunity Z:)
structure at niultiple stations, where otber possibly confoundinc, factors may also vary, would provicle a better "weight of evidence" for TDS toxicity but still would not be conclusive.

Other correlated variables, which may not have been measured, may actually be responsible for the impact on the benthic community. For example, sediment pore water ammonia was not measured in any of the monitoring programs (MapTech, 2004, 2005). Ammonia accumulates in sediments as the result of the natural breakdown of nitrocenous ID
organic compounds, nutn'ent runoff and point sources such as municipal wastewater treatments plants (EPA, 2001b). Indeed, the effects of urbaiilzation and resulting ammonia buildup in sediments have spurred recent studies regardinc, the toxicity of ammonia to fi-eshwater mussels to help explain population declines (e.g. Bartseli et al., 2001; T. Newton, personal communication). Reclamation of Middle Creek would likely result in reduced sediment ammonia concentrations and TDS.

2. Lack of understanding of the mode of action in TDS toxicity.

The authors repeatedly state that "Large swings in TDS concentrations can be harmful to aquatic organisms because the density of the water determines the flow of water into and out of the cells of aquatic organisms." This is a gross oversimplification of ion balance ill aquatic organisms and the citation for the statement is a website designed for teachine, secondary school students and volunteers about stream monitoring. If density alone detennined flow of water between the organism and the exten-lal media then fish and aquatic invertebrates would be able to live in solutions consistinc, of any dissolved tl

material (e.g. sucrose) so long as the media osmolality were correct. It is well known that ionic and osmotic regulation is controlled through 1) active transport of ions, 2) excretion and 3) control of membrane pen-neability. Active transport of ions across biolo-ical membranes is dependent on the extemal ion composition as well as overall concentration. Additionally, all aquatic fish and invertebrates, including the molltisks and sponges which are relatively poor osmoregulators, are hyperosmotic to media with TDS as high as 1500 mg/l (e.g. see discussion in Prosser, 1973). Consequently any TDS toxicity in tlle concentration ranges typical of Callahai-i and Straight Creeks is likely more dependent on ionic composition than ionic strength (see discussion below).

Regarding "swings in TDS" the authors also cite a Society of Environinental Toxicology and Chemis-try (SETAC, 2004) white paper as stating that sudden spikes in TDS may be fatal. The objective of the white paper is to provide a broad overview of the TDS toxicity issue for noii-scientists. The SETAC paper provides guidance for interpretation of WET tests in which toxicity is observed following standard exposure periods from 48 hr to 7 days, suggesting that 1340 mg/l TDS (-2000 @tmhos/cm) be used as a flag valtie for possible TDS toxicity. The authors then (incorrectly) conclude that based on instantaneous field measurements (i.e. unknown exposure duration) of TDS exceeding this value that "There seems to be little doubt that the extremely high TDS colicentrations often preseni-I in Straight Creek are i-esponsible for depressing the sensitive benthic community" (p 8-42). As emphasized in the review of Goodfellow and coworkers (2000), TDS composition as well as exposure magnitude, frequency and duration ultimately detennine whether exposure to high TDS waters is toxic.

3. Disregard for scientific literature on TDS toxicity

Although many studies regarding TDS toxicity have centered on wastewaters with high TDS (e.g. produced waters), which may also contain otber unknown toxicants, sufficient data exist from studies with prepared test solutions to draw some conclusions regardinc, toxic levels of TDS. Generally, high TDS waters enriched with potassium are most toxic to freshwater organisms and those enriched with sulfate are least toxic (Mount et al., 1997). In testing of over 2,900 ion-enriched solutions these investigators found the following ions (in order of decreasing toxicity) to significantly (p=0.05) affect acute survival of C dubia, D. magiia and P. promelas: K'>HCO3 =Mg2-'->Cl->SO4 2-. Although Ca 2' and Na' were not significant, toxicity of salts of these cations was probably associated with the corresponding anions. Validation of these findings can be found in the close agreement between toxicity predicted with the GRI-FW STR program (developed from these data) and toxicity test results with real world samples (Gas Research Institute, 1994). We have also used this program in our laboratory with numerous higli TDS samples and similarly obtained good agreement between predicted aiid measured toxicity.

The relatively high acute toxicity of TDS samples predominated by K' is also apparent in data from other sources (Table 2) and in chronic exposures (Table 3). In addition, chronic studies with C dubia support the notion of the following relative toxicities:

HC03>Cl--'SO4 '- (Lasier et al., 2002; Lasier et al. 2005). Another trend that is apparent in the data is that toxicity appears to be greater in soft waters. Based on these findings, TDS toxicity is expected to be minimal in hard waters with relatively high sulfate concentration.

When used in effluent toxicity testing, Ceriodaphnia tests are more likely to indicate effluent toxicity even when there is no impact to the downstream benthic community (Diamond and Daily, 2000). Consequently, results of TDS toxicity tests with this species can be consiidered a conservative estimate of instream effects. Additionally, the consensus of a team of reviewers representing EPA, state agencies, industry and academia was that TDS toxicity does not require the conservative safety factors traditionally applied to conventional pollutants (Goodfellow et al., 2000).

Because sulfate is the primary component of TDS in Straight and Callahan Creeks, and these waters are typically > 1 50 mg/l hardness, it is clear from the data in Tables 2 and 3 that a standard of no less than 1000 mg/l TDS would be appropriate. Additionally, because TDS composition (rather than bulk value) detem-lines toxic effect, excursions above 1000 mg/l should not be defacto violations of the standard. Site-specific assessment cif high TDS should evaluate potential for toxicity using values for specific TDS compoiients and appropriate models and/or toxicity tests with an appropn'ate species (e.g. C dubia), in a manner similar to that used in the Iowa standard.

Table 1. State TDS Standards

State Standard Reference
-Alaska I 000 mg/l TDS' Chapman et al. 2000
Illinois 1500 mg/l TDS Iowa DNR, 2003
Jowa I 000 mg/12 Iowa DNR, 2004
-Ohio 1500 ni@/l MapTech, 2005
issippi 1000 @tmhos/cm Conductivity
Miss' , , I MapTech, 2005
'Site-specific criterion for niine drainages
2Standard provi(les for site-specific evaluation of TDS. If instream TDS is > I 000 nig/l additional testing (ion analysis ancUor WET tests) is used to detenm'ne if water quality impaired.

Table 2. TDS Acute Toxicity.

Species 48-h EC50 TDS Composition Reference
(mg/1)
C. dubia 516 KCI in moderately hard SW' EPA, 2001
P. promelas 1057
W2
C dubia 2148-2748 NaCl in soft R EPA, 1991 a
3180 NaCl in very hard RW
P. promelas 4948-7948 NaCl in soft RW
5580 NaCl in very hard RW
C. dubia 390->5610 50 salt combinations in RW enriched Mount et al.
-D. magna 630->6470 with K, HCO3, Mg, Cl, Na, Ca 1997
-P. promelas 720->7960 and S04
C. dubia 860->5610 Same data set with K enn'ched
-D. magna 1330->6470 combinations excluded
P. promelas 2500->7960
'SW Synthetic freshwater (TDS = 207.4 mg/1). Total TDS is suni of SW TDS plus added salt.
2RW Reconstituted freshwater (TDS = 48 mg/l for soft, 95 mg/l for moderately hard, 190 mg/l for hard and 380 mg/l for very hard). Total TDS is sum of RW TDS plus added salt.

Table 3. Chronic TDS Toxicity.

Species IC25 EC50 NOEC TDS Composition Reference
(m mg/l mg I
C dubia 440 474 477 KCI in moderately EPA, 2001 a
P. promelas 853 1002 817 hard SW'
C dubia 978 1348 678 NaCl in soft RW' EPA, 1991b
1395 1695 1095 NaCl in mod hard RW
1390 1690 1190 NaCl in hard RW
1380 1780 1380 NaCl in very hard RW
P. promelas 718- 888- 548-678 NaCl in soft RW
978 1348
1295 1595 1095 NaCl in mod hard RW
2490 3390 2190 NaCl in hard RW
3580 4880 2380 NaCl in very hard RW
C dubia 787 1184 ---- Chloride, bicarbonate, Lasier et al.
sulfate mix in soft RW 2004
0. nzykiss e >2000 Mock mine effluents Chapman et
0. mykiss fry >2000 rich in sulfates and al. 2000
C. tentans 1100 Calcium
-S. capricornutum >2000
'SW Synthetic freshwater (TDS 207.4 mg/1). Total TDS is sum of SW TDS plus added salt.
'RW Reconstilhited freshwater (TDS = 48 mg/l for soft, 95 mg/l for moderately hard, 190 mg/l for hard

and 380 mg/l for very hard). Total TDS is sum of RW TDS plus added salt.

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2.4 CIIEMICAL ANALYSES OF STRATA - (Utilize the followina Acid-Base (AB) Account sheet(s) or equivalent
12
formatted infon-natiOD. If eqLiivalent fon-natted information is used and included in the application package, identify the

i-naterial as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

AB Location 14o. ALL-08-96 Surface Elevation 2796.2

Borehole (B); Crop (C); Exposure (E); Other (OT UNDERLINE MAXIMUM POTEN -TIAL ACIDITY(IES)
B (WA) BASED ON PYRITIC SULFUR ANALYSES.

Unit No. Liib. Litliologic Type PH Total Sulfur Pyritic Sulfur MPA NP Excess Acid

ID. No. or NP

3 Shale 9.0 0.14 4.38 30.66 26.29

4 Coal -Low Splint A 3.48

5 Shale 7.7 0.52 16.25 4.86 -11.109

6A Sandstone 7.9 0.10 .>.13 10-32 7.20

6B Sandstone 8.2 0.05 1.56 4.92 3.36

6C Sandstone 8.6 0.00 0.00 32.43 32.43

6D Sandstone 8.4 0.03 0.94 52.57 51.64

7 Coal - Low Splint B

8 Sandy Shale 8.6 0.09 2.81 62.38 59.56

9 Sandstone 8.1 0.12 3.75 15.08 11.33

10 Shale 7.5 1.48 46.25 6.48 -39.78

1 1 Coal - Low Splint C/D

1 2 Sliale 8.4 0.15 4.69 7.55 2.86

1 3 Coal - Low Splint C/D

14 Sandstone 8.8 0.10 2.71 -0.41

15 Coal - Low Splint C/D

1 6 Shale 8.9 0.00 0.00 3.25 3.25

1 7 Sandstone 8.8 0.08 2.50 61.84 59.34

1 8 Shale 7.3 1.64 51.25 4.86 -43.39

19 Coal - Low Splint E 4.19

20 Shale 9.3 0.27 8.44 8.62 0.19

2 1 Coal - Low Splint E

22 Sliale 9.6 0.11 3.44 36.58 33.14

23 Sandstone 9.5 0.10 3.13 45-18 42.05

24 Shale 9.6 0.11 3.44 63.99 60.55

25 SaDdstone 9.2 0.13 4.06 24.72 20,66

26 Sandy Shale 9.7 0.16 5,00 33.89 28.89

27 Shale 9.7 0.10 3.13 38.73 36.60

28 Coal - Taggart A- I

29 Shale 8.0 0.14 4.38 3.84 -0.54

30 Sandstone 9.7 0.22 6.88 60.76 53.89

3 1 Sbale 9.0 0.19 5.94 61.54 55.60

3 2 Coal - Taggart A-2

33 Shale 9.7 0.00 0.00 12.39 12.39
34 Sandstone 9.6 0.00 0.00 6.48 6.48
35 Shale 9.2 0.10 3.13 54.3 1 51.19
31 6 Coal - Taggart
37 Shale 8.9 0.10 3.13 11.85 8.72
38 Sandstone 8.5 0.16 5.00 28.57 23.57
39 Shale 8.9 0.19 5.94 43.56 37.63
40 Coal - Taggart Marker 0.84
4 1 Sliale 9.4 0.17 5.31 5.40 0.09

Report to nearest tenth NP Neutralization Potential
Report to near-est hundredth

2.4 CIIEMICAL ANALYSES OF STRATA - (Utilize the following Acid-Base (AB) Account sheet(s) or equivalent formatted information. If equivalent forrnatted information is used and included in the application package, identify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

4

AB Location I ALL-06-96 Surface Elevation 2611.9

M

Borehole (B); Crop (C); Exposure (E); Other (0) B UNDERLINE MAXIMUM POTENTIAL ACIODITY(IES) (MPA) BASED ON PYRITIC SULFUR ANALYSES.

Unit No. Lab. Lithologic Type PH Total Sulfur Pyritic Sulfur MPA NP Excess Acid
M. No. or NP

I I Sandy Shale 9.5 1 0.15 4.69 41.35 36.66
12 Sandstone 9. I 0.12 3.75 45.94 42.19
1 3 Sandy Shale 9.5 0.10 3.13 44.10 40.98
14 Sandstone 9.3 0.08 2.50 51.04 48.54
1 5 Shale 9.5 0.79 24.69 8.62 -16.06
16 Coal - Taggart A
1 7 Shale 9.8 0.26 8.13 32.81 24.69
I 8 Sandstone 9.7 0.00 0.00 10.64 10.64
1 9 Shale 9.5 0.10 3.1 3 36.25 33.13
20 Coal - Taggart 0.63
2 1 Shale 9.2 0.17 5.31 1.64 -3.68
22 Sandy Shale 9.4 0,11 3.44 41.41 37.98
23 Shale 9.0 0.12 3.75 25.82 22-07
24 Coal - Taggart Marker 0.85
25 Shale 9.5 0.12 3.75 0.56 -3.19

Report to nearesit tenth NP = Neutralization Potential
Report to nearest hundredth

2.4 CHEMICAL ANALYSES OF STRATA - (Utilize the following Acid-Base (AB) Account sheet(s) or equivalent formatted infortnation. If equivalent forrnatted information is used and included in the application package, ide.ntify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

-7 Surface Elevation 3115.8

AB Location 14o. ALL-0 1 -96

Borehole (B); Crop (C); Exposure (E); Other (0) B UNDERLINE MAXIMUM POTENTIAL ACIDITY(JES) (MEPA) BASED ON PYRITIC SULFUR ANALYSES.

Unit No.	Lab. ID. No. or NP	Lithologic Type	PH	Total Sulfur	Pyritic Sulfur	MPA	NP	Excess Acid
44	14732	Shale	9.8	0.23	7.19	60.23	53-04	
45		Coal - Low Splint A					4.82	
46	14727	Sandstone	9.7	0.00	0.00	22.60	22.60	
47		Coal - Low Splint B						
48	14728	Shale	8.6	0.06	1.88	61.84	59.96	
49		Coal - Low Splint C/D						
50	14719	Shale	9.1	0.15	4.69	54.31	49.63	
5 1	147:26	Sandstone	9.6	0.00	0.00	4.86	4.86	
52	147.31	Shale	9.5	0.17	5.31	9.16	3.85	
53		Coal - Low Splint E					3.85	
54	147-119	Shale	9.6	0.12	3.75	50.55	46.80	

Report to nearest tenth NP = Neutralization Potential

Report to neare-it hundredth

DMLR-PT-034D

Rev. 6195 76

2.4 CHEMICAL ANALYSES OF STRATA - (Utilize the following Acid-Base (AB) Accotint sheet(s) or equivalent formatted inforrnation. If equivalent forrnatted information is used and included in the application package, idelitify the material as Attachment 2.4.)

ACID-BASE ACCOUNT SHEET

rfa

SU

2689.9

7-

AB Location No. LS-97-4 ce Elevation

Borehole (B)- Crop (C); Exposure (E); Other (0) UNDERLINE rAAXIMUM POTENTIAL ACIDITY(IES)

B

(MPA) BASED ON PYRITIC SULFUR ANALYSES.

Unit Lab.113. Lithologic Type PH Total Sulfur Pyritic MPA NP Excess Acid

No. No. Sulfur or NP

1 8 35649 Sandy Shale 8.4 0.06 2.50 3.55 1.05
1 9 35650 Sandstone 8.2 0.07 2.19 20.11 17.92
20A 46865 Shale 8.9 0.74 23-13 '32.43 9.31
20B 46866 Shale 9.1 0.37 11.56 36.85 25.29
20C 4686 Shale 9.2 0.43 13.44 36.36 22.92
20D 46868 Shale 9.2 0.44 13.75 36.36 22.61
20E 46869 Sbale 9.0 0.42 13-13 41.27 28.15
2OF 46870 Shale 8.9 0.45 14.06 40.29 26.23
2OG 46871 Sandstone 6.8 1.63 50-94 52.08 1.15
20H 46872 Sliale 9.0 0.65 20.31 60.93 40.61
201 4 6 8 7_31 Shale 9.2 0.02 0.63) 169.75 169.13
20J 46874. Shale 9.2 0.70 21.88 54-05 3)2.17
20K 46875 Shale 9.0 0.77 24.06 38.82 14.76
20L 46876 Shale 6.1 3.63 113.44 9.83 -103.61
20M 46877 Shale 5.5 3.48 108.75 14.25 -94.50
2 1 Coal - Low Splint A Rid. - 6.63 2.64
22 35652 Sliale 8.8 0.18 5.63 17.42 11.80
23 Coal - Low Splint A - 1.07 0.47
24 35653 Shale 8.8 0.18 5.63 7.13 1.51
25 Coal - Low Splint B
26 35654 Shale 8.9 0.08 2.50 3.10 0.60
27 35655 Sandstone 9.1 0.00 0.00 7.68 7.68
28 Coal - Low Splint C/D - 1.46 0.43
29 35656 Shale 9.0 0.18 5.63 2.21 -3.42
30 35657 Sandstone 9.3 0.06 1.88 8.92 7.05
35658 Sliale 9.1 0.15 4.69 3.55 -1.14
32 Coal - Low Splint E - 6.07 2.06
33 35659 Sandy Sliale 9.1 0.59 18.44 5.334 -13.10
34A 46878 Sandstone 9.3 0.31 9.69 33.41 23.73)
34B 46879 Sandstone 9.5 0.22 6.88 30.47 23.59
46880 SaDdstone 9.7 0.00 0.00 23-10 23.10

34D 46881 Sandy Shale 9.3 0.07 2.19 42.75 40.56
34E 46882 Sandstoiie 9.5 0.15 4.69 44.71 40.03
35 35661 Sandy Shale 9.2 0.13 4.06 16.08 12.02
36 35662 Sandstone 9.5 0.00 0.00 22.79 22.79
37 Coal - Taggart A I - 1.40 0.48
3 8 35663 Shale 9.0 0,24 7.50 4.89 -2.61
39 Coal - Taggart A2 - 1.29 0.37
40 35664 Sandy Shale 9.0 0.10 3.13 3.55 0.42
41 35665 Sandstone 9.3 0.16 5.00 53.67 48.67
42 3566.6 Sandy Shale 9.3 0.07 2.19 23.24 21-05
43 Coal - Taggart - 0.59 0.20
44 35667 Sandy Shale 9.2 0.04 1.25 20.11 18.86
45 35668 Sandstone 9.4 0.00 0.00 29.06 29.06
46 35669 Shale 9.1 0.11 3.44 9.37 5.93
47
48 Coal - Taggart Marker - 0.67 0.00
35670 Shale 9.0 0.09 2.81 3.10 0.29
Report to nearest tenth NP = Neutralization Potential
Report to nearest hundredth

2.5 LOCATION OF ACID-BASE SAMPLING POINTS
ACID-BASE SAWLING POINTS Total Number: 4
Loc. No. Elevation Latitude Longitude Loc. NO. Elevation Latitude Longitude
ALL-08-96 2796.2 36058'28" 82045'49" ALL-06-98 2611.9 36058'56" 82 04 6'l 5 "
LS-97-4 2689.9
ALL-0 1 -96 3115.8 36"59'13 82046'45" 36D59'35" 82047'l 2 "

GROUND WATER HYDROLOGY

2.6 WATER SUPPLY INVENTORY INFORMATION - (Use fon-n WSJ-034D. Reference the location of the information as Attachment 2.6.)
N/A - There are no developed water resources within a one-half i-nile radius of the proposed permit area or within the potential imp-act area of the proposed underground mining.

2.7 GROUND WATER BASELINE MONITORING PROGRAM
Three sELmpling points have been established for the collection of premining data to reflect seasonal variations in groundwater quantity and quality for representative aquifers in the general vicinity of the proposed operations. The monitoring point locations are indicated on the GeoloU Map. GW- I is a Taggart Marker seam mine discliarge located in a downdip area near the middle of the pen-nit. Tlis point provides representative i-nonitoring of perched groundwaters associated with the Tag-art Marker seam, the lowest mining horizon. GW-2 and GW-3 are existing monitoring wells located on P.N. 1401567. These monitoring points are representative of the alluvial system and base flow of Callahan Creek. A well construction data sheet for the alluv.ial wells are included as Attachment 2.19.
Monitoritig at GW-1 was conducted from March 1997 through July 1997 with six (6) samples collected on a 21-day cycle. Monitoring at GW-2 was conducted from February 1995 through July 1997 with samples collected on a monthly basis. Monitoring at G'%1-3 was conducted from July 1996 through January 1998. The baseline data collected is included for all monitoring locations in Attachment 2.8.

2.8 GROUND WATER BASELINE AND WELL CONSTRUCTION DATA - (Use forms GWB-034D, GDM-034D, and WCD-034D. Reference the location of the infon-nation as Attachment 2.8.)

See Attachment 2.8

ENVIR ONMENTAL MONITORING, INCORPORATED
ENVIRONMENTAL CONSULTANTS A ANALYTICAL LABORATORIES
P.O. BOX 11 90 A NORTON, VIRGINIA 24273 A 276/679-6544

April 4, 2005

Mr. Phil Mullins, P.E.
Cumberland Resources, Inc.
P.O. Box 2560
Wise, VA 24293

RE: Review of Total Dissolved Solids Concentrations
Pe-rmitted Ouffalls - Cumberland Resources
EtAl Project No. 2073.7

Dear Mr. Mullins:

You reqLiested Environmental Monitoring, Inc. (EMI) to collect water samples from perrnifted sediment control structures utilized by Cumberland Resources. The samples were collected from the top of the water near the permifted discharge. location on structures containing water. Samples were collected from the top of each structure even if there was no discharge from the ouffall. Three structures were observed to be dry. A. total of 30 samples were collected for analysis. No samples were collected from the actual permifted ouffalls. Samples were analyzed for Specific Conductivity and Total Dissolved Solids (TDSI by the EMI laboratory.

The results of laboratory analysis are aftached in summary for your review. The summary compares the TDS results to the potential effluent limitation value of 334 mgA value you provided. Based on this comparison 23% of the sites were considereci to be immediately problematic or expected to exceed the 334 mgll limitation if'imposed. An additional 17% of the sites were considered marginal or within 25%, of the 334 mg/i limit. It is the opinion of the consultant as many as 1/3 of the sites evaluated could be expected to exceed the anticipated effluent limitation o-f 334 mg/i on a regular basis. Compliance with the proposed effluent limitation fcir TDS would be extremely difflcult for the permit holder. Methods for effluent treatment currently utilized by the coal mining industry will not be effective foi- TDS reduction.

TDS values. were compared to Specific Conductivity in an effort to determine if a relationship could be established. A regression analysis was performed on the data set providing a r2 value of 0.9792. The function describing the relationship is TDS = Specific Conductivity x 0 6733 - 27.171. A typical ratio for TDS to Conductivity is 2/3. Only one data point was observed to be outside 2.5

Standard Deviations from the mean. The function provided above was not significantly impacted by removing the potential outlier and a decision was made to contiriue to consider the subject point within the calculations.

If you sliould have any further questions regarding this evaluation, please feel free to conta'd me at our Norton, Virginia office (276) 679-6544.

Respectfully submifted,

ENVIRONME ONITORING, INC.

/'F@'Y` rter, Chemist
Project Manager

Attachments

Cumbedand Resources - Total Dissolved Solids Evaluation
2073.7 1 I I I
@@a ch pond.
TRies were collected by grab from top of ea
Where no sample s oollected the Do was dry. >334 >250<334 <250
Site Identification Date-Collected Sample No Current Flow gpm Spec@.Cond TDS mgA Problemaflc Marginal Accepta le TDS/C
1601656 004 U29/2005 674893 500 306 177 0 0 1 58%
1601656 003 3/29/2005 674894 0
409 278 0 1 0 680".
1601656 002 3/29/2005 674895 25 2461 0 0 1 67%
i6010-51, UV W2912005 674896 75 337 208 0 0 1 62%
1201805 002 3129/2005 674897 212 122 0 0 1 58%
601876 001 3/29/2005 674898 75 352 212 0 0 1 600/o
601876 002 3/29/2005 T74899 0 366 249 0 0 11 680/o
1601876 003 3/2912005 674900 0 138 81 0 o II 590/0
1601876 005 3M/2005 674901 0 31 19 0 0 1 61%,
1601738 002 3/2WO05 674902 0 0 1
1501773 005 3/2912005 674903 0 375 --- 212- 0 -@6 1 57%1
15OW73 007 3/29/2005 674904 0 368 233 0 0 I 63%
1601738 006 3/29/2005 674905 75 1075 795 1 0 0 74%
1601738 08T 3r2912005 674906 0 820 596 I -o 0 73%
1601738 004 3/29/2005 674907 0
1601738 003 3/29/2005 674908 0 1
1601738 009 3/29/2 5 674909 2@@7 684 439 1 1 0 @@O 64%
1601738 15T 3/29/2005 674910 10 116 74 0 0 1 64%
1201612 001 3/29/2005 674911 i(O 423 268 0 1 @@O 63%
1601738 017 3/29/2005 674912 50 171 0 -@@O 1 57%
1501773 001 3129/2005 674913 50 364 191 0 0 1 52%
1601738 007 3/29/2005 674914 3000 228 99 0 0 1 43%
1501773 010 3/29/2005 674915 75 164 98 0 0 1 60%
1301769 003 3/29/2005 674916 0 887 540 1 o @@O 61%
1301769 001 3/29/2005 674917 40 2085 1373 1 0 0 66%
1501773 D02 312912005 674918 10 __@341 2091 0 0 1 390/0
1501773 003 3129/2005 674919 0 610 346 1 0 0 57%
1501773 008 3/29/2005 674920 0 5331 311 0 1 0 58%
1501773 009 3/29/2005 674921 0 5401 2861 0 I 0 53%
1201828 A 3/29/2005 674922 0 894 533 1 0 0 60%
1201890 001 3/29/2005 674923 0 467 290 0 1 0 62%
1201921 001 3/2912005 674924 0 213 99 0 0 1 46%
1201921 002 3/29/2005 674925 0 64 32 0 0 1 50%
@Cou-nt -- Problematic Marginal Acceptable
30 7 5 1 9
23% 17% 63%

TDS vs Cond

1600

1400
y 0.6733x - 27.171

R 2 0.9792
1200

1000

10 800
co

600
An
Q

i2 400 -

200 -

o

500 1000 1500 2000 25DO

-200

Specific Conductivity

TDS/Cond Rabo

90% -

80% -

70% -

60%

0
50% -

0
0 I I I I
40% -

Error bar set to 2.5 Std. Dev. Only one value outside range.
30% -

20% -

10% -

0%
0 5 10 15 20 25 30 35
Observation Number

RECEIVED

PENNSTUART
GEO. E. PENN (I 895-1 93 1) 1 3 2005 G.R.C. STUART (RETIRED)
Wm. A. STUART (I 922-1 976) Since 18% DEQ,SWRO JOHN B. HEMMINGS (RETIRED)

Wm. W. ESKRIDGE ATTORNEYS ATLAW ELIZABETH R. WALTERS"I
STEPHEN M. HODGES PostOffice Box 2M ERic R. THIESSEN
W. CHALLEN WALLING Abliigdoii, Virg@iiaia 24212-2M LESLIE S. BLANCHARD
WADE W. MASSIE """V ANDREW M. HANSON
DANIEL H. CALDWELL 208 East Mafia Street DANIELLE S. KiSER'll
BLAIR TARio A. ZA
MICHAEL F. Abiw,doia, Vir-iiiia 24210-2904 IDI ..T L-N.E...'11R.1111A
WILLIAM M. MOFFET it' JOHN A. MARTIN
MARK L. EsPO51TO "I Telephow 276/628-5151 JESSE F. NARRON
TIMOTHY W. GRESHAM Facsiiiiie 276/628-.%21 CAMERON S. BELL
H. ASHBY DICKERSON Offices iii Abiii-doia atid RkhiiioiA Virg@iiiia aiid KAR, Lou FRANK
BYRum L. GEISLER "I r ANN, L. MUSGROVE
JILL MORGAN HARRISON v Bristol, Teiiiiessee LAURA E. WILSON"" v
RICHARD E. LADD, JR. All Attoriievs Liceiise(i in Vir,,6nia F-xcept as Noted BRIAN J. RIFE
W. BRADFORD STALLARD Additioiial Bar Mciiibersliips: WHITNEY J. A. CAUDILL
RAMESH MURTHY CA; 11 NC; "I TN; Iv WV;vKY; v, WI JAMEs R. PERKIN5'11
MARK E. FRYE TRACEY A. BERRY V'..T 11CE-ED III VIII.I.IA
LiSA FRI51NA CLEMENT

Writer's Direct Access:
276/623-4405
shodqesCcD_Pennstuart.com

April 13, 2005

HAND-CARRIED

Nancy T. Nortcon, P.E.
Department of Environmental Quality
P.O. Box 1688
Abingdon, VA 24212-1688

Re: Cumberland Resources Corporation's Comments to
Callahan Creek Draft TMDL Report

Dear Ms. Norton:

Oirl behalf of Cumberland Resources Corporation, I enclose comments to
the draft Total Maximum Daily Load (TMDL) study for Callahan Creek in Wise County.

Tftat Cumberland requests that it be notified of all future proceedings at
DEQ or SWCB pertaining to any of the issues addressed in the Draft Report, the
finalization of tfie Draft Report, or its submission to EPA, SWCB or any other
govermnental enitity, and that Cumberland be provided a copy of comments by all other
parties on the Di-aft Report.

C-ommunications to Cumberland should be directed to me and to:

Phillip Mullins, P.E.
Cumberland Resources Corporation
P.O. Box 2560
Wise, VA 24293
Phone: 276/679-0804
Fax: 276/679-1541
E-mail: Vmu11ins(&,crcva.c0m

If you have any questions, comments or concems, please feel free to call me.
Sincerely yours,

ST EN M. HODGES

ERT/mdh
Enclosure

cc: Mr. Phil Mullins
Mr. Michael D. Lawless, CPG
Mr. C. E. Bolton, Jr.

Abingdon: 573677-1

Summary Comments on the draft TMDL Report, "Fecal Bacteria and General Standard Total Maximum Daily Load Development for the Powell River Basin"

Introduction

In 2004, the consulting firm of MapTech, Inc. was retained by the Virginia Department of Mines, Minerals and Energy (DMME) and the Virginia Department of Environmental Quality (DEQ) to develop a Total Maximum Daily Load (TMDL) Report for Straight Creek and Callahan Creek. Both of these streams have recreational use and aquatic life use impairments and both streams were scheduled for TMDL report submittal to EPA by April 2006, based on an EPA consent decree.

Virginia has a public participation process that includes public notification and public meetings during TMDL studies. This process was observed for these two watershed studies by conducting meetings in June 2004, August 2004 and February 2005 for watershed stakeholders and landowners. The June meetings for each watershed were held during the daytime and included locality and agency stakeholders for the purpose of gathering information and additional data that would be helpful in the TMDL studies. The August meetings were advertised and open to interested persons for the purpose of describing the TMDL study process and seeking additional data or anecdotal information for the study. At the February 2005 TMDL meetings, the draft TMDL report findings were presented. Details of these meetings are in Chapter 13 of the TMDL Report.

During the study, DEQ, DMME and MapTech staff responded to stakeholder requests for data and preliminary evaluation results as requested. Additional meetings with stakeholders were held to discuss specific program and technical questions as they arose. The opportunity to contact DEQ and discuss concerns about the TMDL study was publicized in the TMDL public notices. Representatives from the Virginia Department of Conservation and Recreation (DCR) and DEQ presented the Straight Creek TMDL recommendations to the Lee County Board of Supervisors at their March 15, 2005 Board meeting. This additional presentation was based on Lee County Board request.

The TMDL report was released on the Virginia WEBSITE on February 9, 2005, one day prior to the last Straight Creek public meeting and about two weeks prior to the Callahan Creek public meeting. An important component of the public participation process is a 30-day public comment period for draft TMDL reports. Stakeholders requested additional time to review the TMDL report citing its complexity and volume as reasons more time was needed. As a result of this request, the public comment for the Straight Creek and Callahan Creek portions of the document were both extended from March 14 and March 23, respectively, to April 13, 2005.

Public Commenter Summary

Three letters were received requesting additional time to review the TMDL report. Within the first 30 days of the public comment period DEQ had two data requests as well. None of these correspondences specifically addressed the content of the draft TMDL report. Six separate comment documents about the TMDL content were received. All of them were received on April 13, 2005, the end of the public comment period. These six comments were received from the following:

1. Lone Mountain Processing, Inc. regarding Straight Creek in particular (LMPI)
2. Penn Stuart for Cumberland Resources regarding Callahan Creek (CRC)
3. Straight Creek TMDL Group – Comments about Straight Creek compiled by Biological Monitoring, Inc. under contract to mining industry interests in the watershed(BMI)
4. Virginia Dept. of Conservation and Recreation regarding the entire document (DCR)
5. Virginia Mining Association supporting the Straight Creek TMDL Group Comments (VMA)
6. Mid-Atlantic Environmental Law Center regarding the entire document (MAELC)

The Straight Creek TMDL Group provided supplemental comments on the draft document on May 23, 2005. The comments were a technical review of the GWLF model used to determine pollutant loadings for the TMDL report. These comments are not directly addressed here but were considered in revising the TMDL document.

Summary of Comments

Generally, the comments fell into 7 categories;

1. Benthic Macroinvertebrate assessment comments –
    a. Reference stream choices questioned based on timing, ecoregion and changing the reference stream from sampling event to sampling event (BMI 1.2.1, 1.2.2,1.2.3; CRC)
    b. Rapid Bioassessment Method inadequate to determine impairment (BMI 1.1, 1.4)
    c. Reference stream approach inadequate to determine if the stream is impaired, Multi-metric indexes are more appropriate (BMI 1.3)
    d. Virginia Stream Condition Index (a multi-metric index) is inappropriate in the Central Appalachian ecoregion (LMPI #8)
2. Data inadequacies
    a. Bacteria site locations not representative of entire watershed (LMPI #4)

   b. Benthic sampling events frequency inadequate to undertake trend analysis (BMI #1.2.1)
   c. Benthic site 6BSRA003.62 needed more sampling events before drawing comparisons between it and station SA from another study (LMPI #9)
   d. Specific components of TDS are necessary to determine stressor status (LMPI #12, CRC IV b)
   e. DMME data was not considered in the study (CRC III a)
   f. Chronic toxicity testing inadequate (CRC III d)
3. Model comments
   a. Model runoff curve numbers inconsistent with literature values (LMPI #16 BMI 3.3#3)
   b. Flow data output from HSPF model inappropriate for use as calibration for GWLF model (LMPI #15; BMI 3.3)
   c. Stream gage data inappropriate for Straight Creek (LMPI #2)
   d. Hydrology calibration -questions about the adequacy of flow data (LMPI #2, 7, BMI 3.1))
4. Reference Watershed selection
   a. Middle Creek does not meet the criteria for reference watershed selection (LMPI #3, 13, 14; CRC IV a)
   b. Middle Creek reductions of TDS are not supported by the delisting document (CRC IV i)
5. Benthic Stressor Conclusions and load recommendations-
   a. Comments and questions about total dissolved solids being a stressor and to what TDS limit the benthic community negatively responds (BMI 2.2, LMPI #10, CRC III)
   b. Scientific methodology/data-literature cited for TDS and conductivity stressor conclusions inappropriate (BMI 2.0, LMPI 10, CRC III)
   c. Other streams have good benthics with escalated TDS values (BMI 2.2.5, CRC IIIa)
   d. Background TDS values in Callahan Creek exceed recommended controls (CRC IV d)
   e. Baseflow loadings of TDS in Callahan Creek will not be reduced based on recommended BMPs of the study (CRC IV e)
   f. Reduction of TDS loadings would require expensive treatment facilities (CRC IV f)
   g. TSS is not adequate as a representative sediment loading for benthic impairment (CRC IV g)
   h. Habitat was ignored in the stressor analysis (BMI 2.2.3; CRC III c, IV h)
6. Legal Requirements not met
   a. Water quality standards differ materially from federal law (CRC I a, b)
   b. Draft report gives no basis for costs and benefits or economic feasibility (CRC I c, d, f)
   c. Fails to distinguish between discrete segments of Callahan Creek in the notice and the study (CRC I g)
   d. Does not provide APA processes for promulgation of regulations (CRC I e)
   e. TMDL process not applied properly (CRC II)

7. General comments-
    a. Document too cumbersome (DCR, BMI, LMPI, CRC)
    b. Inadequate documentation or explanations for conclusions within the document (BMI, LMPI, CRC, MALC)
    c. Implementation of the TDS TMDL could put Cumberland out of business resulting in loss of about 370 jobs (CRC V c)
    d. The TMDL should be based on sound scientific principles and properly collected data (CRC IV 3)
    e. Suggestions for additional implementation language (DMME, DCR)

Comment Responses

The responses from DEQ, DMME, and MapTech follow for each public comment document received during the comment period. The responses are in order to match comments made in each separate document. References to the six public comment documents(*i.e.*, section and item number) precedes each response. All references to the TMDL document refer to the original draft document reviewed by the commenters.

Responses to Keith Mohn of Lone Mountain Processing, Inc. (LMPI) Comments:

LMPI #1. Several commenters echo your feelings about combining two TMDL segments into one document. The contractor made every effort to clearly define the segments in chapter discussions. Between table of contents and figure labels, the document is set up to allow the reader to find those document parts that are of interest. However, based on this comment, the two watershed reports are being separated.

LMPI #2. Not including a hydrology validation is not a case to dismiss the HSPF model as unacceptable. The purpose of validation is to demonstrate how well a calibrated model responds to different circumstances. In this case, the circumstances would be a different time period with different precipitation. For a watershed with surface mining as a major land use, such as the case with the Straight Creek watershed, the land characteristics change dramatically with time. Because of this, a time period was selected with a relatively stable amount (acres) of disruption due to mining. Instead of dividing the observed data taken during this time period between calibration and validation, all the data during the time period was used for calibration. The logic behind this decision was: the more data used to calibrate, the more accurate the model would be. Typically, if a model does not perform well in validation, the calibration is "re-visited" to improve the model. So, many modelers argue that, when data is limited, a better use of data is to apply all available data to calibration and forgo the validation step. MapTech performed statistics on the differences between the observed and modeled stream flow (Section 4.7.1.2), which show that the final hydrology model is accurate. Validation was not done for Straight Creek because the data was more valuable when used for calibration.

The term "lack of data" was improper in the paragraph mentioned (pg xxxvii) and the statement has been changed from "Hydrology validation was not performed for either Callahan Creek or Straight Creek due to lack of data" to "Hydrology validation was not performed for either Callahan Creek or Straight Creek because a stable time period was chosen for hydrology modeling for each stream and all observed data collected during these time periods was used for hydrology calibration".

The USGS Station number was mistyped in the Executive Summary. The sentence has been changed from "The stream flow in the North Fork Powell River watershed including Straight Creek was calibrated with the flow values from USGS Station #03531500" to "The stream flow in the North Fork Powell River watershed including Straight Creek was calibrated with the flow

values from USGS Station #03530500 in the North Fork Powell River at Pennington Gap." The drainage area of USGS Station #03530500 is approximately 71 square miles.

The comment on the use of the Jonesville USGS Station #03531500 in the Executive Summary also applies to Chapter 4. "For the North Fork Powell River, flow data were available at USGS Station #03530500 during the period 10/1/1944 through 9/30/1951, 10/1/1978 through 9/30/1981, and 10/1/1993 through 10/3/1995. A linear regression was performed on this data using continuous data from USGS Station #03531500 on the Powell River" (the Jonesville station). For clarification, the last sentence in the first paragraph on page 4-19 was changed from "The resulting data were continuous daily flow values from 10/1/1944 through 9/30/2003" to "The resulting data were continuous daily flow values at USGS Station #03530500 in the North Fork Powell River at Pennington Gap from 10/1/1944 through 9/30/2003". The data from USGS Station #03530500 was used in the hydrology calibration of the contributing watershed, which includes Straight Creek.

This is an acceptable and approved method for calibrating a hydrologic model. The DEQ data measurements taken in Straight Creek and further measurements collected by BMI during the TMDL study were referred to as well to verify the calibration.

LMPI #3. Middle Creek was used as the reference watershed to set the TMDL water-quality endpoints for TDS and sediment. The TDS endpoint was based on monitored values of TDS concentrations in Middle Creek. Being a concentration endpoint, there is no need for an adjustment based on watershed size differences. The sediment endpoint was based on modeling the annual sediment load in Middle Creek. Since the sediment load that the aquatic community can tolerate is related to the size of the stream and the resulting habitat availability, the size of the reference watershed was scaled to simulate an appropriate sediment load endpoint for the impaired streams. This methodology to account for differences between the TMDL segment and the reference watershed is defined in the draft document.

There are many water constituents (possible benthic stressors) that have no Virginia State Standard, including TDS. It was decided that in the absence of a State Standard, 90th percentiles for constituents monitored in a unimpaired stream segment would be used to provide a conservative indication of a probable stressor and make it more obvious to the reader when values for a particular constituent were excessively high. For these watersheds, we would have arrived at the same conclusions without using the 90th percentile values, because the values of TDS and conductivity were excessively high in comparison to literature values. DEQ benthic data shows that the McClure River is not impaired. The McClure River was used to help establish the most probable stressor. However, the McClure was not used as the reference watershed to model endpoint scenarios.

The EPA secondary drinking water standard value is not relevant to aquatic life use. These values are based on different designated uses. Comparing an EPA drinking water standard to a benthic in-stream endpoint is not appropriate. For example, humans can drink water with 0 mg/L of dissolved oxygen (DO) in it, but benthic macroinvertabrates cannot live in a stream with 0 mg/L DO. The TDS drinking water standard has no relevance to the biological response of benthic macroinvertabrates.

LMPI #4. The purpose of Bacterial Source Tracking (BST) during TMDL development is to determine the major source(s) of bacteria in a watershed. The bacteria TMDL was based on the sampling station where the bacteria source tracking data was collected. The overall BST results give an idea to the reductions necessary to achieve the TMDL goal of zero exceedances of the bacteria standard. According to the result of the BST analysis, the predominate source of bacteria is human at this station in Straight Creek (Figure 2.9). Citizens living in the watershed and VDH have agreed with the results of the BST analysis. The comment "Along the excluded creeks, there is no public sewage service, whereas, approximately 135 residences and businesses are served along Straight Creek" is contradictory to the comment that the BST results are invalid. If the predominate bacteria source upstream of Puckett Creek and Stone Creek (at the current BST station) is human, and the majority of the additional bacteria from Puckett Creek and Stone Creek is human (because "there is no public sewer service" available), the overall BST results would not change if the BST station was at the outlet of Straight Creek. Further monitoring to identify specific sources could be performed during implementation plan development if stakeholders feel more data is necessary.

LMPI #5. The sentence "There was an extended public comment period after the final public meetings and no written comments were received" was only a placeholder. It was there to remind the contractor to discuss written comments in Chapter 13 and in the Executive Summary. The sentence was highlighted yellow to stand out from the document so readers would know that it would be addressed once the comment period was finished. This language in the Executive Summary and the Public Participation Chapter of the TMDL documents is being revised now that the public comment period has concluded and will be available July 11, 2005.

LMPI #6. This statement reflects the EPA guidance for the definition of what constitutes an impaired stream. All exceedances of the bacteria standards **are** treated equally. The TMDL must bring the stream into compliance with the law, no single sample greater than 235 cfu/mL *E. coli* and no geometric mean greater than 126 cfu/mL *E. coli.* The severity of the violations were considered when prioritizing and scheduling TMDL studies.

LMPI #7. The reply to this comment was explained in #2 above. Rainfall and flow information was considered for the timeframe the model was run. The flow of Straight Creek was not calibrated to current conditions, the modeling time periods chosen are documented in Table 4.5 (Section 4.5) and Table 10.1 (Section 10.4).

LMPI #8. The TMDL draft document notes that EPA has approved the VASCI for validation and calibration in Virginia. Therefore, reference to it is appropriate. The VASCI document cited (A Stream Condition Index for Virginia Non-Coastal Streams, 9/2003) notes the following: "The West Virginia index is calibrated for the Central Appalachians and may be more appropriate for VADEQ to use, primarily because the Central Appalachians are a very small part of Virginia but comprise a large portion of West Virginia". The WVASCI was applied to the raw benthic counts in Straight Creek and the results were comparable to the VASCI. In fact, at the March 2005 Association of Mid-Atlantic Aquatic Biologists Workshop in Berkeley Springs, WV a paper was presented by Versar, Inc. entitled "Integrated Assessment of Stream Conditions in Maryland, Virginia and West Virginia." The author noted that when the VA and WV indexes were used

together, the results were statistically correlated ($R^2 = 0.92$). Versar futher noted that the WV index consistently gave scores that were a little higher than the VASCI. According to VADEQ biologists this is because the WVASCI does not exclude the caddisfly family Hydropsychidae from the EPT taxa and %EPT metrics. Hydropsychidae are a moderately pollution tolerant family that thrives on organic matter and some members of the family are also tolerant to metals. The VASCI does not include this family in the metrics that pertain to pollution sensitive organisms.

The VASCI does not apply specifically to limestone springs; however, the use of the VASCI in areas with underlying limestone geology is acceptable. In other words, "limestone springs" does not equal "limestone geology". Otherwise, it would not be fit for the entire Shenandoah Valley where it is has been found to be highly accurate.

LMPI #9. The DEQ site was used for assessment purposes and is the reason the stream was placed on the TMDL list. Out of the four VADEQ benthic monitoring sites, only 6BSRA000.11 had better habitat scores than 6BSRA003.62. Therefore 6BSRA003.62 is an appropriate monitoring site for Straight Creek. Additional data provided ancillary information. More elaborate sampling designs were not deemed necessary. However, at the implementation phase, stakeholders may look at this as something they wish to collect.

LMPI #10. Numerous references have been added to Section 8.4.1 since the initial draft document was produced. An excerpt of the revised Stressor Identification Chapter is provided below.

> *"A study of TDS toxicity in a coal mining watershed in southeastern Ohio found the lowest observed effect concentration (LOEC) on the test organism Isonychia bicolor (a species of Mayfly) was 1,066 mg/L (Kennedy, 2002). The author carefully noted that this concentration was specific to the watershed studied, but noted that similar studies with the same test organism and TDS with varying ionic compositions were toxic between 1,018 and 1,783 mg/L (Kennedy, 2002). The study suggested that aquatic organisms should be able to tolerate TDS concentrations up to 1,000 mg/L; however, the test organism used was Chironomous tentans, which is considerably more pollution tolerant than Isonychia bicolor (Kennedy, 2002). Research also indicates that the likely mechanism(s) of TDS benthic macroinvertebrate mortality is from gill and internal tissue dehydration, salt accumulation and compromised osmoregulatory function. In fact, the rate of change in TDS concentrations may be more toxic to benthic macroinvertebrates than the TDS alone (Kennedy, 2002).*
>
> *A recent report on the effects of surface mining on headwater stream biotic integrity in Eastern Kentucky noted that one of the most significant stressors in these watersheds was elevated TDS (Pond, 2004). Elevated TDS concentrations impact pollution sensitive mayflies the most. Figure 8.50 from this report shows that "drastic reductions in mayflies occurred at sites with conductivities generally above 500 µmhos/cm" (approximately 375 mg/L TDS) (Pond, 2004).*

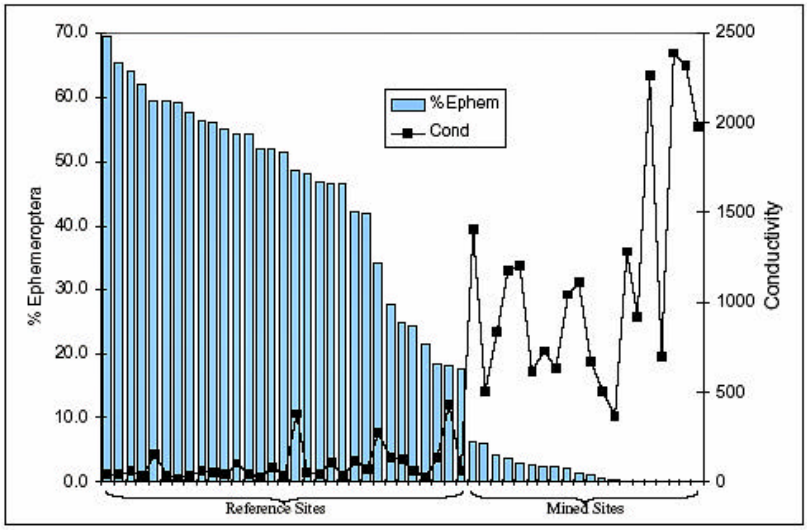


Figure 8.5 The relationship between %Ephemeroptera and conductivity from reference and mined sites (Pond, 2004).

Pond speculated that the increased salinity may irritate the gill structures on mayflies and inhibit the absorption of oxygen but research has not confirmed this. He also noted that not all mayflies are sensitive to increases in dissolved ions. For example, the genera Baetis, Isonychia *and* Caenis *commonly inhabit streams with elevated conductivity (Pond, 2004). The benthic monitoring results from VADEQ and ECI sampling showed that mayflies made up only 15% and 16% of the total benthic assemblage, respectively. A typical reference station in this part of the state can be expected to have at least nearly 50% mayflies out of the total assemblage. These surveys only produced family level data but it is significant that in the VADEQ and ECI data the families Baetidae, Isonychiidae and Caenidae comprised 83 and 87% of the total mayflies, respectively."*

The references in Section 8.4.1 all support the statement from the Merrick's thesis that high conductivity is associated with poor benthic health. It should be noted that Merrick had to pass a thesis dissertation that involved a review of his procedures, results, and thesis document before he was given a M.S. degree from Virginia Tech. The committee that reviewed his work consisted of Dr. Donald Cherry, Dr. Carl Zipper, Dr. Rebecca Currie, and Dr. Preston Durrill who are respected professors in their fields.

The fact that Virginia has not yet adopted a water quality standard for conductivity and/or TDS does not mean that these constituents do not contribute to benthic impairments.

LMPI #11. The TMDL draft document notes that organic matter level will be reduced as a result of implementing the fecal bacteria TMDL in the watershed because of the bacteria and organic matter attributed to straight pipes. While the amount of organic matter in the stream is higher than what can be expected in similar streams, organic matter does not contribute to the benthic impairment nearly as much as sediment and TDS. A long-term study by the Kentucky DEP on coal mining watersheds documented this fact (Pond, 2004).

LMPI #12. The TDS documentation is sound. While it is true that the precise relationship between TDS and conductivity varies with the constituent make-up of the TDS, it is consistent that as TDS increases conductivity increases. The references added to Section 8.4.1 (#10 above) show more than enough supporting evidence to cite TDS as a probable stressor in Straight Creek and Callahan Creek. Furthermore, the preliminary review of the stressor identification chapter by an EPA aquatic biologist familiar with coal mining watersheds, confirmed that the evidence presented was sufficient to cite TDS as a most probable stressor. (Email from Peter Gold, USEPA Region III to Charles Martin, January 10, 2005 3:01 pm)

LMPI #13. If a reference watershed were identical to that being studied, it would be identical in terms of impairment as well. A reference watershed does not need to be similar to the target watersheds, as in-stream conditions are the issue of concern for aquatic health. Similarity between reference and impaired watersheds, as is the case with these watersheds, helps to ensure the likelihood of successful remediation. Middle Creek is the best reference watershed available, given its non-impaired status and similarity to the impaired streams, including having been impacted by mine activity. DEQ and DMME are confident in the choice of this reference watershed.

LMPI #14. The goal of proportioning the reference watershed is to determine an appropriate sediment load endpoint for the TMDL (see response to comment #3), not to create an identical watershed. The GWLF model does not take land use location into account. However, GWLF treats the reference watershed and the impaired watershed the same in this respect. During implementation plan development, targeting of remediation can be considered based on proximity of sediment sources to the stream.

LMPI #15. The GWLF model was developed for use in ungauged watersheds, so technically calibration is not required. Hydrology calibration was preformed to ensure accurate stream flow. The term "back calculating" is not appropriate. A linear regression was used to determine the data values missing from USGS Station #03530500 using data from USGS Station #03531500. This is appropriate because the USGS Station #03531500 drainage area includes the Straight Creek and North Fork Powell River watersheds. The twelve years of data that was collected at USGS Station #03530500 is sufficient to determine a linear regression equation between it and the USGS Station #03531500 downstream. Use of a hydrograph developed from stream gage data is an acceptable method of modeling the system. The HSPF model provided a mechanism for putting the flow data in the appropriate format useful to the GWLF model.

LMPI #16. The most important procedure to follow when using GWLF is to stay consistent when assigning parameter values to the reference and the impaired watersheds. As long as the same procedure for determining the curve number (CN) values (as well as the other parameters) were used for Middle Creek and Straight Creek, the relative amounts of sediment leaving the watersheds is accurate. Determination of CN is not an absolute science. It is impacted by soil type, land cover, and modeling approach. Ranges of values have been determined for specific land uses in specific soil hydrologic groups. Within this framework, a modeler chooses CN for a given land use based on similarity to reported land uses, and knowledge of the specific area being modeled. Additionally, CN can be calibrated. One example of modeling approach affecting CN is the choice of CN for water. A CN of 100 indicates that all water being modeled

is coterminous with the stream network and all rainfall on this area will leave the system through the stream network, however, in these watersheds, the vast majority of water identified in the land use data is related to ponds constructed to control runoff from mined lands. There are various approaches to dealing with this situation. A lower CN can be used indicating that some portion of the rainfall hitting these ponds will be captured. Or, a CN of 100 can be used and adjustments can be made to other parameters in the model to account for pond storage capacity.

Lastly, ground-truthing CN values is not a typical practice with the use of GWLF and is not necessary. Ground truthing would require extensive field studies similar to those used to develop representative CN values in the first place. Because of the somewhat subjective nature of CN selection, additional modeling was performed. These changes resulting from this are are incorporated into the Allocation Chapter in the revised documents. In reviewing the modeling, additional changes were made in the KLSPC factor in order to provide consistency between the reference and impaired watersheds.

These changes are incorporated into the final model and revised "GWLF Landuse Parameters for Existing Conditions in the Impaired and Referenced Watersheds" tables. Additionally, land use categories were revised in **Chapter 10** "Modeling Procedure: Linking the Sources to the Endpoint". The revised Tables based on the CN, elevation, and land use updates are named "GWLF parameters for existing conditions in the impaired and reference watersheds", "GWLF parameters by land use for existing conditions in the impaired and reference watersheds", "Land use areas for the impaired, reference and area-adjusted reference watersheds" and "Existing sediment loads for the impaired and reference watersheds." These revisions also occur in the draft document Chapter 11 in tables "Comparison of categorized sediment loads for the impaired and area-adjusted reference watersheds", "TMDL targets for the impaired watershed", "Required sediment loads from the impaired watershed", "Final TMDL allocation scenario for the impaired watershed."

The sensitivity analysis originally included in the document was "borrowed" from an earlier TMDL, where urban-influenced channel erosion was the dominant factor. A new sensitivity analysis has been developed and is in the Modeling Procedures Chapter in the revised documents.

LMPI Summary comments. Successful implementation of corrective actions to improve water quality is dependent on stakeholder involvement. DEQ and DMME welcome your offer to provide assistance in the implementation planning stage.
Thank you for your thoughtful comments. The TMDL draft document is being revised to clarify some issues and to capture information provided by the commenters. These revisions will be available for public comment between July 11 and August 11, 2005.

Responses to Penn Stuart / Cumberland Resources Corporation's (CRC) Comments to Callahan Creek TMDL:

CRC I Paragraph 1. The TMDL study and draft report process is mandated by State and Federal law. While it may have regulatory implications, it is not adoption of a water quality standard but a total maximum daily load, which includes a waste load allocation. The development of total maximum daily loadings includes a waste load allocation for permitted discharges in the watershed; however this is not a standard. Confusion on this point may have arisen based on a statement in the Executive Summary of the TMDL report. Reference to a standard being developed in the Executive Summary has been removed from the revised documents.

CRC I Paragraph 2. The TMDL process is watershed specific and does not develop standards but develops loads for those pollutants that the TMDL study identifies as causing violations of designated uses for state waters.

CRC I a. That pollutants identified in a TMDL study need to be identified by EPA in the Clean Water Act is an incorrect assumption. There may not be limits developed and promulgated by EPA for these pollutants but it is not because they are not possible pollutants within these areas.

CRC I b. The Draft TMDL Report submitted by the SWCB to the EPA pursuant to 33 USC § 1313.D is not a proposed water quality standard. The Draft TMDL Report instead proposes a load at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety. Because the Draft TMDL Report is not a proposed standard, the requirements of Va. Code § 62.1-44.15(3a) are inapplicable.

CRC I c. As stated above, because the Draft TMDL Report is not a proposed standard, the requirements of Va. Code § 62.1-44.15(3a) are inapplicable.

CRC I d. The Draft TMDL Report submitted by the SWCB to the EPA pursuant to 33 USC § 1313.D is not the implementation plan to achieve fully supporting status for impaired waters contemplated in Va. Code § 62.1-44.19:7. The implementation plan includes the date of expected achievement of water quality objectives, measurable goals, the corrective actions necessary and the associated costs, benefits and environmental impact of addressing impairment and the expeditious development and implementation of TMDLs. While the Draft TMDL Report is a necessary portion of the implementation plan, its limited purpose is to propose a load at a level necessary to achieve the applicable water quality standards with seasonal variations and a margin of safety. Because the Draft TMDL Report is not the plan contemplated in Va. Code § 62.1-44.19:7, the requirements of that statute are inapplicable.

CRC I e. Once the report has been approved by EPA, then promulgation as part of the Water Quality Management Plan regulation will be dealt with in a different venue. The Draft TMDL Report submitted by the SWCB to the EPA pursuant to 33 USC § 1313.D is not the implementation plan to achieve fully supporting status for impaired waters contemplated in Va. Code § 62.1-44.19:7. The implementation plan includes the date of expected achievement of

water quality objectives, measurable goals, the corrective actions necessary and the associated costs, benefits and environmental impact of addressing impairment and the expeditious development and implementation of TMDLs. While the Draft TMDL Report is a necessary portion of the implementation plan, its limited purpose is to propose a load at a level necessary to achieve the applicable water quality standards with seasonal variations and a margin of safety. Because the Draft TMDL Report is not the plan contemplated in Va. Code § 62.1-44.19:7, the requirements of that statute are inapplicable.

CRC I f. The TMDL is not a water quality standard.

CRC I g. A TMDL study looks at all of a watershed and determines the sources of pollutants that impact the water quality. Once the study is underway, it is not appropriate to focus on discrete segments and it is acceptable procedure to look upstream in the watershed to limit the pollutants. Models used in TMDL studies account for the fate and transport of pollutants and so discrete segments are not appropriate but rather mouths of subwatersheds are used to determine the loadings for the watershed. The Draft TMDL Report is limited in purpose to propose a load at a level necessary to implement the applicable water quality standards with seasonal variations and a margin of safety.

CRC I h. Assessment of sources and allocations to loads and waste loads is the purpose of the water quality models and the survey of all point sources and non point sources in the watershed.

CRC II a. Background conditions and low flow events were modeled to determine the TMDLs. Seasonal variations were considered by modeling multiple years for both Callahan Creek and Straight Creek. There are no standards set in TMDL studies just loadings and load reductions for pollutants that impact designated uses for the watershed. The evaluation of causes of impairment was made according to EPA guidance and in accord with other studies. EPA has approved the methodology used by Virginia in other similar studies. DEQ and DMME have worked together in development of the resource extraction TMDLs so that remediation methodologies and reasonable assurance of achieving improved water quality could be reviewed and addressed as the TMDL study occurred. With knowledgeable input from the NPDES program staff, these issues were reviewed and addressed throughout the study. After the TMDL is accepted and in place an Implementation Plan may be developed where the BMPs or remediation methodologies can be addressed.

CRC II b. The data was sufficient to reach the conclusions for the TMDL study. Additional data is necessary to determine the best course or the priorities for reducing loads of these pollutants. That data should be acquired during the TMDL Implementation Plan development since determination of the most cost effective corrective actions is the most effective way to achieve improved water quality.

CRC II c. Monitoring during and after corrective actions have been put in place, allows feed back and provides the basis to re-examine model assumptions. The TMDL report recommends using existing Best Management practice activities in a proactive manner to improve water quality in terms of the TDS and TSS parameters. The models are accepted by EPA and assumptions within the models allow a margin of safety in applying the load reductions. The

ultimate endpoint for the aquatic life use is having healthy benthic communities and not the stressor reduction requirements.

CRC III a. Based on comments from the public, the stressor analysis is more extensive in the final draft document. However, DEQ and DMME have confidence in the document as presented.

DEQ and DMME repeatedly asked the stakeholders for data to use for the TMDL study. Based on the comment that data sets were not incorporated in the study, your specific data sets were requested. Since CRC failed to produce the data sets in a timely manner, DMME staff reviewed permit application information from CRC and transmitted this data set to MapTech in late May. The contractor considered all available data. For quantitative analyses data was screened so it met criteria designed to insure that bias due to site location or sampling frequency were not incorporated into the model or into the stressor analysis. Review of the additional data is discussed in the final document, however, this review did not alter the identification of stressors. Discussion of this data is provided in the revised Water Quality Assessment Chapter for Callahan Creek.

CRC III b. The endpoint measurement for improving water quality in Callahan Creek is having a healthy benthic community. The waste load allocation based on a concentration of 334 mg/L is only recommended for future underground discharge sources in the watershed. The discharges from future permitted activities need to be consistent with watershed waste load allocations and TMDL reports. It is not a standard and permitting evaluation/issuance would be based on the watershed reductions in place at the time the permit application was reviewed. The correction of straight pipes is required to meet the bacteria, TDS and sediment TMDLs. It is assumed that this will be a priority when the Implementation Plan is written and followed. It is noted, however, that straight pipes are not a significant source of TDS or sediment, but have been included in the allocation of these TMDLs because the correction of straight pipes in necessary to meet the bacteria TMDL.

Again, the focus of the Powell River Basin Draft TMDL document is to establish final allocation scenarios that will allow the streams to repair themselves and meet existing water quality standards. The focus is not to determine what must be done to implement these scenarios. Chapter 12 is presented to demonstrate ideas and procedures that may be utilized during implementation.

Furthermore, the comparison between a drinking water standard and a surface water quality permit discharge limit for Callahan Creek to improve the benthic community living in the stream is inappropriate. For example, humans can drink water with 0 mg/L of dissolved oxygen (DO) in it but benthic macroinvertabrates cannot live in a stream with 0 mg/L DO. The TDS drinking water standard has no relevance to the biological response of benthic macroinvertabrates. The purposes of drinking water standards and general quality standards are different.

CRC III c. Habitat is an important consideration for healthy benthic communities however paired with pollutant stressors, the benthic communities are far less likely to improve. Habitat degradation as it relates to sediment was considered and that is why sediment is a probable

stressor. Benthic monitoring in the mountainous regions of Virginia following catastrophic flooding (where there was extensive scouring and channel relocation) shows that macroinvetebrate communities can return to a not impaired status generally within several years. Therefore, the comments about habitat destruction in the late 19th century and even a decade ago are irrelevant. The purpose of the TMDL is to return Callahan Creek to its fullest potential, without impacts from anthropogenic sources. It is understood that poor habitat can lead to a lack of richness and poor community structure, however; pollutants are present at excessive concentrations in the watershed and they must be lowered to acceptable levels. Reducing loadings of sediment, and TDS in the watershed should also be included.

The waters in Callahan Creek are only expected to return to a state where the benthic community is healthy (as observed by 2 consecutive non-impaired benthic surveys) and the bacteria water quality standard is met. It is understood that coal mining has been and still is a present land use in the Callahan Creek watershed. This is why mining ponds were modeled. This is one reason why Middle Creek was chosen as the reference watershed. This is why abandoned mine lands (AML) were included as a land use. This is also why reclamation of AML is a stipulation of the final TMDL allocation.

CRC III d. No, TDS is a probable stressor in Callahan Creek. The toxicity test was a screening tool and not the only study element in the stressor analysis tool box. Conductivity and TDS are correlated, however; this comment blends them into the same measurement, making it difficult to respond to these comments, as they are in error. The toxicity test referred to consisted only of introducing healthy organisms to water from the stream. The effect of TDS on benthic communities depends on the fluctuations of TDS levels as well as high concentrations.

Additional references will be added to the Draft TMDL documents in the revised TMDL Endpoint; Stressor Identification Chapters, see LPMI#10] It should be noted that Merrick had to pass a thesis dissertation that involved a review of his procedures, results, and thesis document before he was given a M.S. degree from Virginia Tech. The committee that reviewed his work consisted of Dr. Donald Cherry, Dr. Carl Zipper, Dr. Rebecca Currie, and Dr. Preston Durrill who are respected professors in their fields. Since the initial draft numerous other sources have been added that support the conclusions reached in the report.

The commenters are correct that TDS levels of 419 mg/L may not have a stressing effect on fathead minnows and Ceriodaphnia. This is because these two organisms have been shown to be considerably more tolerant to TDS than sensitive benthic macroinvertebrates, particularly mayflies. This is why Kennedy (2002) used the test organism *Isonychia bicolor* (a facultative mayfly) in his study of a coal mining stream in Ohio. In the same paper Kennedy referenced a study noting that benthic macroinvertrates should be able to tolerate TDS concentrations up to 1,000 mg/L. However, he noted that the test organism in that study was a member of the chironomid family and was much more pollution tolerant than the sensitive organisms most affected by high TDS concentrations. The Kentucky DEP (Pond, 2004) released the results of a comprehensive four-year study on the effects of surface mining and residential development on headwaters streams in Eastern Kentucky. The results clearly indicated that significant shifts in benthic macroinvertebrate communities began at conductivity levels of 500 µmhos/cm (approximately 375 mg/L TDS). In support of their findings the Kentucky DEP cited research in

West Virginia where non-impaired benthic communities were found below hollow fills from surface coal mining but in every case the conductivity was less than 200 µmhos/cm.

CRC IV a. The land use areas in the Powell River Basin Draft TMDL document are correct. Thirty-one percent of the area of Callahan Creek is correctly designated as being permitted for mining. The initial comparison table was developed using land use data based on aerial photography and not permit information, and reflected the amount of active mining at the time that the photo was taken. The differences in the agricultural land are not significant. The reference watershed approach is not for the purpose of establishing standards. Middle Creek was used as the reference watershed to set the TMDL water-quality endpoints for TDS and sediment. Efforts are made in selection of a reference watershed to locate a comparable watershed, one with the potential for delivery of the stressors of interest, so that the TMDL endpoints are adequate to ensure a healthy aquatic community upon remediation. Middle Creek is a watershed that has had the same potential stressors, and represents measured endpoint conditions that are adequate to ensure a healthy aquatic community. The information provided in these comments seem to support this position.

CRC IV b. These issues are more appropriate for the Implementation Plan development. Once a pollutant is identified as a stressor, the land users need to focus on how to reduce its loading to the stream. However, in a Technical Issue paper published by the Society of Environmental Toxicology and Chemistry (SETAC, 2004) the relative acute freshwater toxicity of common ions to Ceriodaphnia were (from most toxic to least) Potassium (K^+) > bicarbonate (HCO_3^-) > magnesium (Mg^{2+}) > chloride (Cl^-) > sulfate ($SO4^-$) > bromide (Br^-). This confirms that the ions present in Callahan Creek are some of the most toxic to aquatic life. Additionally, it is scientifically incorrect to refer the TDS concentrations in the ground water in the Callahan Creek watershed as "natural". They are the direct result of anthropogenic activities primarily related to mining. Exposing large areas of underlying rock strata to erosion and resulting increase in dissolved ions in the ground water is not natural.

CRC IV c. Although Langmuir findings are interesting, a TMDL is by definition a watershed-specific study. Averages or ranges over the entire continent are not relevant to the TMDL document. DMME requires subsurface monitoring of hollow fills. There is no pre-mining groundwater data, which would show natural conditions. So, the data reported for Callahan Creek do not reflect a natural condition. Additionally, this discussion focuses on groundwater rather than surface water. The TMDL was developed for surface water. According to VADEQ biologists the highest (natural) conductivity values they have seen are from a small watershed with a geology of what is known as "marl" limestone. In this case maximum conductivities of 600 & 700 are possible. Conductivities in Callahan Creek far exceed these levels. Background conditions were considered using in stream measurements of this parameter and calibrating the model to these background concentrations.

CRC IV d. Background levels were considered.

There is no data presented that concludes human discharges are the predominate source of TDS to Callahan Creek. We do not agree with this statement.

The consideration of background loads for a TMDL is intended to ensure that all loads are accounted for. In calibrating the model, the background loads are accounted for. In the case of General Standard TMDLs, if it were possible to go back in time and measure true background loads in the stream before human disturbance, these values would be useful in establishing a TMDL endpoint. Since that is not possible, a reference watershed approach is used. Once a TMDL endpoint is established that will ensure the health of the aquatic community, staged implementation is intended to allow stakeholders to achieve water quality goals without implementing control measures that exceed the needs of the aquatic community.

CRC IV e. Runoff from any specific site does **not** necessarily have to be 334 mg/L. This is the TDS **in-stream** endpoint at which we can be sure the benthic community will return and thrive. It is **not** the purpose of this TMDL report (or any other) to stop mining in the watershed. Its purpose is to identify the stressor(s) on the aquatic life, identify the sources of this stressor, and determine at what level the aquatic life will be healthy. It is not within the scope of the TMDL to set water quality standards, specify BMPs, or establish standards for reclamation.

Chapter 12 of the Powell River Basin Draft TMDL document is present to demonstrate possible BMPs to discuss during the Implementation Plan development. This is not a list of the BMPs that will be implemented, merely a list of possibilities. These best management practices are site specific and it is expected that each stakeholder can weigh the pros and cons of various methods during the implementation plan development. Ultimately, reducing soil erosion and the interface between water and disturbed soils will be an effective remedy to the stressors on the benthic communities in Callahan Creek. Documentation of the benefits of remining to improve benthic community assemblages and water quality is included in the TMDL report. Remining is viewed as a corrective action or a mitigation tool for improving water quality. Clarification of implementation activities is provided in the revised Implementation Chapters.

CRC IV f. Water treatment using chemical additives or reverse osmosis is not the intention of the TMDL draft document. Choosing corrective actions that are far less expensive and more familiar to the stakeholder community are the recommendations for the first phase in reducing sediment and TDS in the system. Only after these tools are exhausted and water quality goals are not met, would other relief measures be considered. Watersheds are not fixed systems. They are dynamic systems with changing land uses and resulting stream characteristic changes. The path that is recommended in the TMDL report cannot predict all of these future changes. It is our hope that knowledge of what impacts increased sediment, TDS and Bacteria loadings to the system will result in better choices with lower loadings being achieved. In the event that all practical approaches are exhausted, a Use Attainability Analysis (UAA) can be performed to change the designated use of the creek, but only after all practical approaches are exhausted. See Implementation Chapter discussion on removing a designated use.

CRC IV g. No reductions were recommended for TSS permitted dischargers. Sediment from permitted mining areas were modeled as discharging 70 mg/L, the current permit maximum. The sediment TMDL does not have any reductions to sediment from mining operations as long as the concentration is not above 70 mg/L. The TMDL was actually developed for a sediment load to the stream rather than a TSS concentration. The load calculated for permitted discharges

was based on the modeled runoff flow volumes and the 70 mg/L permitted maximum concentration. The expectation is that the over all annual load will not be exceeded. McClure River data was a measure of in stream concentrations. It did not account for point source discharge limits. This is a fundamental point that seems to be misunderstood in many of the comments expressed in this document. The argument does not apply.

CRC IV h. The purpose of a TMDL is to set a course for bringing the stream into compliance with the law. The TMDL gives a final allocation scenario that, if met, will allow the stream to meet the designated use(s) in question. After a TMDL is accepted and in place an implementation plan must be developed where the BMPs or remediation methodologies can be addressed. Implementation plans are developed by stakeholders within the watershed. Phased approaches to reductions are directed by the participants. Those participants can choose to acquire better or more specific data upon which to make decisions as to how the reductions should be reached. But these comments are not relevant to the TMDL draft document. Reclamation and subsequent improvement in the benthic community in Middle Creek supports the contention that coal mining in watersheds is not the end of any viable aquatic communities.

CRC IV i. Although pH may have increased at the same time that TDS declined in Middle Creek, this does not discount that reductions in TDS also affect the biota. Data in the referenced MapTech draft was not collected and analyzed by MapTech. This data is from sampling efforts by the Companies operating in Middle Creek and from DMME sampling projects.

A comparison of data from the nearest DMME permitted measuring point on Middle Creek (4120018 from 4/96 to 9/99) with recent data collected (9/04 to 1/05) reveals a clear downward trend in TDS concentrations. The recent data was collected at two different sites both downstream of 4120018. The median TDS concentration for 4120018 is 319 mg/L and when data from both recent sites is evaluated the median TDS concentration is 234 mg/L. A median analysis in SPSS indicates that the difference is statistically significant ($Z = -2.307$). When the new station nearest to 4120018 was analyzed by itself (median TDS of 243 mg/L versus 319 mg/L) there was still a downward trend but it was not statistically significant ($Z = -1.535$). The standard deviation of the recent data is 39 mg/L and the maximum value recorded is 438 mg/L compared to a standard deviation of 218 mg/L and maximum concentration of 1,240 mg/L at 4120018. Therefore, TDS as a former stressor in Middle Creek cannot be dismissed.

With respect to pH, the trend toward higher pH values began long before 2002 as the Figure I-1 for MPID station 4120018 clearly depicts. The trend line was statistically significant $R^2 =$ 68.5%.

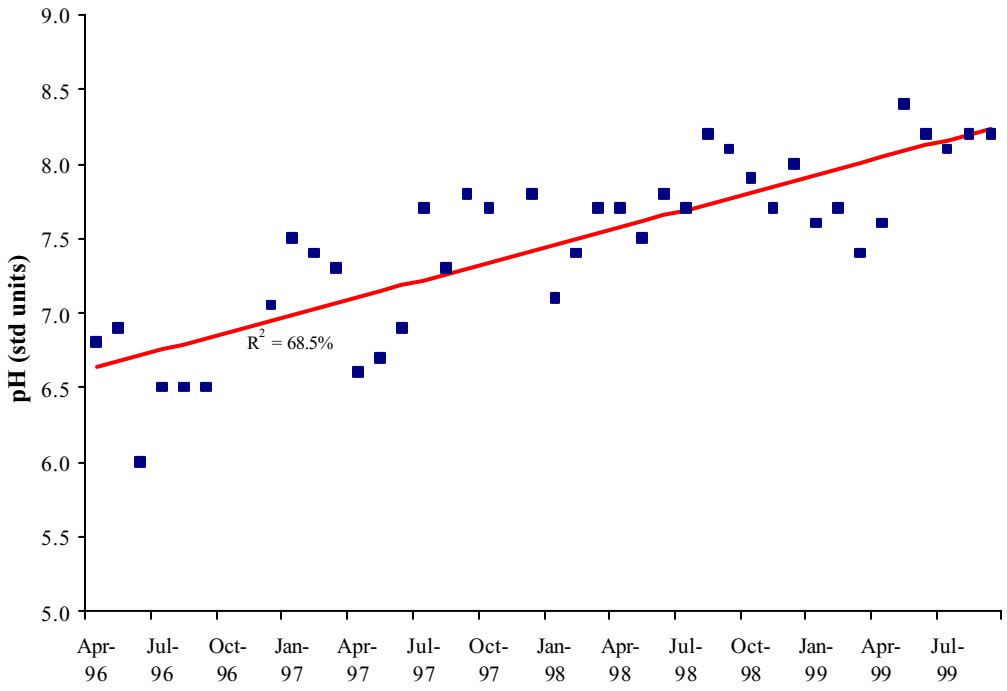


Figure I-1 Field pH values at MPID 4120018.

The lack of standards for TDS is not a viable argument as to its not being a stressor to the benthic community.

CRC V a. The report is being revised for clarity on the issue of point source limitations. The following sentence, in section 11.2.2:

> *Based on the need to meet the endpoint during low stream flow conditions, the direct discharges to Callahan Creek need to be at or below this endpoint (334 mg/L).*

will be replaced with:

> *Based on the need to meet the endpoint during low stream flow conditions, the direct discharges (i.e., discharges that do not require a storm event to cause flow) to Callahan Creek need to be at or below this endpoint (334 mg/L).*

Treating sedimentation ponds as nonpoint sources is a method associated with modeling the sources. It should not be confused with the VPDES program requirements. Since the ponds discharge in response to rainfall events, this input to the stream is best handled as nonpoint input for use in the model.

For clarity, a point source (or direct discharge) is a flow and pollutant source that dumps directly into a stream at a known location and requires no precipitation to cause flow. Deep mine discharges are point sources.

A permitted source is not always a point source. Because all mine operations have permits, they are lumped into the WLA in Tables 11.1 and 11.3. The mine ponds have permits, but they collect runoff water from the active mine surface area. Therefore, these ponds are modeled as non-point sources. The comment "These discharges [ponds] are permitted through the VPDES program, which by definition makes them point sources" is incorrect. This by definition makes them part of the WLA in the final TMDL.

It is hoped that this discussion clarifies that the direct discharge referred to in the quote above is for deep mine discharges and VAG400340 (a residential discharge).

The argument that the 334 mg/L TDS and higher is associated with natural in stream concentrations is erroneous. It is scientifically incorrect to refer the TDS concentrations in the ground water in the Callahan Creek watershed as "natural". They are the direct result of anthropogenic activities primarily related to mining. Exposing large areas of underlying rock strata to erosion and resulting increase in dissolved ions in the ground water is not natural.

CRC V b. EPA, as one of the funding agencies, stipulated that the multiple linear regression method would not be used for the Callahan Creek TMDL study. Comparing the two methods and the conclusions drawn from this exercise cannot change the results of the Callahan Creek draft study. However, every effort was made to accommodate data and time extension requests from the stakeholders.

The revised report in the TMDL Endpoint: Stressor Identification Chapters clarify that the McClure River was not used as a reference watershed. There are many water constituents (possible benthic stressors) that have no Virginia State Standard, including TDS. It was decided that in the absence of a State Standard, 90th percentiles for constituents monitored in a unimpaired stream segment would be used to provide a conservative indication of a probable stressor and make it more obvious to the reader when values for a particular constituent were excessively high. For these watersheds, we would have arrived at the same conclusions without using the 90th percentile values, because the values of TDS and conductivity were excessively high in comparison to literature values.

DEQ benthic data shows that the McClure River is not impaired. The McClure River was used to help establish the most probable stressor. However, the McClure was not used as the reference watershed to model endpoint scenarios. McClure was a stream with coal mining impacts that has shown non-impaired benthic communities. Using 90th percentile values for screening purposes from this mined watershed was acceptable. The text made it clear that parameters exceeding the 10% threshold were not automatically assumed to be possible or probable stressors: "*Depending on the habitat and benthic metrics, additional chemical evidence and references documenting potential problems for aquatic life, a parameter with excessive values may be considered a possible or probable stressor".* Completion of the stressor analysis clearly indicated that TDS and sediment were the most probable stressors.

EPA reviewed the stressor analysis procedures used for this TMDL study and concurred with the findings and the method used. It is unfortunate that the writer finds this confusing and indefensible because embracing the findings of this document would increase the success of implementing corrective actions.

CRC V c. These comments have been addressed elsewhere in the responses to this document, see CRC IV f. There are mechanisms built into this TMDL process to address economic costs such as a UAA if the actions taken in the watershed do not result in improved benthic communities. The DEQ and DMME staff is sensitive to these concerns and issues and implementation of best management practices familiar to the industry stakeholders has been clarified in the Implementation Chapter of the revised documents, with the hope that the aquatic life use can be restored.

Responses to PennStuart/ Cumberland Resources Corporation's Attached Peter F. DeLisle – Coastal Bioanalysts, Inc. (CBI) Comments to Callahan Creek TMDL:

CBI Paragraph 1. There seems to be a fundamental misunderstanding of the TDS wasteload allocation. There is a valid scientific basis behind the endpoint concentration and it has been applied using an EPA approved method and model.

CBI 1 Paragraph 1. A TMDL loading is based on a demonstratable value where benthic impairment does not occur and this is so in Middle Creek.

CBI 1 Paragraph 2. Not only is data correlation considered but the weight of evidence for high TDS values in Middle Creek was also considered in developing the TMDL. EPA as well as DEQ and DMME staff all support the conclusions documented in the TMDL report.

CBI 1 Paragraph 3. This is an intriguing comment that sediment pore water ammonia is the stressor but, the macroinvertebrates present in the stream, for the most part, are not in the pore spaces and will not be affected by possible toxic levels in the interstitial spaces. Furthermore, recommendations to reduce bacteria loadings to the stream by correcting straight pipe discharges at the same time that TDS and TSS reductions occur address possible interactions between stressors.

CBI 2. These comments do not disprove that there is a relationship between TDS and composition of aquatic communities. The TMDL report is not disregarding the magnitude, frequency or duration of TDS and benthic exposure.

CBI 3. A diverse set of sources were considered in the analysis of TDS as a stressor in Callahan Creek. Additional references have been added regarding TDS impacts. The documents, referred to by the commenter suggest that levels as low as 390 mg/L TDS will be toxic to some aquatic organisms. However, if in achieving TDS reductions, the benthic macroinvertebrate community reacts favorably to less stringent reductions, then the TDS number is inconsequential. It is the aquatic life use that the stressor endpoints seek to protect. It is the recovery of the macroinvertebrate community that is the goal of the TMDL process. Reaching a certain TDS level is not the TMDL goal. Once the stream no longer has benthic impairment, it will be

delisted. The discussion offered in this document does not prove that 1000 mg/L is protective of the diverse community of organisms expected to inhabit Callahan Creek. The toxicity screening that was performed at the EPA laboratory indicated that the creek water was not toxic, and yet, the aquatic community is moderately impaired. This may reflect the inadequacy of the toxicity studies in predicting aquatic community health. Hence, toxicity is only one part of the "weight of evidence" argument for the benthic stressors.

Responses to Straight Creek TMDL Group and Biological Monitoring Inc. (BMI)Comments:

BMI 1.1 The RBP assessments were used to assess impairment, not to identify stressors. Temporal trends in benthic data collected twice yearly is not key to identifying stressors or TMDL endpoints. Ecoregions were not ignored in the analysis. The stream was moderately impaired each time it was sampled. Multi-Metric Indexes (MMIs) developed for VA and WVA were applied to the data and the impairments were confirmed. Additionally, samples supplied by the commenters verified the impairment status of the stream.

BMI 1.2.1 RBP II benthic macroinvertebrate assessment has proven to be a scientifically valid tool for determining levels of impairment in streams (Plafkin et al. 1989, Wright et al. 1995, Hewlett 2000). Although genus/species level taxonomy may provide more information on ecological/environmental relationships and sensitivity to impairment, family level identification provides a higher degree of precision among samples (Barbour et al. 1999). The RBP II was not designed to predict cause/effect relationships, however, degradation to benthic macroinvertebrate communities due to increased conductivity and sedimentation from surface mine drainage is well documented in the technical literature at the family, genus and species level of identification in ecoregion 69 (Pond 2004, Green et al. 2000, Hartman et al. 2004).

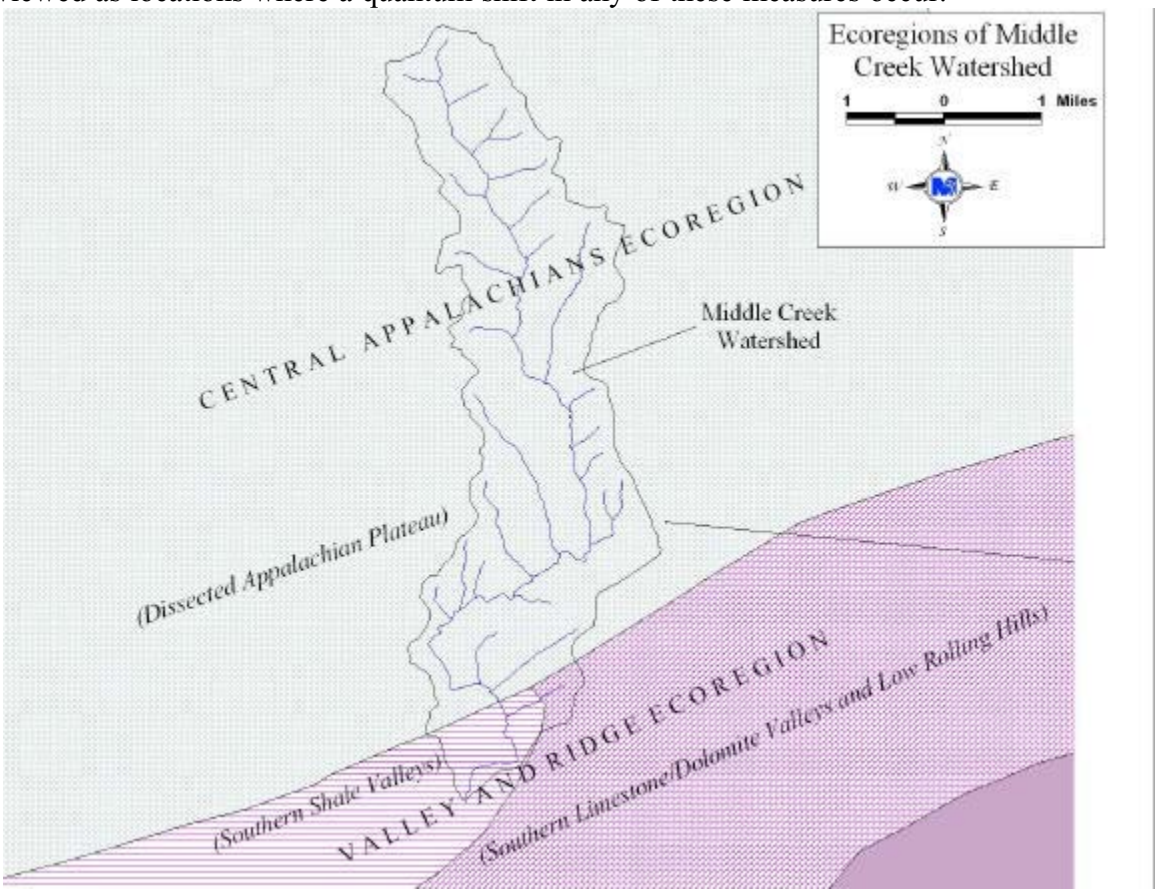
The lack of this level of benthic survey data does not exclude determination of a stressor. During subsequent implementation plan development, stakeholders could pursue precise source determination if this is an important issue to the stakeholders. While more information is always better, as noted by the commenter, RBPII is "adequate when conducting cursory or initial investigations." No analysis of the benthic community alone would be adequate to determine stressors. The determination of stressors in this case was based on reviewing benthic data, water chemistry data, and habitat data, with full recognition of the limitations of the RBPII data.

BMI 1.2.2 The fact that some samples were taken "during resting stages while species are in early instars, smaller, and more difficult to identify" is negligible. Identification to the family level by professional biologists with stereo microscopes is not very difficult regardless of the size of the organism.

During the development of the West Virginia Stream Condition Index (WVSCI), Tetra Tech determined that no clear differentiation in benthic macroinvertebrate communities for the sampling periods (May-September) were discernable, however, the authors did suggests a sampling window of late spring to early summer be used for bioassessment to reduce variability (Tetra Tech 2000). WVDNR suggest that benthic sampling be conducted February 15 – April 15 and October 15-December 15. Therefore, there is no scientific agreement that there is an inappropriate sampling period for this ecoregion.
The importance of time between sampling of paired streams depends on the season. Benthic communities are more stable as water temperatures cool in the fall. This is the time period which BMI referred to as the "resting stages". It is highly unlikely that benthic communities would significantly differ between reference sites and Straight Creek based solely on temporal differences in the fall. Temporal variability may play a more significant role in the spring when

different species of insects start to emerge as adults. However, the two paired sampling events that occurred in the spring that were greater than one month apart showed the same results (impaired) for Straight Creek as did the West Virginia Stream Condition Index (WVSCI) which is based on a reference condition and not paired reference sites. (see next section). Therefore, temporal variation did not have an effect on DEQ's bioassessment ratings during the spring. All of the benthic data indicated impairment.

BMI 1.2.3 The USGS defines ecoregion as "An area of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables." While boundaries have been drawn to help differentiate between ecoregions, the boundaries themselves cannot be viewed as locations where a quantum shift in any of these measures occur.



The figure above indicates Middle Creek's location with respect to the Level III & IV ecoregions. While the sample station at the outlet of Middle Creek may be located in the Valley and Ridge ecoregion (Level III) or more specifically the Southern Shale Valleys (Level IV) ecoregion, 92% of the watershed falls into the same level IV ecoregion as Straight and Callahan Creeks.

In the next section of the comments, BMI refers to a multimetric index used by West Virginia (WVSCI) as an appropriate assessment tool for the Central Appalachians and thus Straight Creek. However, the WVSCI was developed using reference stations from three ecoregions which includes ecoregion 67 (Ridge and Valley) in which the VA reference stations in question are located. Tetra-Tech (2000) determined through statistical analyses that "use of ecoregions to serve as bioregions for benthic assessments of cobble habitats in streams of West Virginia is not

necessary". Since ecoregions "ignore arbitrary political boundaries", Virginia's reference stations located in the Ridge and Valley ecoregion are appropriate and scientifically valid.

BMI 1.3 Figure 2. The "trend line" in figure 2 is deceptive. Although the line is slightly increasing toward better scores over time, an R^2 value of 0.15 indicates that 85% of the variability in the dataset cannot be explained by the line. Without a supporting statistical analysis, it is hard to argue that there is a significant trend displayed here. Even if there is an increasing trend, at this time the majority of the scores using either index confirm impairment.

BMI 2.1 While it is unfortunate that the reviewers do not approve of the presentation of supporting data for the stressor ID, the data do support the conclusions and the linkages set forth in the document are clear. There has been ample opportunity for the reviewers to comment on the candidate causes and suggest alternative causes. No other defendable cause has been identified to date. If any of the conceptual links were not clear to the reviewers, there has been opportunity for these questions to be raised. The only candidate cause in question that the contractor was made aware of was TDS. Additional evidence supporting TDS as a cause of benthic stress has been added to the document.

With regard to the suggestion that the impaired creek was treated as spatially and temporally homogeneous, data locations throughout the main stem of Straight Creek were considered. Data exceeding the 90th percentile value of 525 (mg/L) for TDS were present in the dataset before and after the creek's initial listing. While much of the physiochemical data was collected at 6ASRA001.11, there is impairment upstream and downstream of 6ASRA001.11. The purpose of the TMDL is to determine the load of the pollutant in question that will support aquatic life.

BMI 2.2 Again, it is unfortunate that the reviewers do not approve of the presentation of supporting data for the stressor ID, however, the data do support the conclusions and the linkages set forth in the document are clear. There was no attempt to select a most probable stressor *a priori*. Had there not been supporting evidence for any of the candidates, additional data would have been sought. However, the weight of evidence was strong for the candidates selected. The available data set was collected because these parameters are considered measurements of water quality. The basis for measuring these parameters may be found in the NPDES and coal surface mining regulatory programs, which span nearly 30 years of research and investigation.

With regard to the use of McClure River data, there are many water constituents (possible benthic stressors) that have no Virginia State Standard, including TDS. It was decided that in the absence of a State Standard, 90th percentiles for constituents monitored in a unimpaired stream segment would be used to provide a conservative indication of a probable stressor and make it more obvious to the reader when values for a particular constituent were excessively high. For these watersheds, we would have arrived at the same conclusions without using the 90th percentile values, because the values of TDS and conductivity were excessively high in comparison to literature values. DEQ benthic data shows that the McClure River is not impaired. The McClure River was used to help establish the most probable stressor. However, the McClure was not used as the reference watershed to model endpoint scenarios.

With regard to performing quantitative analysis only on larger datasets (*i.e.*, sample size > 9), small datasets were reviewed for extreme values, however, the cutoff was made in order to avoid biasing the analysis based on limited datasets. To suggest that the study was invalid because two stations were considered where only 9 data points were available is unreasonable. Ample data exists and was reported to support the conclusions drawn.

"Consistently high measures" means that high values occurred throughout the stream not just any one specific part of it.

The data were sufficient to capture hydrologic influences. If adequate data were available to more thoroughly characterize the stream conditions (though this step is not necessary for the TMDL) the situation would look much worse, since monthly data is considered to be reconnaissance data.

The McClure River 90th percentile values were not meant to establish high values for TDS, these percentiles were simply used so that the reader could reference Straight Creek and Callahan Creek values to values from an unimpaired stream. According to the Kentucky DEP (Pond 2004) a conductivity of 500 umhos/cm (approximately 375 mg/L TDS) is high. The TMDL endpoint for this TMDL was established at 334 mg/L TDS. In the end, a high value of TDS will be that which does not allow the aquatic community to thrive.

Although the entire watershed contributes to Straight Creek, the benthic community in Straight Creek reacts to pollutants in the main stem of the stream not the entire watershed. When data collected at various points in the stream over the coarse of nine years support the conclusion the TDS values are high enough to cause benthic impairment, it is reasonable to conclude that a "most probable stressor" has been found. As for temporal variability, high values of TDS have been observed throughout the monitored period and Straight Creek remains impaired today.

The logic of the argument that benthic health should be improved if the suspected stressor happens to be low at the time of sampling is faulty. The benthic community represents water quality of longer time period than the day the grab sample was taken. The conductivity or TDS could have been twice as high the day or week before the sample was collected.

While the data collected in 2003 by itself cannot support causal evidence of impairment prior to 2003. Spikes of TDS are present in the entire history of sampling. The 2003 data merely indicates that this phenomenon persists, and suggests the degree to which TDS can spike (might have spiked) during un-monitored conditions.

Additional citations and language have been added to the revised TMDL Endpoint; Stressor Identification chapter to address the question of TDS as a stressor. Refer to LMPI #10.

The Stressor ID chapter clearly notes that the published values are repeatedly exceeded. Again the comparison to a 90th percentile value was to show a pattern of high values. The Kentucky DEP considers a conductivity of 500 umhos/cm to be a threshold value, which would translate to a TDS value less than 375 mg/L. The use of the McClure value to demonstrate a pattern of high concentrations in Straight Creek is appropriate and obviously conforms to the published

literature. Since the TMDL endpoint (334 mg/L TDS) is less than the reported values, it is reasonable to expect that it is protective of the aquatic community.

Regarding the frequency of observed extreme values of TDS and conductivity, the data analyzed is monthly or reconnaissance data. The occurrence of these extreme values in monthly data implies that a potentially much more serious problem would be observed if more frequent sampling was available.

The more recent citations clearly indicate that the statements in the stressor ID regarding the impacts of high TDS levels are indeed correct for Straight Creek. The "duty of the SI investigators" in the context of TMDL development is to examine available evidence from a stream, which has been designated as impaired, identify the most likely stressor(s), and establish an endpoint for the stressor(s) that will ensure a healthy aquatic community.

BMI 2.2.2.2 The TMDL was actually developed for a sediment load to the stream rather than a TSS concentration. TSS concentrations formed one line of evidence for this conclusion, but did not stand alone. The load calculated for permitted discharges was based on the modeled runoff flow volumes and the 70 mg/L permitted maximum concentration. The expectation is that the over all annual load will not be exceeded.

BMI 2.2.3.1 Habitat was considered in development of the TMDL. Refer to CRC 3 c.

BMI 2.2.3.2 As indicated by the data provided by the reviewer, many of the lowest scoring habitat indicators either reflect or impact sedimentation (*e.g.*, embeddedness, bank stability, and riparian vegetation). These habitat scores improved over the time period discussed, while indicators related to stream bank alteration did not. While land uses such as those described have an impact on the health of the benthic community, these problems should be addressed during the implementation phase of the TMDL process.

BMI 2.2.3.3 It is understood that some of the habitat parameters are marginal however, many of these parameters reflect the impact of sediment and none justify ignoring the impact of high TDS values on the benthic community. These issues should be a focus in the Implementation stage.

BMI 2.2.4. The stressor ID correctly notes that organic matter is high in Straight Creek and also notes that the sources of it will be addressed by the fecal coliform TMDL. It makes sense that the benthic TMDL should focus on the most serious stressors, TDS and sediment. The straight pipes allocation for reduction of fecal bacteria and TDS contributions to Straight Creek addresses this issue.

BMI 2.2.5 Conversation with West Virginia DEP staff (Personal communication May 17, 2005 EPA Region III annual meeting) yielded information that Twentymile Creek is on the 2004 TMDL list based on benthic macroinvertebrate collections. The argument offered that high TDS and conductivity in Twentymile Creek does not negatively impact the benthics seems untrue or premature since; in fact, the stream is listed for aquatic life use impairment, and a TMDL study is underway.

BMI 3.1-3.3 There were five issues raised with regard to modeling:

1. Modeling of Sediment Ponds and Reclaimed Mine Land in GWLF

The indication of zero sediment load from reclaimed areas in Table 11-8 was inaccurate and has been corrected. The corrected numbers can be provided in the Table "Comparison of Categorized Sediment Loads for the Impaired and Reference Watersheds" in the revised reports. All runoff passing through sediment ponds was allocated the load based on the maximum TSS concentration (70 mg/L). These included loads from active mining and reclaimed areas controlled by ponds. Reclaimed areas outside of permitted areas during the modeled period were modeled as forest.

2. Selection of representative hydrologic period for TMDL allocations

There is a trade off between modeling during a time period when the landscape is stable, and during critical conditions. There are advantages and disadvantages to using either procedure in a watershed influenced by surface mining. The decision was made that hydrologic conditions during the calibration time period, when the highest confidence in model output is available, were adequate to meet the needs for modeling during critical conditions. While there were periods of low flow, representing critical conditions for TDS, there were also periods of high flow representing critical conditions for sediment delivery.

3. No model validation

Not including a hydrology validation is not a case to dismiss the model as unacceptable. The purpose of validation is to demonstrate how well a calibrated model responds to different circumstances. In this case, the circumstances would be a different time period with different precipitation. For a watershed with surface mining as a major land use, such as the case with the Straight Creek watershed, the land characteristics change dramatically with time. Because of this, a time period was selected with a relatively stable amount (acres) of disruption due to mining. Instead of dividing the observed data taken during this time period between calibration and validation, all the data during the time period was used for calibration. The logic behind this decision was: the more data used to calibrate, the more accurate the model would be. Typically, if a model does not perform well in validation, the calibration is "re-visited" to improve the model. So, many modelers argue that, when data is limited, a better use of data is to apply all available data to calibration and forgo the validation step. Validation was not done for Straight Creek because the data was more valuable when used for calibration.

4. Selection of a Representative Modeling Period for Calibration

The Figures 4.8 and 4.9 show the disturbance in the Callahan Creek watershed and the Straight Creek watershed, respectively. In each case a larger drainage area was calibrated in order to take advantage of continuous flow gages down stream. The figures depicting the disturbance in the Upper Powell River watershed (including Callahan Creek watershed) and North Fork Powell River watershed (including Straight Creek watershed) will be added to the final draft version of the Powell River Basin TMDL documents. Additional instantaneous values of flow within the

impaired watersheds were used to assess the models performance within the impaired drainage area.

5. Selection and Calibration of Curve Numbers

The most important procedure to follow when using GWLF is to stay consistent when assigning parameter values to the reference and the impaired watersheds. As long as the same procedure for determining the curve number (CN) values (as well as the other parameters) were used for Middle Creek and Straight Creek, the relative amounts of sediment leaving the watersheds is accurate. Determination of CN is not an absolute science. It is impacted by soil type, land cover, and modeling approach. Ranges of values have been determined for specific land uses in specific soil hydrologic groups. Within this framework, a modeler chooses CN for a given land use based on similarity to reported land uses, and knowledge of the specific area being modeled. Additionally, CN can be calibrated. One example of modeling approach affecting CN is the choice of CN for water. A CN of 100 indicates that all water being modeled is coterminous with the stream network and all rainfall on this area will leave the system through the stream network, however, in these watersheds, the vast majority of water identified in the land use data is related to ponds constructed to control runoff from mined lands. There are various approaches to dealing with this situation. A lower CN can be used indicating that some portion of the rainfall hitting these ponds will be captured. Or, a CN of 100 can be used and adjustments can be made to other parameters in the model to account for pond storage capacity.

Because of the somewhat subjective nature of CN selection, additional modeling was performed. These changes resulting from this are incorporated into the Allocation Chapter in the revised documents. In reviewing the modeling, additional changes were made in the KLSPC factor in order to provide consistency between the reference and impaired watersheds. These changes are incorporated into the final model and revised "GWLF Landuse Parameters for Existing Conditions in the Impaired and Referenced Watersheds" tables. Additionally, land use categories were revised in **Chapter 10** "Modeling Procedure: Linking the Sources to the Endpoint". The revised Tables based on the CN, elevation, and land use updates are named "GWLF parameters for existing conditions in the impaired and reference watersheds", "GWLF parameters by land use for existing conditions in the impaired and reference watersheds", "Land use areas for the impaired, reference and area-adjusted reference watersheds" and "Existing sediment loads for the impaired and reference watersheds." These revisions also occur in the draft document Chapter 11 in tables "Comparison of categorized sediment loads for the impaired and area-adjusted reference watersheds", "TMDL targets for the impaired watershed", "Required sediment loads from the impaired watershed", "Final TMDL allocation scenario for the impaired watershed."

The sensitivity analysis originally included in the document was "borrowed" from an earlier TMDL, where urban-influenced channel erosion was the dominant factor. A new sensitivity analysis has been developed and is in the Modeling Procedures Chapter in the revised documents.

BMI 3.4 The following corrections/changes were made to the document based on suggestions in section 3.4

The sensitivity analyses results in Tables 4.8 and 4.9 are the percent differences between the base scenario (with values documented in Table 4.7) model output and the changed model output (e.g., AGWRC = 0.85). The sensitivity analysis tables have been changed to clarify that all results are a percent difference.

A description of AGWETP has been added to Section 4.7.1. The wording is "…direct ET from shallow groundwater (AGWETP)…".

Injection well data from MPIDs 1070022, 1070230, 1070231, 1070232, 1070233, 1085600, 1085604, 1085605 showed an average of 1003 mg/L TDS after the highest and lowest outliers were removed from the dataset (59,720 mg/L and 10 mg/L).

VDOT stated that in Wise County 7,871 tons of chemicals were applied for snow removal in the winter of 2003/2004 (Branson, 2004) and no brine is applied for dust control. Lee County applies an annual average of 2,100 tons of salt for snow removal and 130,000 gallons of a 38% solution for dust control (Salyer, 2004). These values are county-wide so a "lbs per acre of road" was determined using the total area of road in each county divided by the given salt loads. Paved roads were used to determine the loading rates of salt used to treat snow; unpaved roads were used to determine loading rates from brine applications.

The numbering in Chapter 10 has been corrected.

Responses to Teresa Carter – VA Dept. Conservation and Recreation Comments:

DCR Overall document comments The contractor is dividing the Powell River TMDL document into 2 separate volumes, Straight Creek TMDL and the Callahan Creek TMDL.
DCR Section 12 Implementation comments – This section is being revised to address funding sources for implementation.

Response to Dink Shackleford for Virginia Mining Association Comments:

The comments submitted by Lone Mt. Processing and Powell Mountain Coal have been considered in finalizing the TMDL draft document.

Responses to Mid-Atlantic Environmental Law Center Comments:

MAELC General Comments. A TMDL is specific to a pollutant and water body. The Powell River Basin TMDL document is not "the TMDL" as referred to by MAELC, but is the document, which describes 2 TMDLs for Callahan Creek and 2 TMDLs for Straight Creek. Virginia requires an Implementation Plan for all approved TMDLs, a timeline for correction of water quality problems is part of this planning process. The legal requirements for TMDL implementation are determined by the source (*i.e.*, non-point source or point source). These requirements are discussed in the draft document. Additional details will be incorporated in the Implementation Plan document.

MAELC Fecal Bacteria bullet 1. The NLCD dataset is the most spatially and temporally appropriate for land use identification in the Callahan Creek and Straight Creek watersheds. The only available datasets for the region during the modeling time period are NLCD datasets. Additionally, NLCD data is not used "to establish a TMDL"; rather, it is used to establish land use locations and distributions, as described in the document (Section 4.2).

MAELC Fecal Bacteria bullet 2. There is a discussion of the pets in the TMDL. In identifying significant contributors to fecal pollution in the watersheds, two indicators were considered, size of the source and transport mechanism to the stream. Dogs and cats are the only known pets in these watersheds that have a significant population and defecate on the landscape where runoff events can transport the fecal matter to the stream. Livestock considered pets by the owner (*e.g.,* roosters, goats, etc) were accounted for in the livestock source assessment.

MAELC Fecal Bacteria bullet 3. The TMDL offers adequate information regarding the HSPF considerations. From Chapter 4:

> *"The HSPF model is a continuous simulation model that can account for nonpoint source (NPS) pollutants in runoff, as well as pollutants entering the flow channel from point sources. In establishing the existing and allocation conditions, seasonal variations in hydrology, climatic conditions, and watershed activities can be explicitly accounted for in the model. The use of HSPF allowed for consideration of seasonal aspects of precipitation patterns within the watershed.*
>
> *The HSPF model simulates a watershed by dividing it up into a network of stream segments (each referred to in the model as a RCHRES), impervious land areas (IMPLND) and pervious land areas (PERLND). Each subwatershed contains a single RCHRES, modeled as an open channel, and numerous PERLNDs and IMPLNDs, representing the various land uses in that subwatershed. Water and pollutants from the land segments in a given subwatershed flow into the RCHRES in that subwatershed. Point discharges and withdrawals of water and pollutants are simulated as flowing directly to or withdrawing from a particular RCHRES as well. Water and pollutants from a given RCHRES flow into the next downstream RCHRES. The network of RCHRESs is constructed to mirror the configuration of the stream segments found in the*

physical world. Therefore, activities simulated in one impaired stream segment affect the water quality downstream in the model."

For these reasons, HSPF was chosen as the model for hydrology, bacteria, and TDS modeling.

MAELC Fecal Bacteria bullet 4 The TMDL offers adequate information regarding use of implicit die off. On land, die-off of FC was handled implicitly because there is no parameter in HSPF for land-based FC die-off. The explanation of how the implicit modeling of land-based die-off is done is accurate and complete (Section 4.2.2): "For land-applied fecal matter (fecal matter deposited directly on land), die-off occurring in the field was represented implicitly through model parameters such as the maximum accumulation and the 90% wash off rate, which were adjusted during the calibration of the model. These parameters were assumed to represent not only the delivery mechanisms, but the bacteria die-off as well. Once the fecal coliform entered the stream, the general decay module of HSPF was incorporated, thereby explicitly addressing the die-off rate. The general decay module uses a first order decay function to simulate die-off."

MAELC Fecal Bacteria bullet 5 Modeling period selection is explained in the TMDL (Chapter 4 Section 4.5).

MAELC Fecal Bacteria bullet 6 An MOS was incorporated into the TMDL. It was an **implicit** MOS. Therefore, the descriptions presented are all examples of how the implicit MOS was included. Incorporating an implicit MOS for the bacteria TMDL has been approved by EPA in other TMDLs and is recognized as an appropriate method of assigning an MOS.

MAELC Fecal Bacteria bullet 7 The bacteria TMDL is explained in the executive summary in the section labeled Background and Applicable Standards. EPA has consistently requested that TMDLs be expressed as an annual load. For many pollutants the appropriate unit for load is a mass however, bacteria is not measured as a mass it is measured as colony forming units (cfu).

MAELC Fecal Bacteria bullet 8 Future growth in each watershed was considered during the TMDL study. A study into the future growth of the area was performed using the Wise County (for Callahan Creek) and Lee County (for Straight Creek) Comprehensive Reports. These reports both stated that there would be negligible future urban growth in the counties.

MAELC Benthic bullet 1 The explanation of use of a reference watershed is included in the TMDL. Additionally, the funding for this project is from EPA who requested the use of the reference watershed approach.

MAELC Benthic bullet 2 Information regarding considerations for use of the TMDL model is referenced. See response to Fecal Bacteria Bullet #5.

MAELC Benthic bullet 3 The TMDL does have a discussion of how the nonpoint source contributions were delivered to the stream. The only pathways for a land-based nonpoint source load to enter a surface water body are transportation by surface runoff, interflow or groundwater. Some nonpoint sources, rather than being land-based, are represented as being deposited directly

to the stream (*e.g.*, animal defecation in stream). These sources are modeled similarly to point sources, as they do not require a runoff event for delivery to the stream.

MAELC Benthic bullet 4 The TMDL does address how the three sediment source areas were identified.

MAELC Benthic bullet 5 Modeling periods are discussed in the document (Chapter 4 Section 4.5 for hydrology and Section10.4 for TDS and sediment).

MAELC Benthic bullet 6 A 10% margin of safety is the accepted method of incorporating an MOS in the benthic TMDL. This has been discussed and approved by EPA in other Virginia TMDLs. The TMDL addresses this point.

MAELC Benthic bullet 7 Tons per year for sediment reduction is an accepted method of describing sedimentation reduction and does express a load.

MAELC benthic bullet 8 Future growth in each watershed was considered during the TMDL study. A study into the future growth of the area was performed using the Wise County (for Callahan Creek) and Lee County (for Straight Creek) Comprehensive Reports. These reports both stated that there would be negligible future urban growth in the counties.

Fecal Bacteria and General Standard Total Maximum Daily Load Development for the Powell River Basin - Straight Creek

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Local Stakeholders and Watershed Residents

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EXECUTIVE SUMMARY

Background and Applicable Standards

The mainstem of Straight Creek was initially listed on the *Virginia 1994 TMDL Report* for violations of the bacteria standard and the *Virginia 1996 Section 303(d) TMDL Priority List* for violations of the General Standard (benthic). Elevated levels of fecal coliform bacteria recorded at VADEQ ambient water quality monitoring stations showed that this stream segment does not support the primary contact recreation use (*e.g.,* swimming, wading, and fishing). The modified RBP II method results rated Straight Creek as moderately impaired. The Virginia state standard (9 VAC 25-260-170) specifies that the number of fecal coliform bacteria shall not exceed a maximum allowable level of 400 colony-forming units (cfu) per 100 milliliters (mL). Alternatively, if data is available, the geometric mean of two or more observations taken in a calendar month should not exceed 200-cfu/100 mL. A review of available monitoring data for the watershed indicated that fecal coliform bacteria were consistently elevated above the 400-cfu/100 mL standard. Based on exceedances of the standards recorded at Virginia Department of Environmental Quality (VADEQ) monitoring stations, the stream does not support primary contact recreation (*e.g.,* swimming, wading, and fishing).

The United States Environmental Protection Agency (EPA) directed that the state develop a water quality standard for *E. coli* bacteria to eventually replace the fecal coliform standard. This new standard specifies that the number of *E. coli* bacteria shall not exceed a maximum allowable level of 235-cfu /100 mL (9 VAC 25-260-170). In addition, if data is available, the geometric mean of two or more observations taken in a calendar month should not exceed 126-cfu/100 mL.

The General Standard is implemented by VADEQ through application of the modified Rapid Bioassessment Protocol II (RBP II). Using the modified RBP II, the health of the benthic macro-invertebrate community is typically assessed through measurement of 8 biometrics that evaluate the overall health community. Each biometric measured at a target station is compared to the same biometric measured at a reference (not impaired) station to determine each biometric score. These scores are then summed and used to

determine the overall bioassessment (*e.g.,* not impaired, slightly impaired, moderately impaired, or severely impaired). The modified RBP II method results rated Straight Creek as moderately impaired.

TMDL Endpoint and Water Quality Assessment

Fecal Coliform

Potential sources of fecal coliform include both point source and nonpoint source contributions. Nonpoint sources include: wildlife, grazing livestock, land application of manure, urban/suburban runoff, failed and malfunctioning septic systems, and uncontrolled discharges (*e.g.,* straight pipes). There is one Virginia Pollutant Discharge Elimination System (VPDES) permitted dischargers in the Straight Creek watershed which is not permitted for fecal control.

Fecal bacteria TMDLs in the Commonwealth of Virginia are developed using the *E. coli* standard. A translator developed by VADEQ was used to convert fecal coliform values to *E. coli* values. For the development of these TMDLs, the in-stream *E. coli* target was a geometric mean not exceeding 126-cfu/100 mL and a single sample maximum of 235-cfu/100 mL.

General Standard (benthic)

TMDLs must be developed for a specific pollutant(s). Benthic assessments are very good at determining if a particular stream segment is impaired or not, but generally do not provide enough information to determine the cause(s) of the impairment. The process outlined in the Stressor Identification Guidance Document (EPA, 2000) was used to systematically identify the most probable stressors in Straight Creek. Chemical and physical monitoring data from VADEQ and DMME monitoring point identification sites (MPIDs) provided evidence to support or eliminate potential stressors. The potential stressors are: sediment, toxics, low dissolved oxygen, nutrients, pH, metals, conductivity, temperature and organic matter.

The results of the stressor analysis for Straight Creek were divided into three categories:

Non-Stressor: Those stressors with data indicating normal conditions, without water quality standard violations or without the observable impacts usually associated with a specific stressor, were eliminated as possible stressors.

Possible Stressor: Those stressors with data indicating possible links, but inconclusive data, were considered to be possible stressors.

Most Probable Stressor: The stressor(s) with the most consistent information linking it with the poorer benthic and habitat metrics was considered to be the most probable stressor(s).

The results indicate that for Straight Creek, sediment and total dissolved solids (TDS) are the Most Probable Stressors and, therefore, were used to develop the benthic TMDL.

Sediment is delivered to Straight Creek through surface runoff, streambank erosion, point sources, and natural erosive processes. During runoff events, sediment is transported to streams from land areas. Rainfall energy, soil cover, soil characteristics, topography, and land management affect the magnitude of sediment loading. Livestock concentrations (along stream edge and uncontrolled access to streams), forest harvesting, and construction accelerate erosion at varying degrees.

Sediment transport is a natural and continual process that is often accelerated by human activity. An increase in impervious land without appropriate stormwater control increases runoff volume and peaks, which leads to greater potential for channel erosion. During dry periods, sediment from air or traffic builds up on impervious areas and is transported to streams during runoff events. Fine sediments are included in total suspended solids (TSS) loads that are permitted for wastewater, industrial stormwater and construction stormwater discharge.

Sources contributing to the TDS impairment include both nonpoint contributions and point sources. Nonpoint sources in the Straight Creek watershed are abandoned mine land (AML) (*e.g.,* mine spoils, benches, and disturbed areas), urban areas, and land currently being mined. There are currently 50 permitted discharges in the Straight Creek watershed, one VPDES, and 49 sedimentation basin outlets.

Modeling Procedures

Hydrology

The US Geological Survey (USGS) Hydrologic Simulation Program - Fortran (HSPF) water quality model was selected as the modeling framework to model hydrology, TDS loads and fecal coliform loads.

For purposes of modeling watershed inputs to in-stream water quality, the Straight Creek watershed model consisted of four subwatersheds. The representative flow period used for hydrologic calibration was 10/1/1991 through 3/31/1995. The stream flow in the North Fork Powell River watershed including Straight Creek was calibrated with the flow values from USGS Station #03530500 in the North Fork Powell River at Pennington Gap.

Hydrology validation was not performed for Straight Creek because a stable time period was chosen for hydrology modeling and all observed data collected during this time period was used for hydrology calibration. It was determined that using all available data for calibration would result in a more accurate model.

Fecal Coliform

The fecal coliform water quality calibration for Straight Creek was conducted using monitored data collected at VADEQ monitoring station 6BSRA00.1.11 from October 1990 to September 1994. Modeled fecal coliform levels matched observed levels, indicating that the model was well calibrated.

The allocation precipitation time periods were selected to coincide with the calibration time periods. Modeling during the calibration periods provided the highest confidence in allocation results.

General Standard (benthic) - TDS

There are no existing in-stream criteria for TDS in Virginia; therefore, a reference watershed approach was used to define allowable TMDL loading rates in the Straight Creek watershed. The Middle Creek watershed was selected as the TMDL reference for

Straight Creek due its history of mining activity and recovery from a benthic impairment. The maximum TDS concentration measured in Middle Creek was used as the endpoint for the TMDL (334 mg/L).

General Standard (benthic) - Sediment

There are no existing in-stream criteria for sediment in Virginia; therefore, a reference watershed approach was used to define allowable TMDL loading rates in the Straight Creek watershed. The Middle Creek watershed was selected as the TMDL reference for Straight Creek due to the history of coal mining in both watersheds. The TMDL sediment loads were defined as the modeled sediment load for existing conditions from the non-impaired Middle Creek watershed, area-adjusted to the Straight Creek watershed. The Generalized Watershed Loading Function (GWLF) model (Haith et al., 1992) was used for comparative modeling between the impaired creek and Middle Creek.

Existing Conditions

Fecal Coliform

Wildlife populations, the rate of failure of septic systems, domestic pet populations, and numbers of livestock in the Straight Creek watershed are examples of land-based nonpoint sources used to calculate fecal coliform loads. Also, represented in the model were direct nonpoint sources of uncontrolled discharges, direct deposition by wildlife, and direct deposition by livestock. Contributions from all of these sources were updated to 2004 conditions to establish existing conditions for the watershed. The HSPF model provided a comparable match to the VADEQ monitoring data, with output from the model indicating violations of both the instantaneous and geometric mean standards throughout the watershed.

General Standard (benthic) - TDS

Both point and nonpoint sources of TDS were represented in the model during the hydrology and TDS calibration periods. Permitted sources included discharges of runoff through control structures (sediment retention ponds), as well as discharges from deep mines. Deep mine discharges were modeled by adding a time series of pollutant and flow

inputs to the stream. Nonpoint sources were modeled as having three potential delivery pathways, delivery with TDS in surface runoff, delivery through interflow, and delivery through groundwater. The allocation precipitation time periods were selected to coincide with the calibration time periods. Modeling during the calibration periods provides the highest confidence in allocation results.

General Standard (benthic) - Sediment

The sediment TMDL for Straight Creek was defined by the average annual sediment load in metric tons per year (Mg/yr) from the area-adjusted Middle Creek. The sediment loads for existing conditions were calculated using the period of October 1991 through March 1995 for Straight Creek.

The sediment TMDL is composed of three components: waste load allocations (WLA) from point sources, the load allocation (LA) from nonpoint sources, and a margin of safety (MOS), which was set to 10% for this study. The existing load from Straight Creek was 7,225 Mg/yr. The target sediment TMDL load for Straight Creek is 5,518 Mg/yr.

Load Allocation Scenarios

Fecal Coliform

The next step in the bacteria TMDL process was to reduce the various source loads to levels that would result in attainment of the water quality standards. Because Virginia's *E. coli* standard does not permit any exceedances of the standard, modeling was conducted for a target value of 0% exceedance of the geometric mean standard and 0% exceedance of the single sample maximum *E. coli* standard. Scenarios were evaluated to predict the effects of different combinations of source reductions on final in-stream water quality.

Straight Creek requires:

- 32% reductions in NPS wildlife loads,
- 80% reductions in NPS loads from pasture,
- 99% reductions in urban areas, and
- 100% reductions in loads from straight pipes.

Correcting all straight pipes results in a 2.19% violation of the instantaneous standard and is the Stage I implementation goal.

General Standard (benthic) – TDS

The next step in the TDS TMDL process was to adjust TDS loadings from existing watershed conditions to reduce the various source loads to levels that would result in an in-stream TDS concentration less than 334 mg/L. Scenarios were evaluated to predict the effects of different combinations of source reductions on final in-stream water quality. Allocations were developed at the outlet of Straight Creek. The final load allocation scenario for Straight Creek required:

- 48% reduction in TDS from nonpoint sources, and
- 100% reduction in TDS from direct sources.

The only direct sources of TDS in Straight Creek are straight pipes.

General Standard (benthic) - Sediment

The next step in the sediment TMDL process was to reduce the various source loads to result in average annual sediment loads less than the target sediment TMDL load. Scenarios were evaluated to predict the effects of different combinations of source reductions on final in-stream water quality. Allocations were developed at the outlet of Straight Creek.

The final load allocation scenario for Straight Creek required a 64.58% overall reduction in sediment loads to the stream. The overall reduction includes reductions of 65% from disturbed forest, 79% from AML, as well as 100% reduction from straight pipes (uncontrolled discharges). No reductions to sediment or TSS permitted sources were required.

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 bacteria, TDS and sediment impairments of Straight Creek. The second step is the development of TMDL implementation plans. The final step is to implement the TMDL implementation plan, and to monitor water quality to determine if water quality standards are being attained.

Once EPA approves a TMDL, measures must be taken to reduce pollution levels in the stream. These measures, which can include the installation of best management practices (BMPs), are implemented in an iterative process that is described along with specific BMPs in the implementation plan. 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. Additionally, development of an approved implementation plan will improve a locality's chances for obtaining financial and technical assistance during implementation. With successful completion of implementation plans, Virginia will be well on the way to restoring impaired waters and enhancing the value of this important resource.

To address the bacteria TMDL, reducing the human bacteria loading from straight pipes and failing septic systems should be a primary implementation focus because of the health implications. This component could be implemented through education on septic tank pump-outs as well as a septic system installation/repair program. Livestock exclusion from streams has been shown to be very effective in lowering bacteria concentrations in streams, both by reducing the direct cattle deposits and by providing additional riparian buffers. Reduced trampling and soil shear on streambanks by livestock has been shown to reduce bank erosion.

To address the TDS and sediment TMDLs, It is anticipated that AML reclamation and the correction of straight pipes will be initial targets of implementation. One way to accelerate reclamation of AML is through remining. The Virginia Department of Mines,

Minerals and Energy's (DMME) Division of Mined Land Reclamation (DMLR), The Nature Conservancy, Virginia Tech/Powell River Project, and U. S. Office of Surface Mining are in the process of developing incentives that will promote economically and environmentally beneficial remining operations that reclaim AML sites (DMME, 2004).

There is a measure of uncertainty associated with the final allocation development process. Monitoring performed upon completion of specific implementation milestones can provide insight into the effectiveness of implementation strategies, the need for amending the plan, and/or progress toward the eventual removal of the impairment from the 303(d) list.

Public Participation

During development of the TMDLs for Straight Creek, public involvement was encouraged through three public meetings in the watershed. An introduction of the agencies involved, an overview of the TMDL process, and the specific approach to developing the Straight Creek TMDLs were presented at the first public meeting. Details of the pollutant sources and stressor identification were presented during the second public meeting. Public understanding of and involvement in the TMDL process was encouraged. Input from these meetings was utilized in the development of the TMDLs and improved confidence in the allocation scenarios. The final model simulations and the TMDL load allocations were presented during the final public meeting. There was an extended public comment period after the final public meetings and comments received from six organizations have been addressed. Watershed stakeholders will have the opportunity to participate in the development of the TMDL implementation plan.

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1. INTRODUCTION

1.1 Background

The need for Total Maximum Daily Loads (TMDLs) for Straight Creek is based on provisions of the Clean Water Act. The United States Environmental Protection Agency's (EPA) document, *Guidance for Water Quality-Based Decisions: The TMDL Process* (EPA, 1999), states:

> *According to Section 303(d) of the Clean Water Act and the EPA water quality planning and management regulations, States are required to identify waters that do not meet or are not expected to meet water quality standards even after technology-based or other required controls are in place. The waterbodies are considered water quality-limited and require TMDLs.*
>
> *…A TMDL is a tool for implementing State water quality standards, and is based on the relationship between pollution sources and in-stream water quality conditions. The TMDL establishes the allowable loadings or other quantifiable parameters for a waterbody and thereby provides the basis for States to establish water quality-based controls. These controls should provide the pollution reduction necessary for a waterbody to meet water quality standards.*

The Powell River watershed (USGS Hydrologic Unit Code #06010206) includes portions of Virginia's Wise and Lee Counties. The Powell River flows through Virginia and Tennessee and joins Clinch River at the Norris Reservoir. Straight Creek (located in Lee County) is a tributary to the Powell River and is part of the Upper Tennessee River Basin. (Figures 1.1 and 1.2)

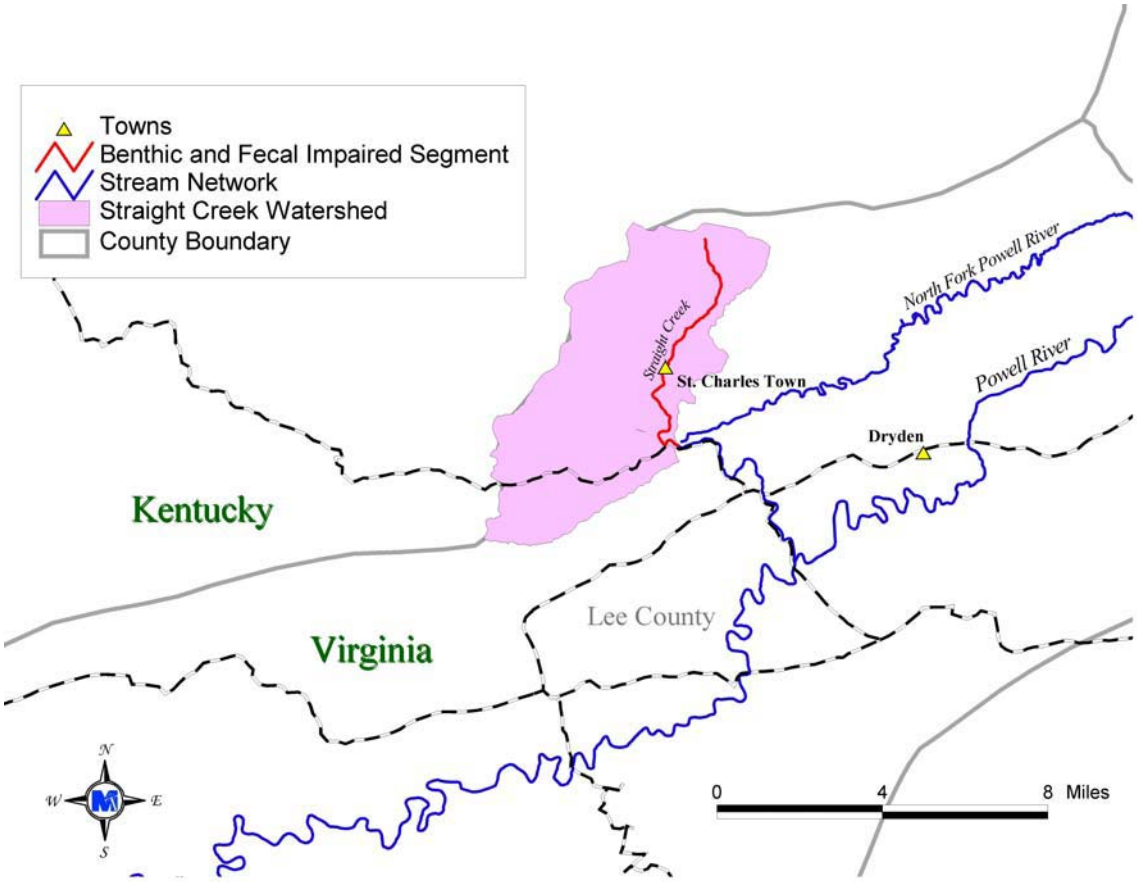

Figure 1.1 Location of the Straight Creek watershed.

Fecal violations at VADEQ ambient monitoring station 6BSRA001.11 on Straight Creek (waterbody ID #VAS-P20R) led to Straight Creek, from the headwaters north of Monarch to its confluence with North fork Powell River (6.66 miles), being placed on the 1994 *TMDL Report*. Straight Creek remained on the 1996 *Section 303(d) TMDL Priority List* for violations of the fecal coliform (FC) bacteria standard. In addition, Straight Creek, Stone Creek and tributaries (38.1 miles) were listed for violations of the General Standard (benthic) in 1996 based on monitoring at VADEQ biological station 6BSRA000.40.

These listings remained on the *Virginia 1998 Section 303(d) TMDL Priority List* for violations of the FC bacteria standard and the General Standard (benthic). The 6.66-mile segment of Straight Creek has remained on the Virginia 2002 and 2004 Section 303(d)

lists for bacteria violations based on additional monitoring performed at VADEQ ambient station 6BSRA001.11. While the 1996 and 1998 Section 303(d) lists included a broad description of Straight Creek, Stone Creek and tributaries, in the 2002 and 2004 Section 303(d) lists the individual impairments were specifically defined. The 6.66-mile segment of Straight Creek remained on the *Virginia 1998 Section 303(d) TMDL Priority List* for not supporting aquatic life based on monitoring at VADEQ biological stations 6BSRA000.11, 6BSRA000.40, 6BSRA000.54, 6BSRA001.10, 6BSRA002.48, and 6BSRA003.62. As contracted by DMME, this TMDL was developed for Straight Creek from its headwaters to the confluence with the North Fork Powell River as listed in 2002. However, all load allocations identified in subsequent chapters reflect reductions required in all contributing subwatersheds.

PART II: FECAL BACTERIA TMDLS

2. TMDL ENDPOINT AND WATER QUALITY ASSESSMENT

2.1 Applicable Water Quality Standards

According to 9 VAC 25-260-5 of Virginia's State Water Control Board *Water Quality Standards*, the term "water quality standards" means "…provisions of state or federal law which consist of a designated use or uses for the waters of the Commonwealth and water quality criteria for such waters based upon such uses. Water quality standards are to protect the public health or welfare, enhance the quality of water and serve the purposes of the State Water Control Law and the federal Clean Water Act."

As stated in Virginia state law 9 VAC 25-260-10 (Designation of uses):

> *A. All state waters, including wetlands, are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.*
>
> *D. At a minimum, uses are deemed attainable if they can be achieved by the imposition of effluent limits required under §§301(b) and 306 of the Clean Water Act and cost-effective and reasonable best management practices for nonpoint source control.*

Because this study addresses both fecal bacteria and benthic impairments, two water quality criteria are applicable. Section 9 VAC 25-260-170 applies to the fecal coliform impairment, whereas the General Standard section (9 VAC 25-260-20) applies to the benthic impairment.

2.2 Applicable Criteria for Fecal Bacteria Impairments

Prior to 2002, Virginia Water Quality Standards specified the following criteria for a non-shellfish supporting waterbody to be in compliance with Virginia's fecal standard for contact recreational use:

> *A. General requirements. In all surface waters, except shellfish waters and certain waters addressed in subsection B of this section, the fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria*

> *per 100 mL of water for two or more samples over a 30-day period, or a fecal coliform bacteria level of 1,000 per 100 mL at any time.*

If the waterbody exceeded either criterion more than 10% of the time, the waterbody was classified as impaired and the development and implementation of a TMDL was indicated in order to bring the waterbody into compliance with the water quality criterion. Based on the sampling frequency, only one criterion was applied to a particular datum or data set. If the sampling frequency was one sample or less per 30 days, the instantaneous criterion was applied; for a higher sampling frequency, the geometric criterion was applied. These were the criteria used for listing the impairment included in this study. Sufficient fecal coliform bacteria standard violations were recorded at VADEQ water quality monitoring stations to indicate that the recreational use designations are not being supported.

The EPA has since recommended that all states adopt an *E. coli* or *enterococci* standard for fresh water and *enterococci* criteria for marine waters by 2003. The EPA is pursuing the states' adoption of these standards because there is a stronger correlation between the concentration of these organisms (*E. coli* and *enterococci*) and the incidence of gastrointestinal illness than with fecal coliform. *E. coli* and *enterococci* are both bacteriological organisms that can be found in the intestinal tract of warm-blooded animals. Like fecal coliform bacteria, these organisms indicate the presence of fecal contamination. The adoption of the *E. coli* and *enterococci* standard is in effect in Virginia as of January 15, 2003.

The new criteria, outlined in 9 VAC 25-260-170, read as follows:

> *A. In surface waters, except shellfish waters and certain waters identified in subsection B of this section, the following criteria shall apply to protect primary contact recreational uses:*
>
> *1. Fecal coliform bacteria shall not exceed a geometric mean of 200 fecal coliform bacteria per 100 mL of water for two or more samples over a calendar month nor shall more than 10% of the total samples taken during any calendar month exceed 400 fecal coliform bacteria per 100 mL of water. This criterion shall not apply for a sampling station after the bacterial indicators described in subdivision 2 of this subsection have a minimum of 12 data points or after June 30, 2008, whichever comes first.*

2. E. coli and enterococci *bacteria per 100 mL of water shall not exceed the following:*

	Geometric Mean[1]	*Single Sample Maximum*[2]
Freshwater[3]		
E. coli	*126*	*235*
Saltwater and Transition Zone[3]		
Enterococci	*35*	*104*

[1] For two or more samples taken during any calendar month.

[2] No single sample maximum for *enterococci* and *E. coli* shall exceed a 75% upper one-sided confidence limit based on a site-specific log standard deviation. If site data are insufficient to establish a site-specific log standard deviation, then 0.4 shall be used as the log standard deviation in freshwater and 0.7 shall be as the log standard deviation in saltwater and transition zone. Values shown are based on a log standard deviation of 0.4 in freshwater and 0.7 in saltwater.

[3] See 9 VAC 25-260-140 C for freshwater and transition zone delineation.

These criteria were used in developing the bacteria TMDL included in this study.

2.3 Selection of a TMDL Endpoint.

The first step in developing a TMDL is the establishment of in-stream numeric endpoints, which are used to evaluate the attainment of acceptable water quality. In-stream numeric endpoints, therefore, represent the water quality goals that are to be achieved by implementing the load reductions specified in the TMDL. For the Straight Creek TMDL, the applicable endpoints and associated target values can be determined directly from the Virginia water quality regulations (Section 2.1). In order to remove a water body from a state's list of impaired waters, the Clean Water Act requires compliance with that state's water quality standard. Since modeling provided simulated output of *E. coli* concentrations at 1-hour intervals assessment of TMDLs was made using both the geometric mean standard of 126 cfu/100 mL and the instantaneous standard of 235 cfu/100 mL. Therefore, the in-stream *E. coli* targets for these TMDLs were a monthly geometric mean not exceeding 126 cfu/100 mL and a single sample not exceeding 235 cfu/100 mL.

2.4 Selection of a TMDL Critical Condition.

EPA regulations at 40 CFR 130.7 (c)(1) require TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of Straight Creek is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and help in identifying the actions that may have to be undertaken to meet water quality standards. Fecal coliform sources within the Straight Creek watershed are attributed to both point and nonpoint sources. Critical conditions for waters impacted by land-based nonpoint sources generally occur during periods of wet weather and high surface runoff. In contrast, critical conditions for point source dominated systems generally occur during low flow and low dilution conditions. Point sources, in this context, also include nonpoint sources that are not precipitation driven (*e.g.,* direct fecal deposition to stream).

A graphical analysis of measured fecal coliform concentrations versus the level of flow at the time of measurement showed that there was no obvious critical flow level in Straight Creek (Figure 2.1). High concentrations were recorded in all flow regimes.

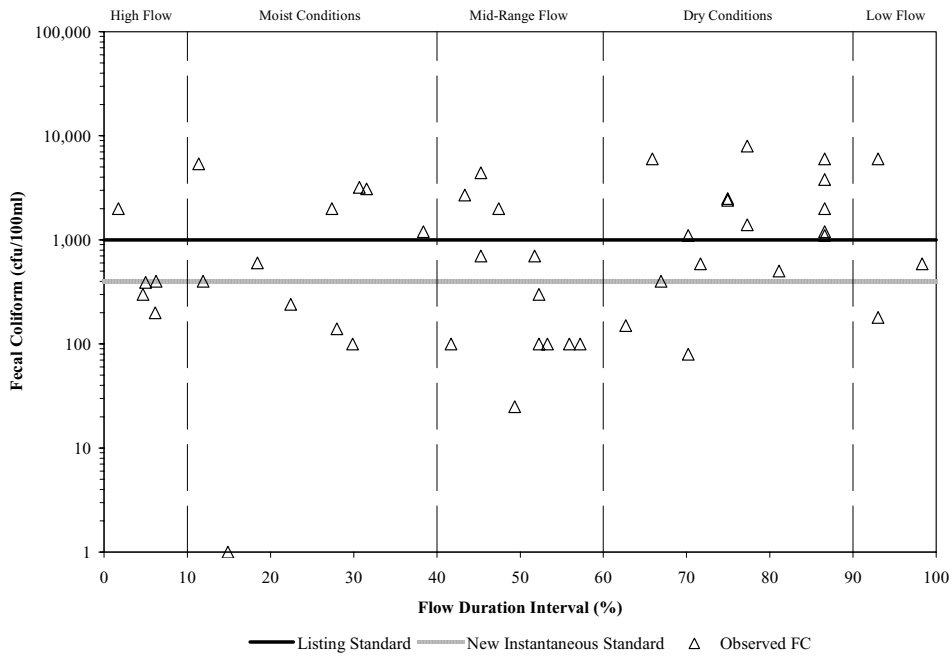

Figure 2.1 Relationship between fecal coliform concentrations in Straight Creek (VADEQ station 6BSRA001.11) and discharge at USGS Station #03400800.

2.5 Discussion of In-stream Water Quality

This section provides an inventory of available observed in-stream monitoring data throughout the Straight Creek watershed. An examination of data from water quality stations used in the Section 303(d) assessments and data collected during TMDL development were analyzed. Sources of data and pertinent results are discussed.

2.5.1 Inventory of Water Quality Monitoring Data

The primary sources of available water quality information for Straight Creek are:

- bacteria enumerations from 4 VADEQ in-stream monitoring stations used for TMDL assessment (Figure 2.2, Tables 2.1 and 2.2), and
- bacterial source tracking from one VADEQ in-stream monitoring station analyzed during TMDL development.

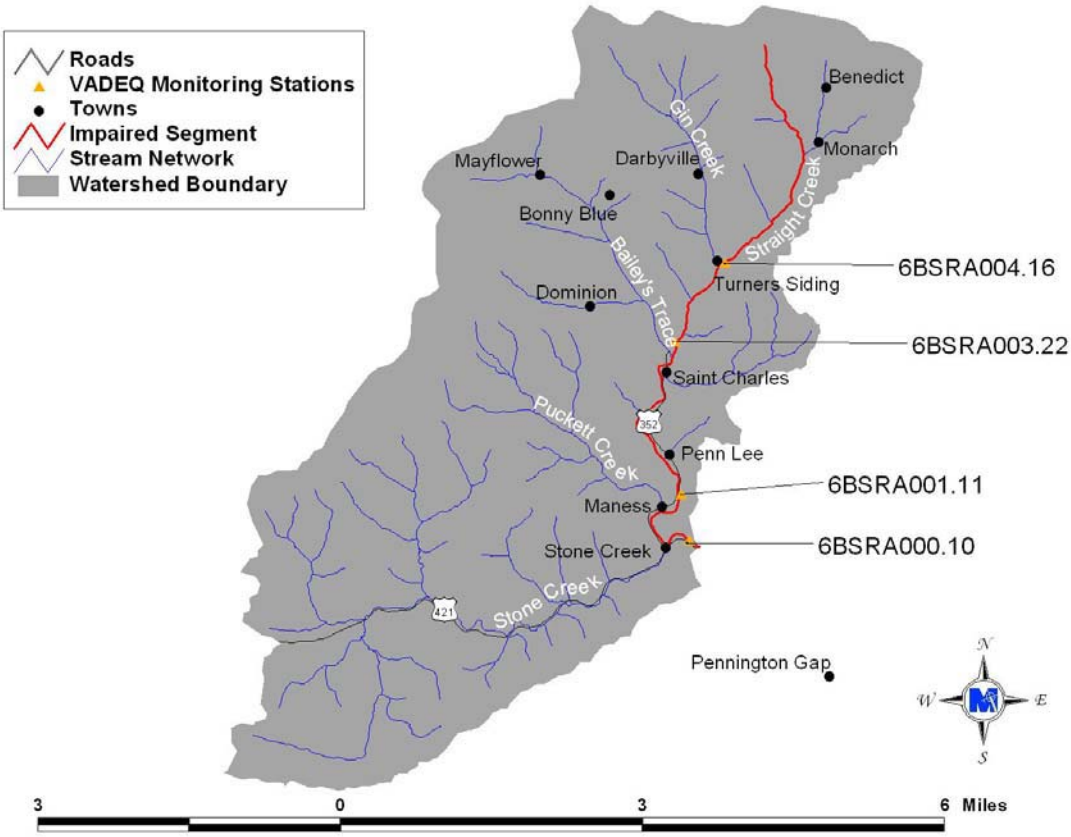

Figure 2.2 Location of VADEQ water quality monitoring stations used for the bacteria TMDL assessment in the Straight Creek watershed.

Table 2.1 Summary of fecal coliform monitoring conducted by VADEQ for Straight Creek from July 1990 through March 2004.

Stream	VADEQ Station	Count (#)	Minimum (cfu/100mL)	Maximum (cfu/100mL)	Mean (cfu/100mL)	Median (cfu/100mL)	Standard Deviation	Violations[1] %	Violations[2] %
Straight Creek	6BSRA001.11	47	0	8,000	1,595	600	1,984	45	57
Straight Creek	6BSRA003.22	9	130	1,800	809	820	526	22	78
Straight Creek	6BSRA004.16	9	150	2,000	1,137	1,300	678	67	78

[1] Violations are based on the pre-2003 fecal coliform instantaneous standard (1,000 cfu/100mL)
[2] Violations are based on the current fecal coliform instantaneous standard (400 cfu/100mL)

Table 2.2 Summary of *E. coli* monitoring conducted by VADEQ for Straight Creek from March 2000 through March 2004.

Stream	VADEQ Station	Count (#)	Minimum (cfu/100mL)	Maximum (cfu/100mL)	Mean (cfu/100mL)	Median (cfu/100mL)	Standard Deviation	Violations[1] %
Straight Creek	6BSRA000.10	4	25	2,000	600	188	941	50
Straight Creek	6BSRA001.11	7	20	800	381	140	393	43
Straight Creek	6BSRA003.22	9	50	1,800	651	780	556	67
Straight Creek	6BSRA004.16	9	50	800	511	650	301	78

[1] Violations are based on the new *E. coli* instantaneous standard (235 cfu/100mL)

2.5.1.1 Water Quality Monitoring for TMDL Assessment

Data from Straight Creek collected by VADEQ were analyzed from July 1990 through March 2004 and are shown in Tables 2.3 and 2.4. These tables summarize the bacteria samples collected at the in-stream monitoring stations used for TMDL assessment. Fecal coliform samples were taken for the express purpose of determining compliance with the state instantaneous standard limiting concentrations to less than 1,000 cfu/100 mL. Therefore, as a matter of economy, samples showing fecal coliform concentrations below 100 cfu/100 mL or in excess of a specified cap (*e.g.*, 8,000 or 16,000 cfu/100 mL, depending on the laboratory procedures employed for the sample) were not analyzed further to determine the precise concentration of fecal coliform bacteria. The result is that reported concentrations of 100 cfu/100 mL most likely represent concentrations below 100 cfu/100 mL, and reported concentrations of 8,000 or 16,000 cfu/100 mL most likely represent concentrations in excess of these values. *E. coli* samples were collected to evaluate compliance with the state's current bacterial standard, as well as for bacterial source tracking analysis. The current instantaneous standard for *E. coli* is 235 cfu/100mL.

2.5.1.2 Water Quality Monitoring Conducted During TMDL Development

Ambient water quality monitoring was performed from July 2003 through June 2004. Specifically, water quality samples were taken at one site in the Straight Creek watershed (Figure 2.3). All samples were analyzed for fecal coliform and *E. coli* concentrations and for bacteria source (*i.e.,* human, livestock, pets, or wildlife) by the Environmental Diagnostics Laboratory (EDL) at MapTech, Inc. Table 2.3 summarizes the fecal coliform and *E. coli* concentration data at the ambient station. Bacterial source tracking (BST) is discussed in greater detail in Section 2.6.1.

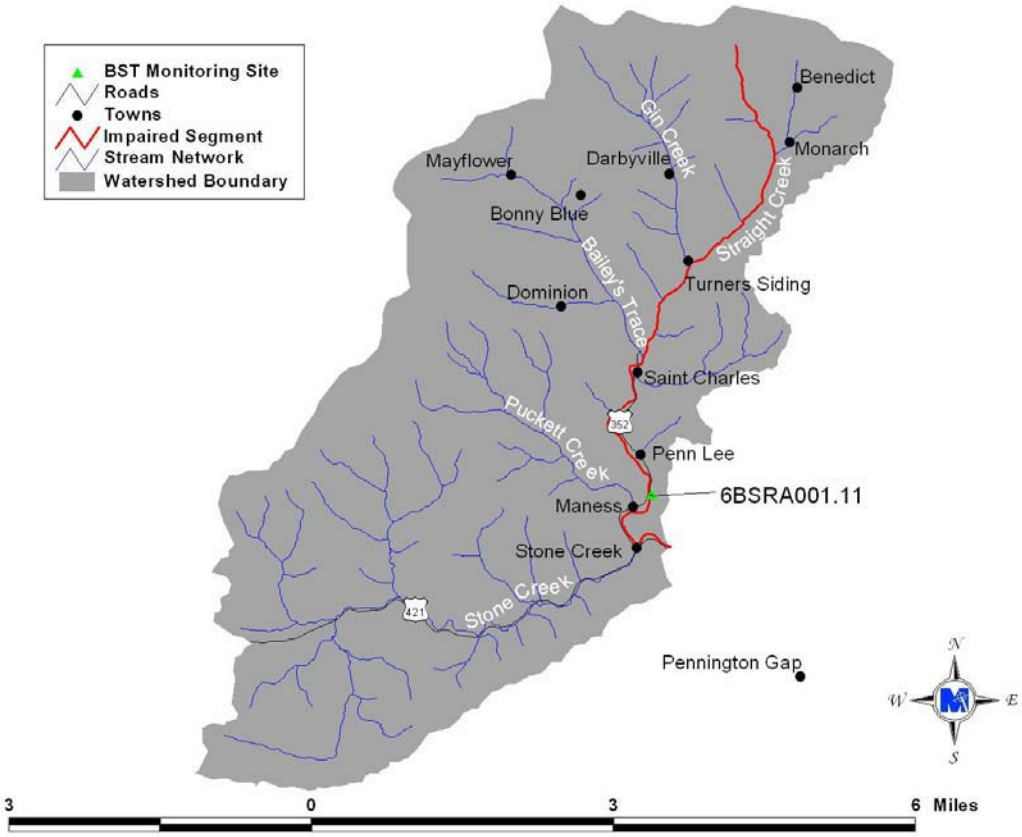

Figure 2.3 Location of the BST water quality monitoring station in the Straight Creek watershed.

2.6 Analysis of BST Data

The data collected were analyzed for frequency of violations, patterns in fecal source identification, and seasonal impacts. Results of the analyses are presented in the following sections.

2.6.1 Bacterial Source Tracking

MapTech, Inc. was contracted to perform analyses of fecal coliform and *E. coli* concentrations as well as bacterial source tracking. Bacterial source tracking is intended to aid in identifying sources (*i.e.,* human, pets, livestock, or wildlife) of fecal contamination in water bodies. Data collected provided insight into the likely sources of fecal contamination, aided in distributing fecal loads from different sources during model calibration, and will improve the chances for success in implementing solutions.

Several procedures are currently under study for use in BST. Virginia has adopted the Antibiotic Resistance Analysis (ARA) methodology implemented by MapTech's EDL. This method was selected because it has been demonstrated to be a reliable procedure for confirming the presence or absence of human, pet, livestock and wildlife sources in watersheds in Virginia. The BST results were reported as the percentage of isolates acquired from the sample identified as originating from humans, pets, livestock, or wildlife.

BST results of water samples collected at an ambient station in the Straight Creek watershed are reported in Table 2.3. The BST results indicate the presence of all sources (*i.e.,* human, wildlife, livestock, and pets) contributing to the fecal bacteria violations. The fecal coliform and *E. coli* enumerations are given to indicate the bacteria concentration at the time of sampling. The proportions reported are formatted to indicate statistical significance (*i.e.,* **BOLD** numbers indicate a statistically significant result), determined through two tests. The first was based on the sample size. A z-test was used to determine if the proportion was significantly different from zero (*alpha* = 0.10). Second, the rate of false positives was calculated for each source category in each library, and a proportion was not considered significantly different from zero unless it was greater than the false-positive rate plus three standard deviations.

Human was the most predominating sources of fecal bacteria, followed by wildlife. These results are consistent with local residents insight as to the sources of fecal contamination in these streams.

Table 2.4 summarizes the results for the station with load-weighted average proportions of bacteria originating from the four source categories. The load-weighted average considers the level of flow in the stream at the time of sampling, the concentration of *E. coli* measured, and the number of bacterial isolates analyzed in the BST analysis. Human is shown as the predominate source.

Table 2.3 Bacterial source tracking results from water samples collected in the Straight Creek impairment.

Station	Date	Fecal Coliform (cfu/100 mL)	*E. coli* (cfu/100 mL)	Percent Isolates classified as[1]:			
				Wildlife	Human	Livestock	Pets
6BSRA001.11	7/21/03	3,300	260	**25%**	**37%**	**17%**	**21%**
	8/20/03	6,600	550	**25%**	**21%**	**37%**	**17%**
	9/17/03	350	300	**54%**	4%	**42%**	0%
	10/15/03	120	500	0%	8%	**84%**	8%
	11/17/03	580	142	**80%**	4%	8%	8%
	12/16/03	280	60	**21%**	**37%**	**17%**	**25%**
	1/12/04	60	96	**38%**	**50%**	8%	4%
	2/17/04	600	94	0%	**84%**	8%	8%
	3/17/04	170	76	**12%**	**80%**	0%	8%
	4/20/04	170	280	8%	**55%**	**33%**	4%
	5/12/04	120	20	**67%**	0%	0%	33%
	6/21/04	290	320	0%	**66%**	**17%**	**17%**

[1]**BOLD** type indicates a statistically significant value.

Table 2.4 Load weighted average proportions of fecal bacteria originating from wildlife, human, livestock, and pet sources.

Station ID	Stream	Wildlife	Human	Livestock	Pet
6BSRA001.11	Straight Creek	18%	44%	26%	11%

2.6.2 Trend and Seasonal Analyses

In order to improve TMDL allocation scenarios and, therefore, the success of implementation strategies, trend and seasonal analyses were performed on precipitation, fecal coliform concentrations, and water chemistry results. A Seasonal Kendall Test was used to examine long-term trends. The Seasonal Kendall Test ignores seasonal cycles when looking for long-term trends. This improves the chances of finding existing trends in data that are likely to have seasonal patterns. Additionally, trends for specific seasons can be analyzed. For instance, the Seasonal Kendall Test can identify the trend (over many years) in discharge levels during a particular season or month.

A seasonal analysis of precipitation and fecal coliform concentrations was conducted using the Mood Median Test. This test was used to compare median values of precipitation, and fec Water quality monitoring data collected by VADEQ were described in Section 2.5. The Seasonal Kendall Test was conducted on fecal coliform

concentrations collected at stations used in TMDL assessment if sufficient data were available. All stations showed no overall trends. All stations in the Straight Creek watershed showed no seasonality in fecal coliform concentrations.

al coliform concentrations in each month.

2.6.2.1 Fecal Coliform Concentrations

2.6.2.2 Precipitation

Daily precipitation measured at Pennington Gap, Virginia was used in analyses for Straight Creek. Total monthly precipitation measured in Pennington Gap, Virginia from January 1980 to March 2004 was analyzed, and no overall, long-term trend or seasonality (using the Moods Median Test) was found.

2.6.2.3 Summary of In-stream Water Quality Monitoring Data

A wide range of fecal coliform concentrations has been recorded in the watershed. Concentrations reported during TMDL development were within the range of historical values reported by VADEQ during TMDL assessment. Exceedances of the instantaneous standard were reported in all flow regimes, leaving no apparent relationship between flow and water quality.

3. SOURCE ASSESSMENT

The TMDL development described in this report includes examination of all potential sources of fecal coliform in the Straight Creek watershed. The source assessment was used as the basis of model development and ultimate analysis of TMDL allocation options. In evaluation of the sources, loads were characterized by the best available information, landowner input, literature values, and local management agencies. This section documents the available information and interpretation for the analysis. The source assessment chapter is organized into point and non-point sections. The representation of the following sources in the model is discussed in Section 4.

3.1 Watershed Characterization

The National Land Cover Data (NLCD) produced cooperatively between USGS and the EPA was utilized for this study. The collaborative effort to produce this dataset is part of a Multi-Resolution Land Characteristics (MRLC) Consortium project led by four U.S. government agencies: EPA, USGS, the Department of the Interior National Biological Service (NBS), and the National Oceanic and Atmospheric Administration (NOAA). Using 30-meter resolution Landsat 5 Thematic Mapper (TM) satellite images taken between 1990 and 1994, digital land use coverage was developed identifying up to 21 possible land use types. Classification, interpretation, and verification of the land cover dataset involved several data sources (when available) including: aerial photography; soils data; population and housing density data; state or regional land cover data sets; USGS land use and land cover (LUDA) data; 3-arc-second Digital Terrain Elevation Data (DTED) and derived slope, aspect and shaded relief; and National Wetlands Inventory (NWI) data. Approximate acreages and land use proportions for the impaired watershed are given in Table 3.1.

Table 3.1 Current land use area for the Straight Creek watershed.

Land use	Straight Creek (acres)
AML	1,991
Barren	4.6
Commercial	17
Forest	14,142
Pasture/Hay	42
Permitted Mining	1,310
Residential	145
Row Crops	8.5
Water	6
Wetlands	3.2
Total	**17,670**

The majority of AML in the Straight Creek watershed is highwalls and their associated benches. The land area of the Straight Creek watershed is approximately 17,700 acres, with forest as the primary land use (Figure 3.1).

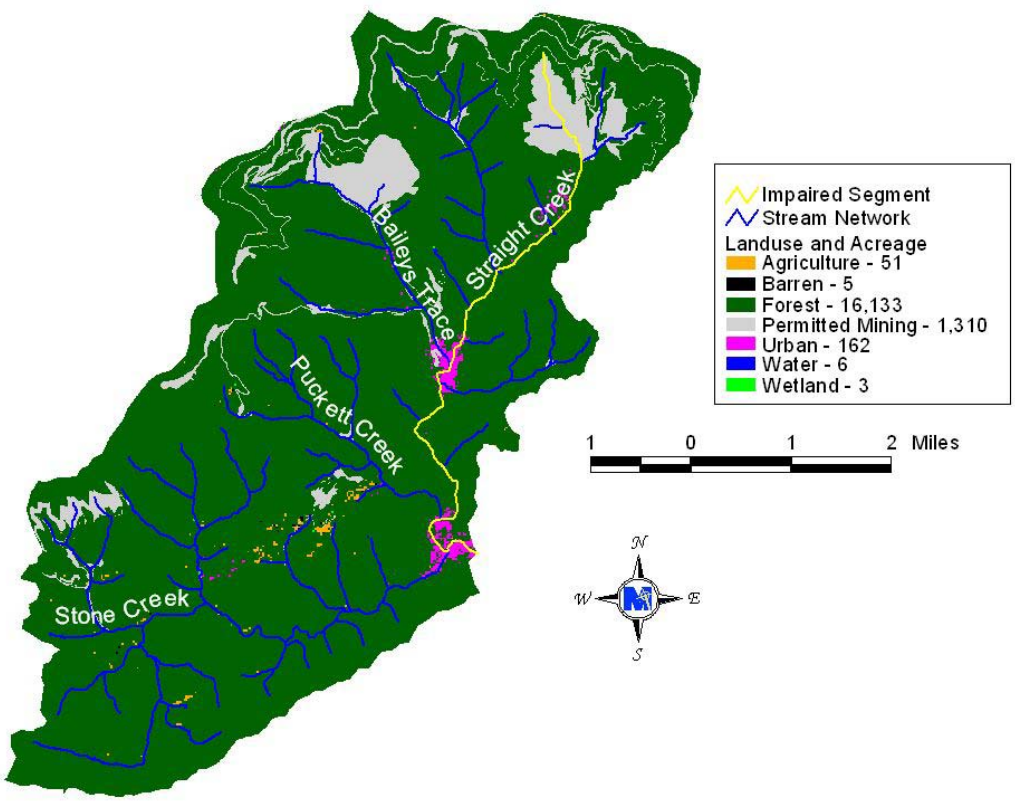

Figure 3.1 Land use in the Straight Creek watershed.

The estimated human population within the Straight Creek drainage area is 1,353 (USCB, 1990, 2000). Among Virginia counties, Lee County ranks 23rd for the number of all cattle and calves and 9th for beef cattle (Virginia Agricultural Statistics, 2001). Lee County is also home to 470 species of wildlife, including 55 types of mammals (*e.g.,* beaver, raccoon, and white - tailed deer) and 155 types of birds (*e.g.,* wood duck, wild turkey, Canada goose) (VDGIF, 2004).

For the period 1955 to 2004, the portion of the Powell River watershed near the town of Pennington Gap received average annual precipitation of approximately 49.48 inches, with 47% of the precipitation occurring during the May through October growing season (SERCC, 2004). Average annual snowfall is 17.5 inches with the highest snowfall occurring during January (SERCC, 2004). Average annual daily temperature is 54.6 ºF. The highest average daily temperature of 85.5 ºF occurs in July, while the lowest average daily temperature of 23.9 ºF occurs in January (SERCC, 2004).

3.2 Assessment of Point Sources

One non-mining point source is permitted in the Straight Creek watershed through the Virginia Pollutant Discharge Elimination System (VPDES). Figure 3.2 shows the permitted location. Permitted point discharges that may contain pathogens associated with fecal matter are required to maintain a fecal coliform concentration below 200 cfu/100 mL. Currently, these permitted dischargers are expected not to exceed the 126 cfu/100mL *E. coli* standard. Table 3.2 summarizes data from this point source.

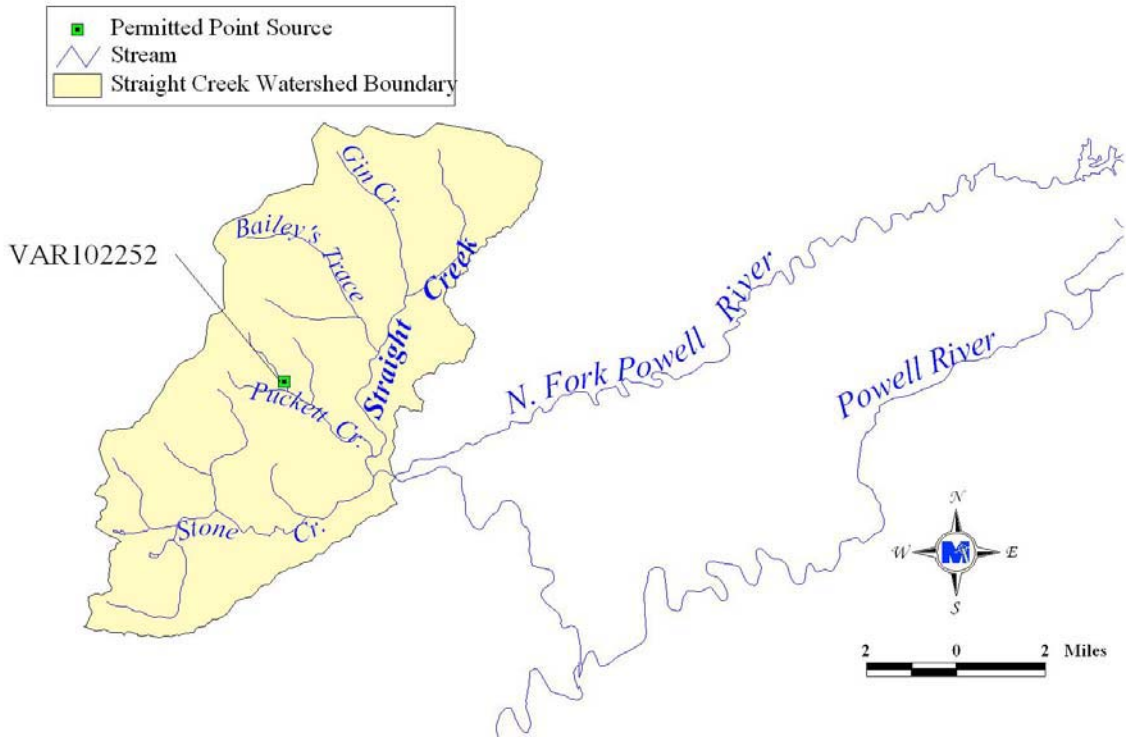

Figure 3.2 Location of VPDES permitted point sources in the Straight Creek watershed.

Table 3.2 Summary of VPDES permitted point sources in the Straight Creek watershed.

Facility Name	Permit No	Design Flow (MGD)	Permitted For Fecal Control	Data Availability	Receiving Stream
VDOT Jonesville - 0754 052 P59, N501	VAR102252	NA	No	ND	Puckett Creek

* ND – no data, facility not required to submit monitoring data, NA – Not available

3.3 Assessment of Nonpoint Sources

In the Straight Creek watershed, both urban and rural nonpoint sources of fecal coliform bacteria were considered. Sources include residential sewage treatment systems, livestock, wildlife, and pets. Sources were identified and enumerated. MapTech collected samples of fecal coliform sources (*i.e.,* wildlife, livestock, and human waste) and enumerated the density of fecal coliform bacteria to support the modeling process, and to expand the database of known fecal coliform sources for purposes of bacterial source tracking (Section 2.6.1). Where appropriate, spatial distribution of sources was also determined.

3.3.1 Private Residential Sewage Treatment

In the U.S. Census questionnaires, housing occupants were asked which type of sewage disposal existed. Houses can be connected to a public sanitary sewer, a septic tank or a cesspool, or the sewage is disposed of in some other way. The Census category "Other Means" includes the houses that dispose of sewage other than by public sanitary sewer or a private septic system. The houses included in this category are assumed to be disposing sewage directly to the stream. Population, housing units, and type of sewage treatment from U.S. Census Bureau were calculated using GIS (Table 3.3).

Table 3.3 Human population, housing units, houses on sanitary sewer, septic systems, and other sewage disposal systems for 2004 in the Straight Creek watershed.

Impaired Segment	Population	Housing Units	Sanitary Sewer	Septic Systems	Other *
Straight Creek	1,353	635	80	339	216

* Houses with sewage disposal systems other than sanitary sewer and septic systems.

Sanitary sewers are piping systems designed to collect wastewater from individual homes and businesses and carry it to a wastewater treatment plant. Sewer systems are designed to carry a specific "peak flow" volume of wastewater to the treatment plant. Within this design parameter, sanitary collection systems are not expected to overflow, surcharge or otherwise release sewage before their waste load is successfully delivered to the wastewater treatment plant.

When the flow of wastewater exceeds the design capacity, the collection system will "back up" and sewage discharges through the nearest escape location. These discharges into the environment are called overflows. Wastewater can also enter the environment through exfiltration caused by line cracks, joint gaps, or breaks in the piping system.

Typical private residential sewage treatment systems (septic systems) consist of a septic tank, distribution box, and drainage field. Waste from the household flows first to the septic tank, where solids settle out and are periodically removed by a septic tank pump-out. The liquid portion of the waste (effluent) flows to the distribution box, where it is distributed among several buried, perforated pipes that comprise the drainage field. Once in the soil, the effluent flows downward to groundwater, laterally to surface water, and/or upward to the soil surface. Removal of fecal coliform is accomplished primarily by die-off during the time between introduction to the septic system and eventual introduction to naturally occurring waters. Properly designed, installed, and functioning septic systems contribute virtually no fecal coliform to surface waters.

A septic failure occurs when a drain field has inadequate drainage or a "break", such that effluent flows directly to the soil surface, bypassing travel through the soil profile. In this situation the effluent is either available to be washed into waterways during runoff events or is directly deposited in-stream due to proximity. A survey of septic pump-out contractors performed by MapTech showed that failures were more likely to occur in the winter-spring months than in the summer-fall months, and that a higher percentage of system failures were reported because of a back-up to the household than because of a failure noticed in the yard.

MapTech sampled waste from septic tank pump-outs and found an average fecal coliform density of 1,040,000 cfu/100 mL. An average fecal coliform density for human waste of 13,000,000 cfu/g and a total waste load of 75 gal/day/person was reported by Geldreich (1978).

3.3.2 Pets

Among pets, cats and dogs are the predominant contributors of fecal coliform in the watershed and were the only pets considered in this analysis. Cat and dog populations were derived from American Veterinary Medical Association Center for Information Management demographics in 1997. Dog waste load was reported by Weiskel et al. (1996), while cat waste load was measured. Fecal coliform density for dogs and cats was measured from samples collected throughout Virginia by MapTech. A summary of the data collected is given in Table 3.4. Table 3.5 lists the domestic animal populations for the impairment in the Straight Creek watershed.

Table 3.4 Domestic animal population density, waste load, and fecal coliform density for the Straight Creek watershed.

Type	Population Density (an/house)	Waste load (g/an-day)	FC Density (cfu/g)
Dog	0.534	450	480,000
Cat	0.598	19.4	9

Table 3.5 Estimated domestic animal populations in the Straight Creek watershed.

Impaired Segment	Dogs	Cats
Straight Creek	339	380

3.3.3 Livestock

The predominant types of livestock in the Straight Creek watershed are cattle and poultry although all types of livestock identified were considered in modeling the watershed. Animal populations were based on communication with Department of Mines, Minerals, and Energy (DMME), Daniel Boone Soil and Water District (DBSWCD), landowner input, watershed visits, and review of all publicly available information on animal type and approximate numbers known to exist within Lee County. Table 3.6 gives a summary of livestock populations in the Straight Creek watershed. Values of fecal coliform density of livestock sources were based on sampling performed by MapTech. Reported manure production rates for livestock were taken from ASAE, 1998. A summary of fecal coliform density values and manure production rates is presented in Table 3.7.

Table 3.6 Livestock populations in the Straight Creek watersheds.

Impaired Segment	Beef Cattle	Horses	Roosters	Turkeys	Ducks	Geese	Goats
Straight Creek	53	12	40	15	10	15	0

Table 3.7 Average fecal coliform densities and waste loads associated with livestock for Straight Creek watershed.

Type	Waste Load (lb/d/an)	Fecal Coliform Density (cfu/g)
Beef (800 lb)	46.4	101,000
Horse (1,000 lb)	51.0	94,000
Rooster[1]	0.26	586,000
Turkey	0.71	1,332
Duck	0.33	3,500
Goose[2]	0.5	250,000
Goat (140 lb)	5.7	15,000

[1] Based on poultry layer waste load production.
[2] Goose waste load was calculated as 50% greater than that of duck, based on field observations and conversation with Gary Costanzo (Costanzo, 2003).

Fecal coliform produced by livestock can enter surface waters through four pathways. First, waste produced by animals in confinement is typically collected, stored, and applied to the landscape (*e.g.,* pasture and cropland), where it is available for wash-off during a runoff-producing rainfall event. Second, grazing livestock deposit manure directly on the land, where it is available for wash-off during a runoff-producing rainfall event. Third, livestock with access to streams occasionally deposit manure directly in streams. Fourth, some animal confinement facilities have drainage systems that divert wash-water and waste directly to drainage ways or streams. No confined animal facilities were identified in the Straight Creek watershed, so only the second and third pathways were considered.

All livestock were expected to deposit some portion of waste on land areas. The percentage of time spent on pasture for beef cattle was reported by the SWCD, NRCS, VADCR, and VCE (Table 3.8). Horses and goats were assumed to be in pasture 100% of the time.

Based on discussions with DBSWCD, VCE, and NRCS, it was concluded that beef cattle were expected to make a significant contribution through direct deposition to streams,

where access was available, however, it was also discussed that access would be limited on reclaimed mine benches, where most of the cattle are grazed. The average amount of time spent by beef cattle in stream access areas (*i.e.*, within 50 feet of the stream) for each month is given in Table 3.8.

Table 3.8 Average time beef cows not confined in feedlots spend in pasture and stream access areas per day for Straight Creek watershed.

Month	Pasture (hr)	Stream Access (hr)
January	23.3	0.7
February	23.3	0.7
March	23.0	1.0
April	22.6	1.4
May	22.6	1.4
June	22.3	1.7
July	22.3	1.7
August	22.3	1.7
September	22.6	1.4
October	23.0	1.0
November	23.0	1.0
December	23.3	0.7

3.3.4 Wildlife

The predominant wildlife species in the watershed were determined through consultation with wildlife biologists from the Virginia Department of Game and Inland Fisheries (VDGIF), United States Fish and Wildlife Service (FWS), citizens from the watershed, source sampling, and site visits. Population densities were calculated from data provided by VDGIF and FWS, as well as The Center for Conservation Biology, and are listed in Table 3.9 (Bidrowski, 2004; Farrar, 2003; Fies, 2004; Knox, 2004; Norman, 2004; and Rose and Cranford, 1987). The numbers of animals estimated to be in the Straight Creek watershed are reported in Table 3.10. Habitat and seasonal food preferences were determined based on information obtained from The Fire Effects Information System (http://www.fs.fed.us/database/feis) (1999) and VDGIF (Costanzo, 2003; Norman, 2003; Rose and Cranford, 1987; and VDGIF, 1999). Waste loads were comprised from literature values and discussion with VDGIF personnel (ASAE, 1998; Bidrowski, 2003; Costanzo, 2003; Weiskel et al., 1996; and Yagow, 1999). Where available, fecal coliform densities were based on sampling of wildlife waste performed by MapTech.

The only value that was not obtained from MapTech sampling was for beaver. The fecal coliform density of beaver waste was taken from sampling done for the Mountain Run TMDL development (Yagow, 1999). Percentage of time spent in stream access areas and percentage of waste directly deposited to streams was based on habitat information and location of feces during source sampling. Fecal coliform densities and estimated percentages of time spent in stream access areas (*i.e.*, within 100 feet of stream) are reported in Table 3.11. Table 3.12 summarizes the habitat and fecal production information that was obtained.

Table 3.9 Wildlife population density in Lee (Straight Creek) county.

County	Deer (an/ac of habitat)	Turkey (an/ac)	Goose (an/ac)	Duck (an/ac)	Muskrat (an/ac of habitat)	Raccoon (an/ac of habitat)	Beaver (an/mi of stream)
Lee	0.028	0.016	0.004	0.005	2.75	0.0703	3.8

Table 3.10 Wildlife populations in the Straight Creek watershed.

Impairment	Deer	Turkey	Goose	Duck	Muskrat	Raccoon	Beaver
Straight Creek	409	111	75	94	1,541	354	368

Table 3.11 Average fecal coliform densities and percentage of time spent in stream access areas for wildlife for the Straight Creek watershed.

Animal Type	Fecal Coliform Density (cfu/g)	Portion of Day in Stream Access Areas (%)
Raccoon	2,100,000	5
Muskrat	1,900,000	90
Beaver	1,000	100
Deer	380,000	5
Turkey	1,332	5
Goose	250,000	50
Duck	3,500	75

Table 3.12 Wildlife fecal production rates and habitat for the Straight Creek watershed.

Animal	Waste Load (g/an-day)	Habitat
Raccoon	450	Primary = region within 600 ft of perennial streams Secondary = region between 601 and 7,920 ft from perennial streams Infrequent/Seldom = rest of watershed area including waterbodies (lakes, ponds)
Muskrat	100	Primary = waterbodies, and land area within 66 ft from the edge of perennial streams, and waterbodies Secondary = region between 67 and 308 ft from perennial streams, and waterbodies Infrequent/Seldom = rest of the watershed area
Beaver[1]	200	Primary = Perennial streams. Generally flat slope regions (slow moving water), food sources nearby (corn, forest, younger trees) Infrequent/Seldom = rest of the watershed area
Deer	772	Primary = forested, harvested forest land, orchards, grazed woodland, urban grassland, cropland, pasture, wetlands, transitional land Secondary = low density residential, medium density residential Infrequent/Seldom = remaining land use areas
Turkey[2]	320	Primary = forested, harvested forest land, grazed woodland, orchards, wetlands, transitional land Secondary = cropland, pasture Infrequent/Seldom = remaining land use areas
Goose[3]	225	Primary = waterbodies, and land area within 66 ft from the edge of perennial streams, and waterbodies Secondary = region between 67 and 308 ft from perennial streams, and waterbodies Infrequent/Seldom = rest of the watershed area
Duck	150	Primary = waterbodies, and land area within 66 ft from the edge of perennial streams, and waterbodies Secondary = region between 67 and 308 ft from perennial streams, and waterbodies Infrequent/Seldom = rest of the watershed area

[1]Beaver waste load was calculated as twice that of muskrat, based on field observations.
[2]Waste load for domestic turkey (ASAE, 1998).
[3]Goose waste load was calculated as 50% greater than that of duck, based on field observations and conversation with Gary Costanzo (Costanzo, 2003).

4. MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between in-stream water quality and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired water quality endpoint. In the development of TMDLs for the Straight Creek watershed, the relationship was defined through computer modeling based on data collected throughout the watershed. Monitored flow and water quality data were then used to verify that the relationships developed through modeling were accurate. In this section, the selection of modeling tools, parameter development, calibration, and model application are discussed.

4.1 Modeling Framework Selection

The USGS Hydrologic Simulation Program - Fortran (HSPF) water quality model was selected as the modeling framework to simulate existing conditions and to perform TMDL allocations. The HSPF model is a continuous simulation model that can account for nonpoint source (NPS) pollutants in runoff, as well as pollutants entering the flow channel from point sources. In establishing the existing and allocation conditions, seasonal variations in hydrology, climatic conditions, and watershed activities can be explicitly accounted for in the model. The use of HSPF allowed for consideration of seasonal aspects of precipitation patterns within the watershed.

The HSPF model simulates a watershed by dividing it up into a network of stream segments (each referred to in the model as a RCHRES), impervious land areas (IMPLND) and pervious land areas (PERLND). Each subwatershed contains a single RCHRES, modeled as an open channel, and numerous PERLNDs and IMPLNDs, representing the various land uses in that subwatershed. Water and pollutants from the land segments in a given subwatershed flow into the RCHRES in that subwatershed. Point discharges and withdrawals of water and pollutants are simulated as flowing directly to or withdrawing from a particular RCHRES as well. Water and pollutants from a given RCHRES flow into the next downstream RCHRES. The network of RCHRESs is constructed to mirror the configuration of the stream segments found in the physical

world. Therefore, activities simulated in one impaired stream segment affect the water quality downstream in the model.

4.2 Model Setup

Because the nearest continuous stream flow data were observed at a USGS station on North Fork Powell River (#03530500), hydrology was calibrated for an area larger than the drainage area of the impaired stream. All water quality modeling (fecal coliform and benthic) was performed only for the impaired (Straight Creek) watershed.

To adequately represent the spatial variation in the Straight Creek watershed, the drainage area was divided into 4 subwatersheds (Figure 4.1). The USGS Station #03530500 on the North Fork Powell River was the outlet for the hydrologic model. This area includes the Straight Creek watershed and the headwaters of the North Fork Powell River. The subwatersheds used in the modeling for Straight Creek and North Fork Powell are shown in Figure 4.1. The area contributing to the bacteria and benthic impairments in Straight Creek includes subwatersheds 6, 7, 8, and 9.

The rationale for choosing subwatersheds was based on the availability of surface flow data and water quality data (fecal coliform and TDS), which were available at specific locations throughout the watershed. Subwatershed outlets were chosen to coincide with monitoring stations, since output from the model can only be obtained at the modeled subwatershed outlets. The spatial division of the watershed allowed for a more refined representation of pollutant sources, and a more realistic description of hydrologic factors in the watershed.

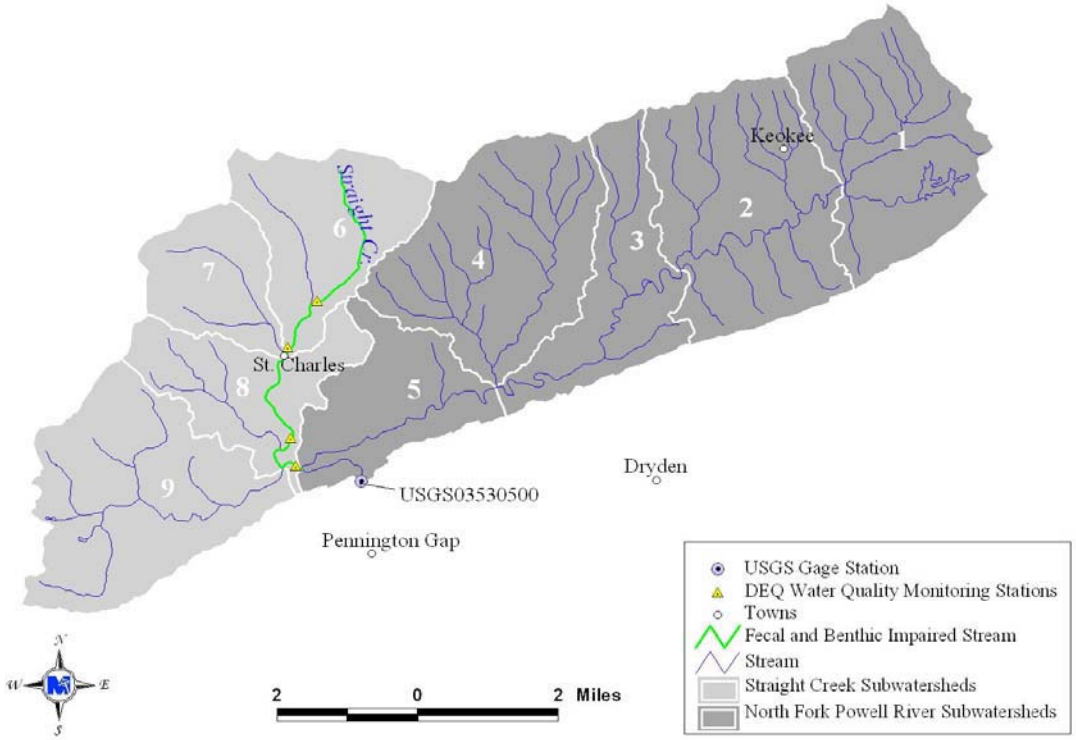

Figure 4.1 Subwatersheds delineated for modeling the hydrology of the North Fork Powell River watershed and the water quality of the Straight Creek watershed.

Using MRLC, U.S. Census Bureau TIGER (Topologically Integrated Geographic Encoding and Referencing), and DMME maps, land use types in the modeled watersheds were identified. The land use types were consolidated into fifteen categories based on similarities in hydrologic features pollutant loadings (Tables 4.1 and 4.2). Within each subwatershed, up to the fifteen land use categories were represented. Each land use had parameters associated with it that described the hydrology of the area (*e.g.,* average slope length) and the behavior of pollutants. These land use types are represented in HSPF as PERLNDs and IMPLNDs. Impervious areas are represented in seven IMPLND types, while there are twelve PERLND types, each with parameters describing a particular land use (Table 4.1 and 4.2). Some IMPLND and PERLND parameters (*e.g.,* slope length)

vary with the particular subwatershed in which they are located. Others (*e.g.*, upper zone storage) vary with season to account for plant growth, die-off, and removal.

Table 4.1 Land use categories for the Straight Creek watershed.

TMDL Land use Categories	Pervious / Impervious (%)	Land use Classifications (MRLC Class No. where applicable)
Abandoned Mine Land	Pervious (70%) Impervious (30%)	Land disturbed by mining operations before 1978 and not reclaimed
Active Mining	Pervious (100%)	Land disturbed by mining operations
Barren	Pervious (70%) Impervious (30%)	Bare Rock/Sand/Clay (31) Transitional (33)
Cropland	Pervious (100%)	Row Crops (82)
Commercial	Pervious (80%) Impervious (20%)	Commercial/Industrial/Transportation (23)
Forest	Pervious (100%)	Deciduous Forest (41) Evergreen Forest (42) Mixed Forest (43)
Livestock Access	Pervious (100%)	Pasture/Hay (81) near streams
Pasture	Pervious (100%)	Pasture/Hay (81)
Reclaimed	Pervious (100%)	Land regraded and revegetated after mining operations
Residential	Pervious (80%) Impervious (20%)	Low Intensity Residential (21) High Intensity Residential (22)
Roads – paved	Impervious (100%)	Paved roads
Roads – unpaved	Impervious (100%)	Gravel and dirt roads
Water	Pervious (100%)	Open Water (11)
Wetlands	Pervious (100%)	Woody Wetlands (91) Emergent Herbaceous Wetlands (92)

Table 4.2 Contributing land use area for the North Fork Powell River watershed.

Land use	Straight Creek and North Fork Powell River watersheds (acres)
Barren	364
Commercial	43
Cropland	19
Forest	38,940
Livestock Access	4
Pasture/Hay	117
Residential	256
Transitional	0
Water	760
Wetlands	71
Abandoned Mine Land	1,991**
Active Mining	2,675
Reclaimed	167
Roads–paved	63
Roads-unpaved	60
Total	**45,530**

For the purpose of modeling the hydrology and TDS loads from AML, only AML sites outside boundaries of current permitted mining permits were incorporated. It was assumed that AML located in current permit areas would be reclaimed when the permit is released.

4.2.1 Mine Land Hydrology Model Setup

Surface mining requires sediment/runoff retention ponds, which are regulated through the Virginia DMME. The outflow from these ponds is modeled through an additional RCHRES for each subwatershed with a retention pond. The disturbed land area contributing to these ponds was accounted for in the RCHRES. The average revegetated land per year was an input into the model to represent average reclamation efforts completed each year. The locations of these ponds in the Straight Creek watershed are shown in Figure 4.2.

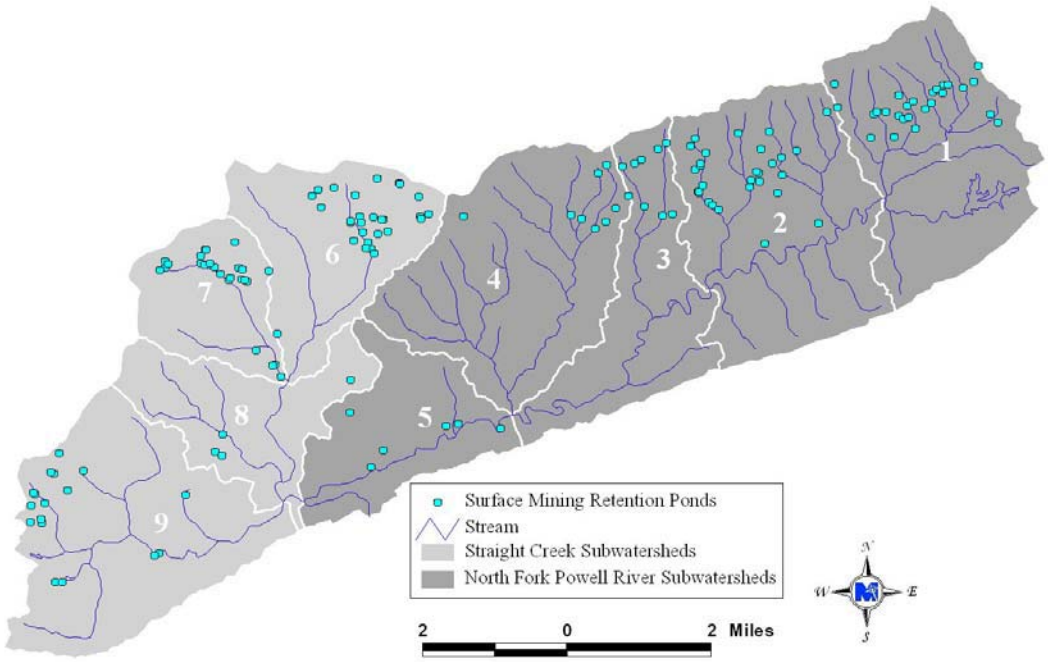

Figure 4.2 Surface runoff retention ponds operational during the calibration time period in the North Fork Powell River and Straight Creek watersheds.

4.2.2 Water Quality Model Setup

Die-off of fecal coliform can be handled implicitly or explicitly. For land-applied fecal matter (fecal matter deposited directly on land), die-off occurring in the field was represented implicitly through model parameters such as the maximum accumulation and the 90% wash off rate, which were adjusted during the calibration of the model. These parameters were assumed to represent not only the delivery mechanisms, but the bacteria die-off as well. Once the fecal coliform entered the stream, the general decay module of HSPF was incorporated, thereby explicitly addressing the die-off rate. The general decay module uses a first order decay function to simulate die-off.

4.3 Source Representation - Fecal Coliform

Both point and nonpoint sources can be represented in the model. In general, point sources are added to the model as a time-series of pollutant and flow inputs to the stream. Land-based nonpoint sources are represented as an accumulation of pollutants on land, where some portion is available for transport in runoff. The amount of accumulation and availability for transport varies with land use type and season. The model allows for a maximum accumulation to be specified. The maximum accumulation was adjusted seasonally to account for changes in die-off rates, which are dependent on temperature and moisture conditions. Some nonpoint sources, rather than being land-based, are represented as being deposited directly to the stream (*e.g.*, animal defecation in stream). These sources are modeled similarly to point sources, as they do not require a runoff event for delivery to the stream. These sources are primarily due to animal activity, which varies with the time of day. Direct depositions by nocturnal animals were modeled as being deposited from 6:00 PM to 6:00 AM, and direct depositions by diurnal animals were modeled as being deposited from 6:00 AM to 6:00 PM. Once in stream, die-off is represented by a first-order exponential equation.

Much of the data used to develop the model inputs for modeling water quality is time-dependent (*e.g.,* population). Depending on the time-frame of the simulation being run, different numbers should be used. For modeling Straight Creek fecal coliform loads, data representing 1995 were used for the water quality calibration period (1990-1994). Data representing 2004 were used for the allocation runs in order to represent current conditions for the impairment.

4.3.1 Point Sources

For permitted point discharges, design flow capacities were used for allocation runs. This flow rate was combined with a fecal coliform concentration of 200 cfu/100 mL, where discharges were permitted for fecal control, to ensure that compliance with state water quality standards could be achieved even if permitted loads were at maximum levels. Nonpoint sources of pollution that were not driven by runoff (*e.g.*, direct deposition of fecal matter to the stream by wildlife) were modeled similarly to point

sources. These sources, as well as land-based sources, are identified in the following sections.

4.3.2 Private Residential Sewage Treatment

Through GIS, the number of septic systems in the subwatersheds modeled for the Straight Creek watershed was calculated by overlaying U.S. Census Bureau data (USCB, 1990; USCB, 2000) with the watershed to enumerate the septic systems. Households were then distributed among residential land use types. Each land use area was assigned a number of septic systems based on census data. In Straight Creek there were an estimated 386 septic systems in 1995. During allocation runs, the number of households was projected to 2004 values (based on current Lee County growth rates -- USCB, 2000) resulting in 339 in the Straight Creek watershed (Table 4.3).

Table 4.3 Estimated failing septic systems and straight pipes (2004) for the Straight Creek watershed.

Impaired Segment	Total Septic Systems	Failing Septic Systems	Straight Pipes
Straight Creek	339	140	216

4.3.2.1 Failing Septic Systems

Failing septic systems were assumed to deliver all effluent to the soil surface where it was available for wash-off during a runoff event. In accordance with estimates from Raymond B. Reneau, Jr. of the Crop and Soil Environmental Sciences Department at Virginia Tech, a 40% failure rate for systems designed and installed prior to 1964, a 20% failure rate for systems designed and installed between 1964 and 1984, and a 5% failure rate on all systems designed and installed after 1984 was used in development of TMDLs for the Straight Creek watershed (Reneau, 2000). Total septic systems in each category were calculated using U.S. Census Bureau block demographics. The applicable failure rate was multiplied by each total and summed to get the total failing septic systems per subwatershed. The fecal coliform density for septic system effluent was multiplied by the average design load for the septic systems in the subwatershed to determine the total load from each failing system. Additionally, the loads were distributed seasonally based

on a survey of septic pump-out contractors to account for more frequent failures during wet months.

4.3.2.2 Uncontrolled Discharges

Uncontrolled discharges were estimated using 1990 U.S. Census Bureau block demographics. Houses listed in the Census sewage disposal category "other means" were assumed to be disposing sewage via uncontrolled discharges such as straight pipes. Corresponding block data and subwatershed boundaries were intersected to determine an estimate of uncontrolled discharges in each subwatershed. After public comment on the estimated numbers indicated that uncontrolled discharges were not being represented adequately, an informal survey was conducted by local VDH personnel, and the numbers were adjusted accordingly (Table 4.3). Fecal coliform loads for each discharge were calculated based on the fecal density of human waste and the waste load for the average size household in the subwatershed. The loadings from uncontrolled discharges were applied directly to the stream in the same manner that point sources are handled in the model. Total dissolved solids (TDS) concentration from human waste for each discharge was estimated as 500 mg/L (Metcalf and Eddy, 1991). A total suspended solids concentration from human waste was estimated as 320 mg/L (Lloyd, 2004). The methods of incorporating TDS and TSS loads into the model are discussed further in Chapter 9.

4.3.2.3 Sewer System Overflows

During the model calibration and allocation periods, there were no reported sewer overflows in the Straight Creek watershed.

4.3.3 Livestock

Fecal coliform produced by livestock can enter surface waters through four pathways: land application of stored waste, deposition on land, direct deposition to streams, and diversion of wash-water and waste directly to streams. Due to the lack of confined animal facilities in this watershed, only deposition on land and direct deposition to streams are accounted for in the model. The number of fecal coliform directed through each pathway was calculated by multiplying the fecal coliform density with the amount

of waste expected through that pathway. Livestock numbers determined for 2004 were used for the allocation runs, while these numbers were projected back to 1995 for the calibration and validation runs for Straight Creek. The numbers are based on data provided by Daniel Boone SWCD, DMME, NRCS, and verbal communication with the local community. Growth rates were taken into account in Lee County as determined from data reported by the Virginia Agricultural Statistics Service (VASS, 1995 and VASS, 2002). The fecal coliform density in as-excreted manure was used to calculate the load for deposition on land and to streams (Table 3.7).

4.3.3.1 Deposition on Land

For cattle, the amount of waste deposited on land per day was a proportion of the total waste produced per day. The proportion was calculated based on the study entitled "Modeling Cattle Stream Access" conducted by the Biological Systems Engineering Department at Virginia Tech and MapTech, Inc. for VADCR. The proportion was based on the amount of time spent in pasture, but not in close proximity to accessible streams, and was calculated as follows:

Proportion = [(24 hr) – (time in confinement) – (time in stream access areas)]/(24 hr)

All other livestock (horse and goat) were assumed to deposit all feces on pasture. The total amount of fecal matter deposited on the pasture land use type was area-weighted.

4.3.3.2 Direct Deposition to Streams

The amount of waste deposited in streams by livestock each day was a proportion of the total waste produced per day by cattle. First, the proportion of manure deposited in "stream access" areas was calculated based on the "Modeling Cattle Stream Access" study. The proportion was calculated as follows:

Proportion = (time in stream access areas)/(24 hr)

For the waste produced on the "stream access" land use, 30% of the waste was modeled as being directly deposited in the stream and 70% remained on the land segment adjacent to the stream. The 70% was treated as manure deposited on land. However, applying it

in a separate land-use area (stream access) allows the model to consider the proximity of the deposition to the stream. The 30% that was directly deposited to the stream was modeled in the same way that point sources are handled in the model.

4.3.4 Biosolids

Investigation of VDH data indicated that no biosolids applications have occurred within the Straight Creek watershed. For model calibration, biosolids were not included.

4.3.5 Wildlife

For each species, a GIS habitat layer was developed based on the habitat descriptions that were obtained (Section 3.3.4). Examples of these layers are shown in Figure 4.3. This layer was overlaid with the land use layer and the resulting area was calculated for each land use in each subwatershed. The number of animals per land segment was determined by multiplying the area by the population density. Fecal coliform loads for each land segment were calculated by multiplying the waste load, fecal coliform densities, and number of animals for each species.

Seasonal distribution of waste was determined using seasonal food preferences for deer and turkey. Goose and duck populations were varied based on migration patterns, but the load available for delivery to the stream was never reduced below 40% of the maximum to account for the resident population of birds. For each species, a portion of the total waste load was considered to be land-based, with the remaining portion being directly deposited to streams. The portion being deposited to streams was based on the amount of time spent in stream access areas (Table 3.12). For all animals other than beaver, it was estimated that 5% of fecal matter produced while in stream access areas was directly deposited to the stream. For beaver, it was estimated that 100% of fecal matter would be directly deposited to streams. No long-term (1995–2004) projections were made to wildlife populations, as there was no available data to support such adjustments.

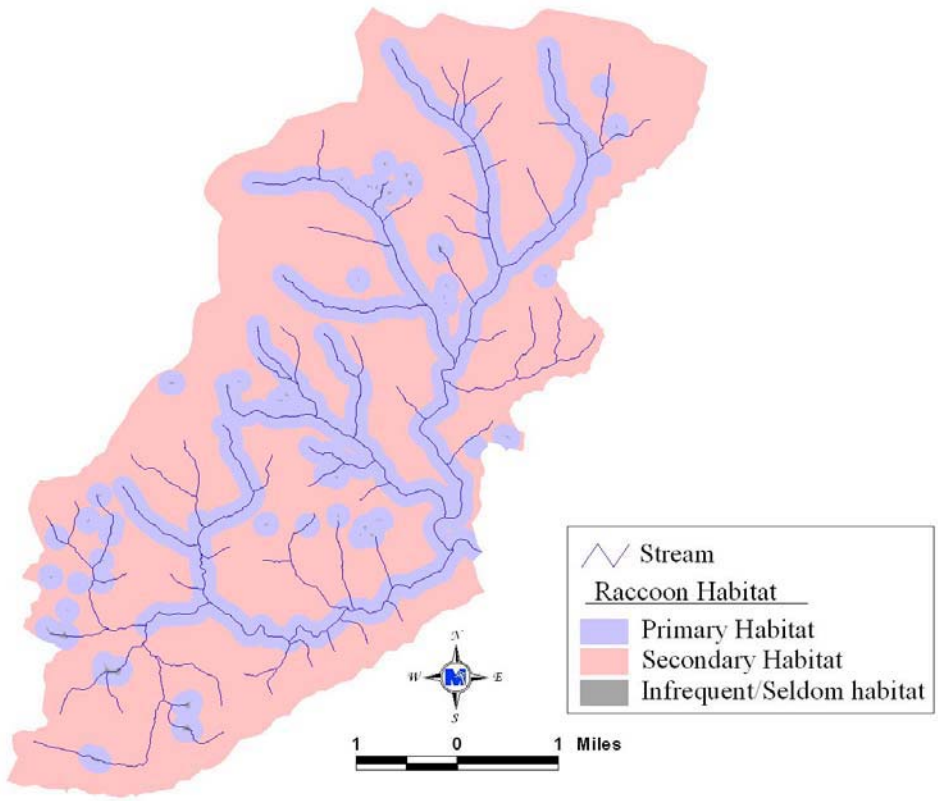

Figure 4.3 Example of raccoon habitat layer in the Straight Creek watershed as developed by MapTech.

4.3.6 Pets

Cats and dogs were the only pets considered in this analysis. Population density (animals/house), waste load, and fecal coliform density are reported in Section 3.3.2. Waste from pets was distributed in the residential land uses. The locations of households were taken from census reports from 1990 and 2000 (USCB, 1990, 2000). Using GIS, the land use and household layers were overlaid, which resulted in number of households per land use. The number of animals per land use was determined by multiplying the number of households by the population density. The amount of fecal coliform deposited daily by pets in each land use segment was calculated by multiplying the waste load, fecal coliform density, and number of animals of both cats and dogs. The waste load was

assumed not to vary seasonally. The population figures for cats and dogs were projected from 1990 data to 1995 and 2004.

4.4 Stream Characteristics

HSPF requires that each stream reach be represented by constant characteristics (*e.g.,* stream geometry and resistance to flow). In order to determine a representative stream profile for each stream reach, cross-sections were surveyed at locations that were representative of the stream for the modeled subwatersheds.

Most of the sections exhibited distinct flood plains with pitch and resistance to flow significantly different from that of the main channel slopes. The streambed, channel banks, and flood plains were identified. Once identified, the streambed width and slopes of channel banks and flood plains were calculated using the survey data. A representative stream profile for each surveyed cross-section was developed and consisted of a trapezoidal channel with pitch breaks at the beginning of the flood plain (Figure 4.4). With this approach, the flood plain can be represented differently from the streambed. To represent the entire reach, profile data collected at each end of the reach were averaged.

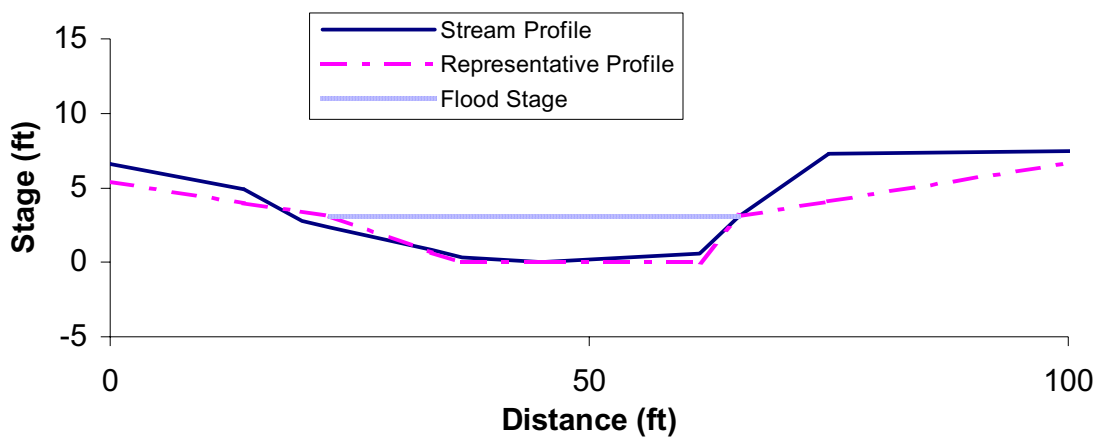

Figure 4.4 Stream profile representation in HSPF.

Conveyance was used to facilitate the calculation of discharge in the reach with different values for resistance to flow (*i.e.,* Manning's *n*) assigned to the flood plains and

streambeds. The conveyance was calculated for each of the two flood plains and the main channel, then these were added together to obtain a total conveyance. Calculation of conveyance was performed following the procedure described by Chow (1959). The total conveyance was then multiplied by the square root of the average reach slope to obtain the discharge (ft^3/s) at a given depth.

A key parameter used in the calculation of conveyance is the Manning's roughness coefficient, *n*. There are many ways to estimate this parameter for a section. The method first introduced by Cowan (1956) and adopted by the Soil Conservation Service (1963) was used to estimate Manning's *n*. This procedure involves a 6-step process of evaluating the properties of the reach, which is explained in more detail by Chow (1959). Field data describing the channel bed, bank stability, vegetation, obstructions, and other pertinent parameters were collected. Photographs were also taken of the sections while in the field. Once the field data were collected, they were used to estimate the Manning's roughness coefficient for the section observed. The pictures were compared to pictures contained in Chow (1959) for validation of the estimates of the Manning's *n* for each section.

The result of the field inspections of the reach sections was a set of characteristic slopes (channel sides and field plains), bed widths, heights to flood plain, and Manning's roughness coefficients. Average reach slope and reach length were obtained from GIS layers of the watershed, which included elevation from Digital Elevation Models (DEMs) and a stream-flow network developed from high resolution National Hydrologic Dataset (NHD) data. These data were used to derive the Hydraulic Function Tables (F-tables) used by the HSPF model (Table 4.4). The F-tables consist of four columns: depth (ft), area (ac), volume (ac-ft), and outflow (ft^3/s). The depth represents the possible range of flow, with a maximum value beyond what would be expected for the reach. The area listed is the surface area of the stream reach or reservoir in acres. The volume corresponds to the total volume of the flow in the reach, and is reported in acre-feet. The outflow is simply the stream discharge, in cubic feet per second. The HSPF model calculates discharge based on volume of water in the reach. For the case of impoundments that were modeled, a minimum volume was set based on design

parameters of the pond. During periods of no discharge from the pond, the only pathway for removal of water from the pond was evaporation.

Table 4.4 Example of an "F-table" calculated for the HSPF Model.

Depth (ft)	Area (ac)	Volume (ac-ft)	Discharge (cfs)
0	0	0	0
0.35	3.09	25.63	0.04
0.7	12.96	39.76	23.87
1.05	13.64	52.06	45.84
1.4	14.37	65.89	72.44
1.75	15.15	81.35	102.9
2.1	15.98	98.56	136.69
2.45	16.87	117.64	173.39
2.8	17.8	138.71	212.7
3.15	18.78	161.86	254.34
3.5	19.82	187.24	298.12
3.85	19.87	190.67	343.86
9.5	20.75	248.72	1275.84
15.15	21.63	311.76	2464.83
20.8	22.52	379.77	3861.02
26.45	23.4	452.77	5454.18
32.1	24.28	530.75	7244.12

4.5 Selection of Representative Modeling Period

Selection of the modeling period was based on three factors: availability of data (discharge and water quality), the degree of land-disturbing activity, and the need to represent critical hydrological conditions. Using these criteria, modeling periods were selected for hydrology calibration, water quality calibration, and modeling of allocation scenarios.

For the North Fork Powell River, flow data were available at USGS Station #03530500 during the period 10/1/1944 through 9/30/1951, 10/1/1978 through 9/30/1981, and 10/1/1993 through 10/3/1995. A linear regression was also performed on this data using continuous data from USGS Station #03531500 on the Powell River. The resulting data were continuous daily flow values at USGS Station #03530500 in the North Fork Powell River at Pennington Gap from 10/1/1944 through 9/30/2003. Fecal coliform data for

Straight Creek were available in the period from 7/11/1990 through 3/12/2001 at various locations throughout the watershed.

Much of the data used to develop the model inputs for modeling water quality is time-dependent. Depending on the time frame of the simulation being run, the model was varied appropriately. Based on a review of mine permit anniversary reports, it was evident that significant landform alterations started to occur in the Straight Creek and the North Fork Powell River watersheds in 1997 (Figures 4.5 and 4.6). The hydrographic landscape of the watershed was relatively stable during the hydrology calibration periods, 10/1/1991-3/31/1995 for the North Fork Powell River. Data representing these periods were used to develop the hydrologic models used in this study.

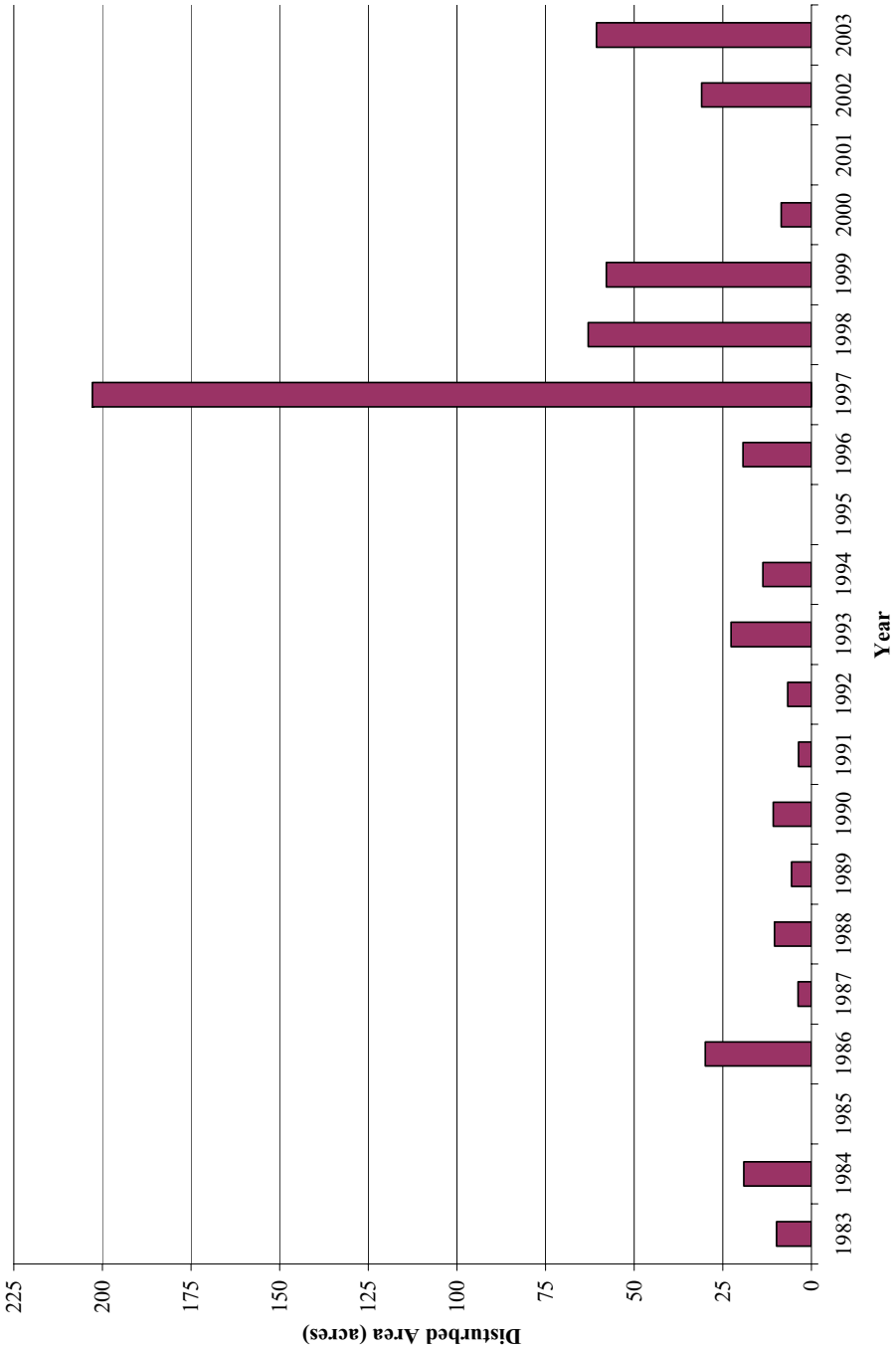

Figure 4.5 Annual land disturbed by mining practices in the Straight watershed.

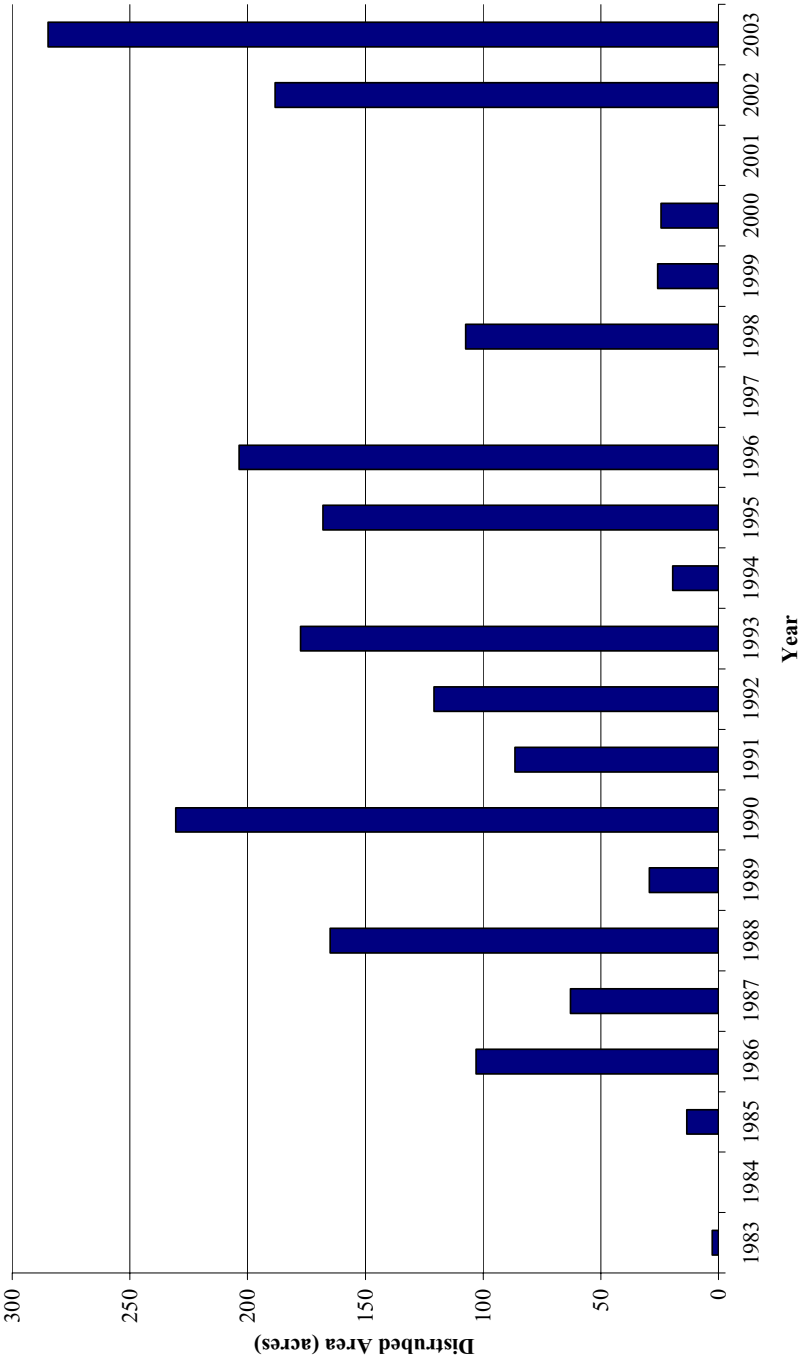

Figure 4.6 Annual land disturbed by mining practices in the North Fork Powell River watershed.

A representative period for water quality calibration for Straight Creek was selected with consideration given to the hydrology calibration period, availability of water quality data, the total land disturbed due to mining operations, and the VADEQ assessment period from July 1992 through June 1997 that led to the inclusion of the Straight Creek segment on the *1998 Section 303(d) Total Maximum Daily Load Priority List and Report* (VADEQ, 1998). With these criteria in mind, the modeling period for fecal coliform water quality calibration was 10/1/1990 through 9/29/1994 (Table 4.5). No fecal coliform water quality validation was performed due to the short timeframe of land use stability. It was determined that using all available data for calibration would result in a more accurate model.

Table 4.5 Summary of modeling time periods for the Straight Creek watershed.

Impairment	Hydrology Calibration	Water Quality (FC) Calibration
Straight Creek	10/1/1991 to 3/31/1995	10/1/1990 to 9/29/1994

The allocation precipitation time periods were selected to coincide with the calibration time periods. Modeling during the calibration periods provides the highest confidence in allocation results.

4.6 Sensitivity Analysis

Sensitivity analyses were conducted to assess the sensitivity of the model to changes in hydrologic and water quality parameters as well as to assess the impact of unknown variability in source allocation (*e.g.,* seasonal and spatial variability of waste production rates for wildlife, livestock, septic system failures, uncontrolled discharges, background loads, and point source loads).

Sensitivity analyses were run on both hydrologic and water quality parameters. The parameters adjusted for the hydrologic sensitivity analyses are presented in Table 4.6 with base values for the model runs given. The parameters were typically adjusted to -50%, -10%, 10%, and 50% of the base value. Where an increase of 50% exceeded the maximum value for the parameter, the maximum value was used and the parameters increased over the base value were reported. The model was run for the hydrology

calibration time period. The hydrologic quantities of greatest interest in modeling NPS pollutants are those that govern peak (high) flows and low flows. Peak flows, being a function of runoff, are important because they are directly related to the transport of NPS pollutants from the land surface to the stream. Peak flows were most sensitive to changes in the parameters governing infiltration such as INFILT (Infiltration) and MON-LZETP (Monthly Lower Zone Evapotranspiration) and AGWRC (Groundwater Recession Rate). To a lesser extent peak flows were sensitive to UZSN (Upper Zone Storage), LZSN (Lower Zone Storage), and direct ET from shallow groundwater (AGWETP). Low flows are important in a water quality model because they control the level of dilution during dry periods. Parameters with the greatest influence on low flows (as evidenced by their influence in the Low Flows and Summer Flow Volume statistics) were AGWRC, INFILT, INTERCEP (interception), MON-LZETP, DEEPFR (Losses to Deep Aquifers) and, to a lesser extent, BASETP (Evapotranspiration from Base Flow). The responses of these and other hydrologic outputs are reported in Table 4.7

Table 4.6 Base parameter values used to determine Straight Creek hydrologic model response.

Parameter	Description	Units	Base Value
AGWRC	Active Groundwater Coefficient	1/day	0.945
BASETP	Base Flow Evapotranspiration	---	0.0345
CEPSC	Interception Storage Capacity	in	0.01 – 0.2
DEEPFR	Fraction of Deep Groundwater	---	0.0 – 0.50
INFILT	Soil Infiltration Capacity	in/hr	0.001 – 0.1154
INTFW	Interflow Inflow	---	1.3
KVARY	Groundwater Recession Coefficient	1/day	0.0
LZSN	Lower Zone Nominal Storage	in	2.0
MON-LZETP	Monthly Lower Zone Evapotranspiration	---	0.01 – 0.8
NSUR	Manning's *n* for Overland Flow	---	0.1
UZSN	Upper Zone Storage Capacity	in	0.05 – 9.952

Table 4.7 Sensitivity analysis results for Straight Creek for hydrologic model parameters (% difference).

Model Parameter	Parameter Change (%)	Total Flow	High Flows	Low Flows	Winter Flow Volume	Spring Flow Volume	Summer Flow Volume	Fall Flow Volume	Total Storm Volume
AGWRC[1]	0.85	1.29	35.89	-40.33	25.03	-8.35	-25.40	7.37	23.90
AGWRC[1]	0.92	1.05	21.64	-25.28	21.38	-5.21	-22.34	2.17	17.68
AGWRC[1]	0.96	0.71	9.74	-12.30	13.20	-0.80	-13.84	-4.04	10.07
AGWRC[1]	0.999	-33.52	-37.89	-24.24	-38.77	-41.76	-32.28	-3.86	-32.37
BASETP	-50	0.14	-0.19	0.33	-0.46	0.41	1.11	-0.47	-0.15
BASETP	-10	0.03	-0.04	0.07	-0.09	0.08	0.22	-0.09	0.02
BASETP	10	-0.03	0.04	-0.07	0.09	-0.08	-0.22	0.10	-0.07
BASETP	50	-0.13	0.20	-0.34	0.47	-0.41	-1.12	0.49	-0.08
DEEPFR	-50	0.44	0.33	0.49	0.42	0.43	0.50	0.46	0.43
DEEPFR	-10	0.09	0.07	0.10	0.08	0.09	0.10	0.09	0.09
DEEPFR	10	-0.09	-0.07	-0.10	-0.08	-0.09	-0.10	-0.09	-0.09
DEEPFR	50	-0.44	-0.33	-0.49	-0.42	-0.43	-0.50	-0.46	-0.43
INFILT	-50	-0.65	22.51	-13.31	10.63	-1.12	-19.62	0.23	0.95
INFILT	-10	-0.14	2.57	-1.56	1.55	-0.09	-3.09	-0.16	-0.12
INFILT	10	0.14	-2.24	1.25	-1.38	0.12	2.68	0.26	0.13
INFILT	50	0.61	-8.24	4.45	-5.06	0.28	10.12	1.61	0.63
INTFW	-50	0.01	0.07	-0.05	0.06	-0.001	-0.05	-0.002	0.02
INTFW	-10	0.03	0.29	-0.20	0.24	-0.004	-0.21	-0.001	0.08
INTFW	10	0.05	0.47	-0.30	0.36	-0.01	-0.32	-0.01	0.07
INTFW	50	0.07	0.66	-0.42	0.49	-0.01	-0.42	-0.02	0.07
LZSN	-50	4.07	14.07	-5.47	11.75	7.15	-7.16	-5.70	3.92
LZSN	-10	0.56	1.71	-0.96	1.39	1.26	-0.76	-1.28	0.03
LZSN	10	-0.50	-1.47	0.84	-1.18	-1.16	0.63	1.15	-0.23
LZSN	50	-2.44	-6.15	2.57	-4.88	-5.06	1.74	3.88	-0.59
MON-INTERCEP	-50	2.21	-3.40	4.70	-3.87	3.19	12.00	0.56	0.21
MON-INTERCEP	-10	0.31	-0.63	0.89	-0.75	0.43	2.13	0.03	0.04
MON-INTERCEP	10	-0.27	0.61	-0.85	0.72	-0.37	-1.89	-0.08	-0.12
MON-INTERCEP	50	-1.17	3.03	-4.94	3.54	-1.21	-9.20	-1.09	0.32
MON-LZETP	-50	21.04	22.12	29.04	29.85	8.78	7.88	48.45	-2.31
MON-LZETP	-10	4.73	3.26	8.07	5.99	1.90	3.10	10.96	-0.09
MON-LZETP	10	-0.51	-0.26	-0.91	-0.65	-0.22	-0.35	-1.14	0.43
MON-LZETP	50	-2.74	-1.39	-4.81	-3.53	-1.17	-1.85	-5.95	1.76
MON-MANNING	-50	0.02	0.44	-0.14	0.19	-0.001	-0.18	-0.01	0.04
MON-MANNING	-10	0.003	0.07	-0.02	0.03	0.0001	-0.03	-0.002	0.01
MON-MANNING	10	-0.003	-0.06	0.02	-0.03	-0.002	0.03	0.005	-0.005
MON-MANNING	50	-0.01	-0.28	0.08	-0.12	-0.003	0.12	0.01	-0.02
MON-UZSN	-50	1.74	7.60	-2.67	5.71	1.49	-2.55	-0.74	2.82
MON-UZSN	-10	0.30	1.25	-0.47	1.07	0.28	-0.48	-0.30	0.50
MON-UZSN	10	-0.29	-1.21	0.45	-1.07	-0.27	0.45	0.38	-0.45
MON-UZSN	50	-1.38	-5.32	2.07	-4.85	-1.51	1.98	2.15	-1.79

[1]Actual parameter value used

The models were run during the corresponding water quality calibration time period for the fecal coliform water quality sensitivity analysis. The three parameters impacting the model's water quality response (Table 4.8) were increased and decreased by amounts that were consistent with the range of values for the parameter.

Since the water quality standard for fecal coliform bacteria is based on concentrations rather than loadings, it was considered necessary to analyze the effect of source changes on the monthly geometric-mean fecal coliform concentration. A monthly geometric mean was calculated for all months during the simulation period, and the values for each month were averaged. Deviations from the base run are given in Table 4.9. All results are plotted by month in Figure 4.7 through Figure 4.9.

In addition to analyzing the sensitivity of the model response to changes in model parameters, the response of the model to changes in land-based and direct loads was analyzed. The impacts of land-based and direct load changes on the annual load are presented in Figure 4.10, while impacts on the monthly geometric mean are presented in Figures 4.11 and 4.12.

It is evident from Figure 4.10 that the model predicts a linear relationship between increased fecal coliform concentrations in both land and direct applications, and total load reaching the stream. For Straight Creek a 100% increase in the land applied loads results in a 32% increase of in-stream loads, while a 100% increase in direct loads results in an increase of approximately 69% for in-stream loads.

The sensitivity analysis of geometric mean concentrations in Figures 4.11 and 4.12 showed that direct loads had the greatest impact, with land-applied loads having a lesser, but measurable impact.

Table 4.8 Base parameter values used to determine water quality model response for the Straight Creek.

Parameter	Description	Units	Base Value
MON-SQOLIM	Maximum FC Accumulation on Land	FC/ac	30
WSQOP	Wash-off Rate for FC on Land Surface	in/hr	1.0
FSTDEC	In-stream First Order Decay Rate	1/day	0.65

Table 4.9 Percent change in average monthly *E. coli* geometric mean for the years 1990-1994 for Straight Creek.

Model Parameter	Parameter Change (%)	Percent Change in Average Monthly *E. coli* Geometric Mean											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
FSTDEC	-50	18.95	23.92	18.67	27.77	28.19	37.65	49.82	42.87	42.64	42.62	36.49	18.94
FSTDEC	-10	3.67	4.41	3.59	5.05	5.13	6.41	7.77	7.10	7.02	7.09	6.23	3.62
FSTDEC	10	-2.97	-3.50	-2.90	-3.98	-4.04	-4.93	-5.81	-5.40	-5.33	-5.40	-4.79	-2.92
FSTDEC	50	-14.61	-16.68	-14.22	-18.73	-19.01	-22.34	-25.32	-24.07	-23.72	-24.12	-21.79	-14.24
SQOLIM	-50	-1.15	-1.70	-1.32	-1.15	-1.75	-0.57	-0.91	-1.15	-0.78	-1.13	-1.69	-2.21
SQOLIM	-25	-0.43	-0.65	-0.49	-0.42	-0.68	-0.22	-0.34	-0.46	-0.30	-0.48	-0.70	-0.93
SQOLIM	50	0.61	0.93	0.68	0.56	0.98	0.30	0.44	0.69	0.42	0.82	1.17	1.61
SQOLIM	100	1.02	1.52	1.10	0.90	1.60	0.49	0.72	1.17	0.70	1.48	2.07	2.92
WSQOP	-50	1.29	1.09	1.15	1.43	1.58	0.42	0.41	1.17	0.72	1.29	1.13	1.32
WSQOP	-10	0.19	0.17	0.17	0.20	0.24	0.06	0.05	0.16	0.09	0.17	0.17	0.21
WSQOP	10	-0.17	-0.16	-0.16	-0.18	-0.22	-0.05	-0.05	-0.14	-0.08	-0.15	-0.15	-0.20
WSQOP	50	-0.70	-0.69	-0.68	-0.72	-0.92	-0.22	-0.19	-0.54	-0.31	-0.57	-0.61	-0.87

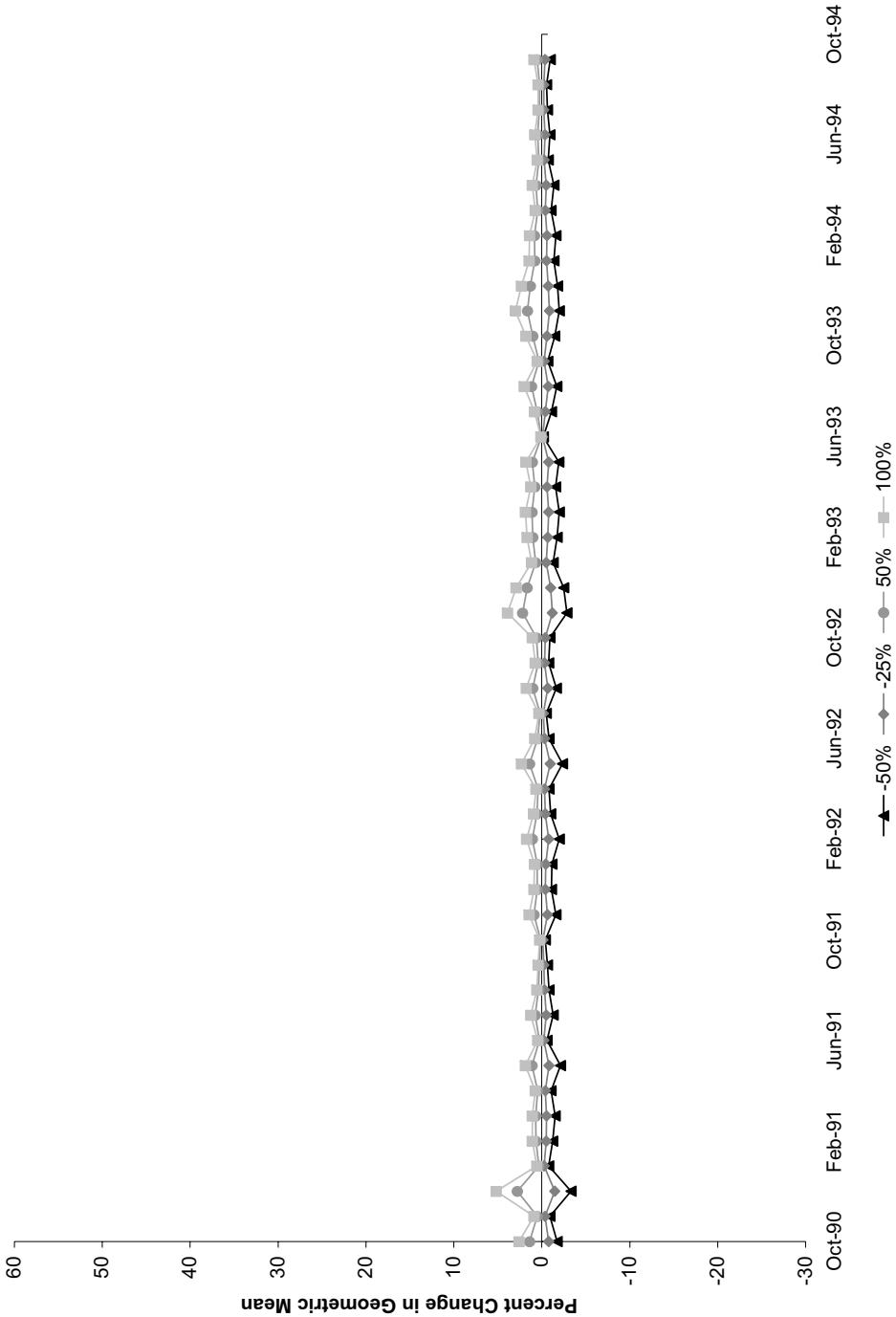

Figure 4.7 Results of sensitivity analysis on monthly geometric-mean concentrations in the Straight Creek watershed, as affected by changes in maximum FC accumulation on land (MON-SQOLIM).

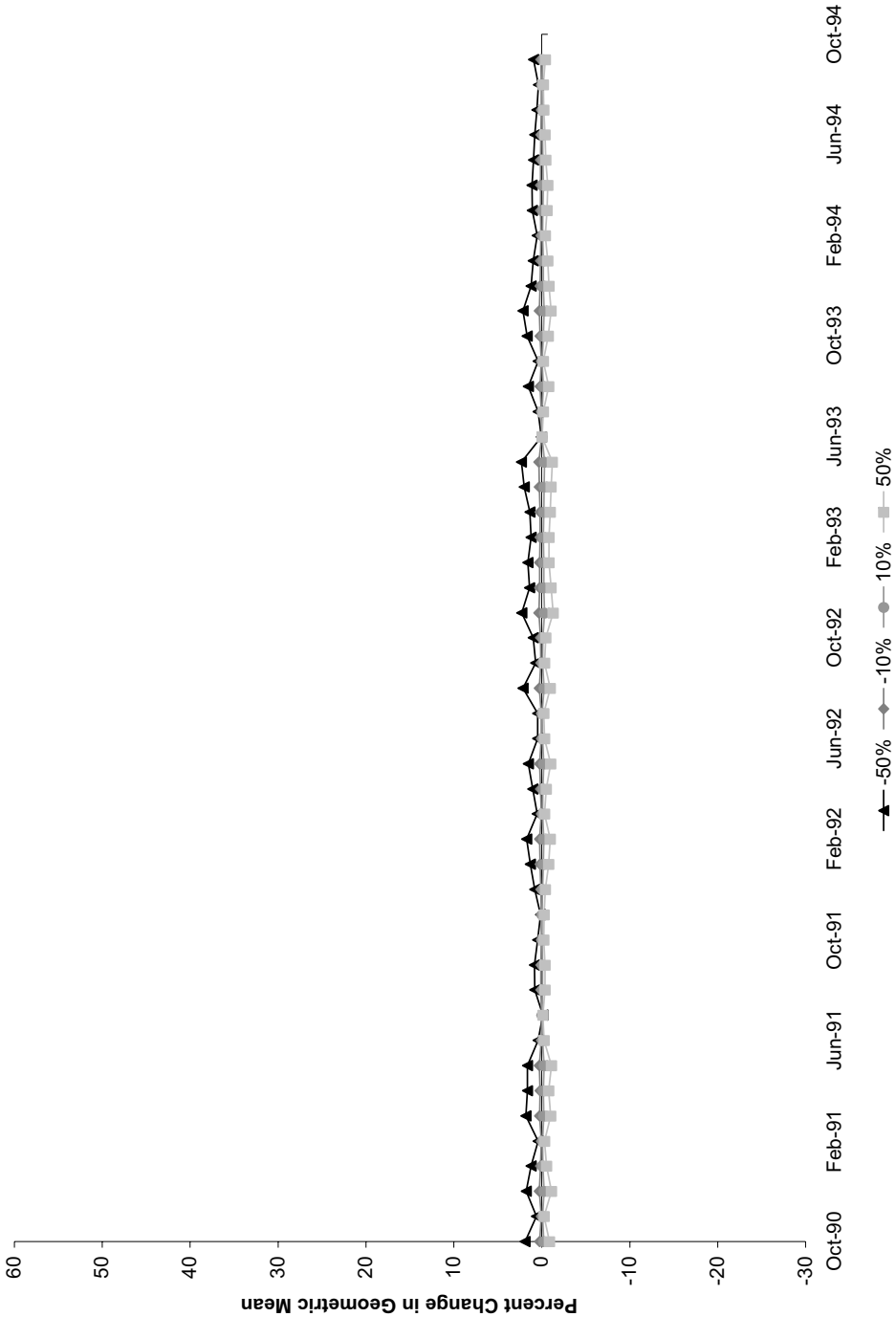

Figure 4.8 **Results of sensitivity analysis on monthly geometric-mean concentrations in the Straight Creek watershed, as affected by changes in the wash-off rate for FC fecal coliform on land surfaces (WSQOP).**

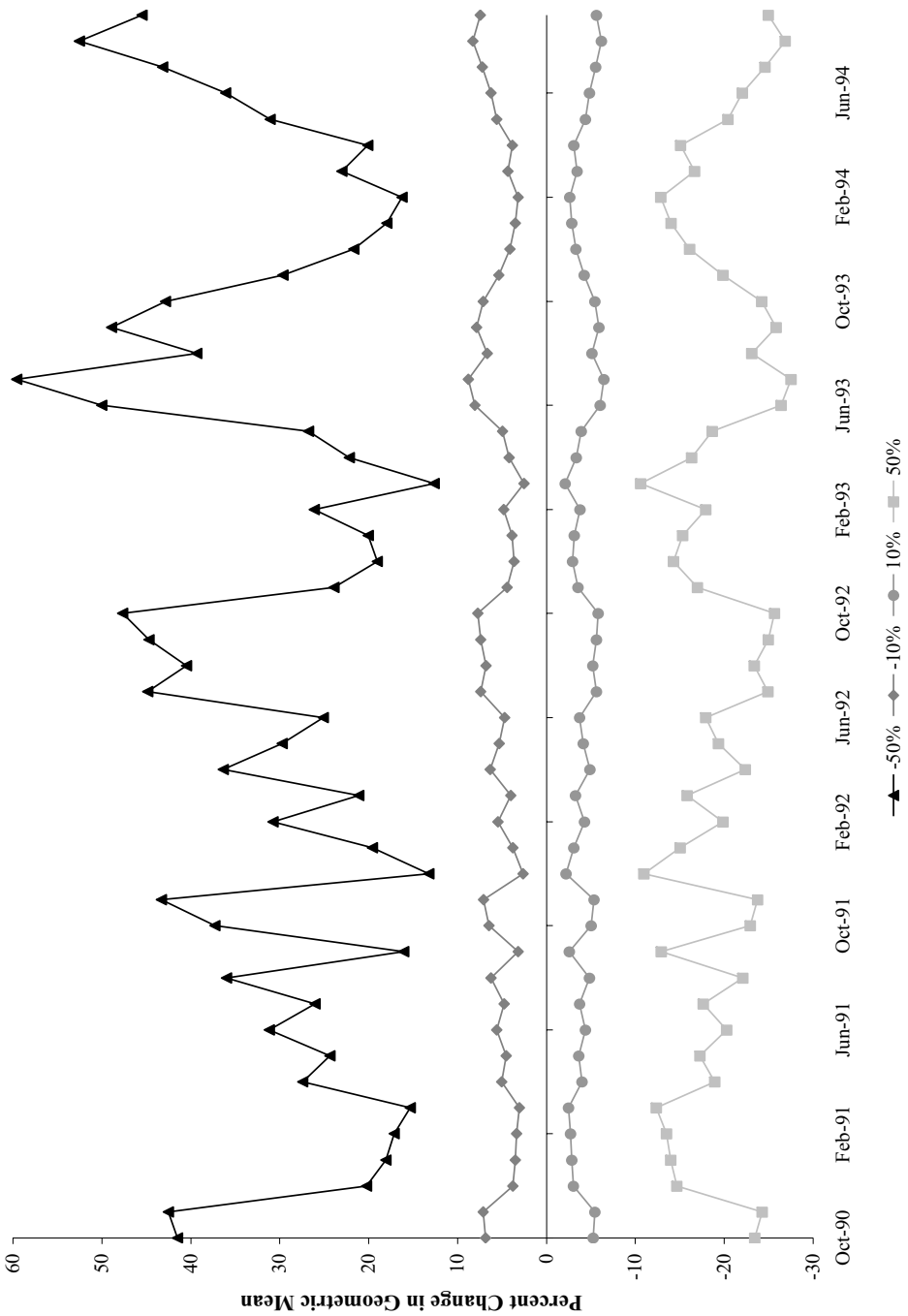

Figure 4.9 **Results of sensitivity analysis on monthly geometric-mean concentrations in the Straight Creek watershed, as affected by changes in the in-stream first-order decay rate (FSTDEC).**

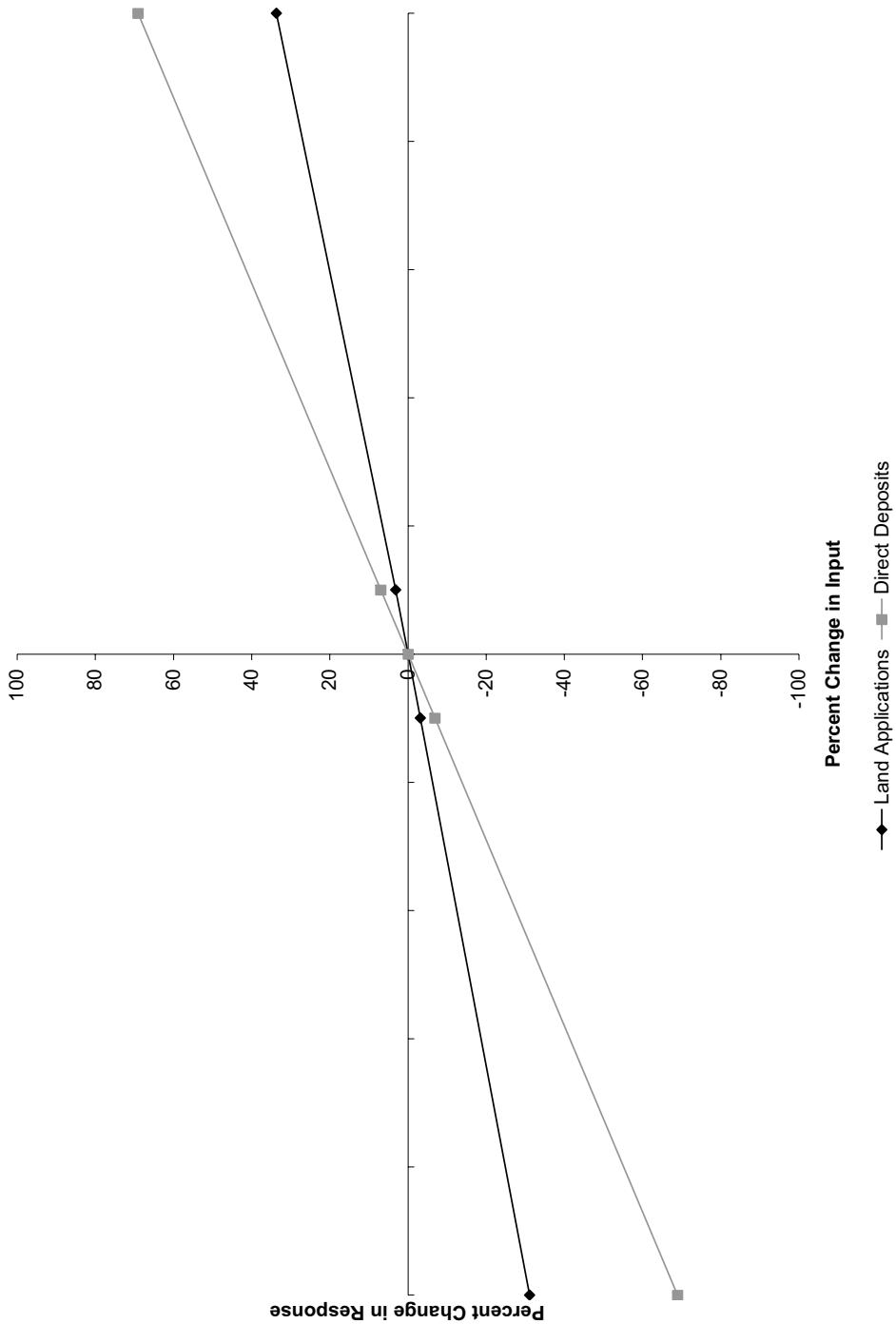

Figure 4.10 Total loading sensitivity to changes in direct and land-based loads for the Straight Creek watershed.

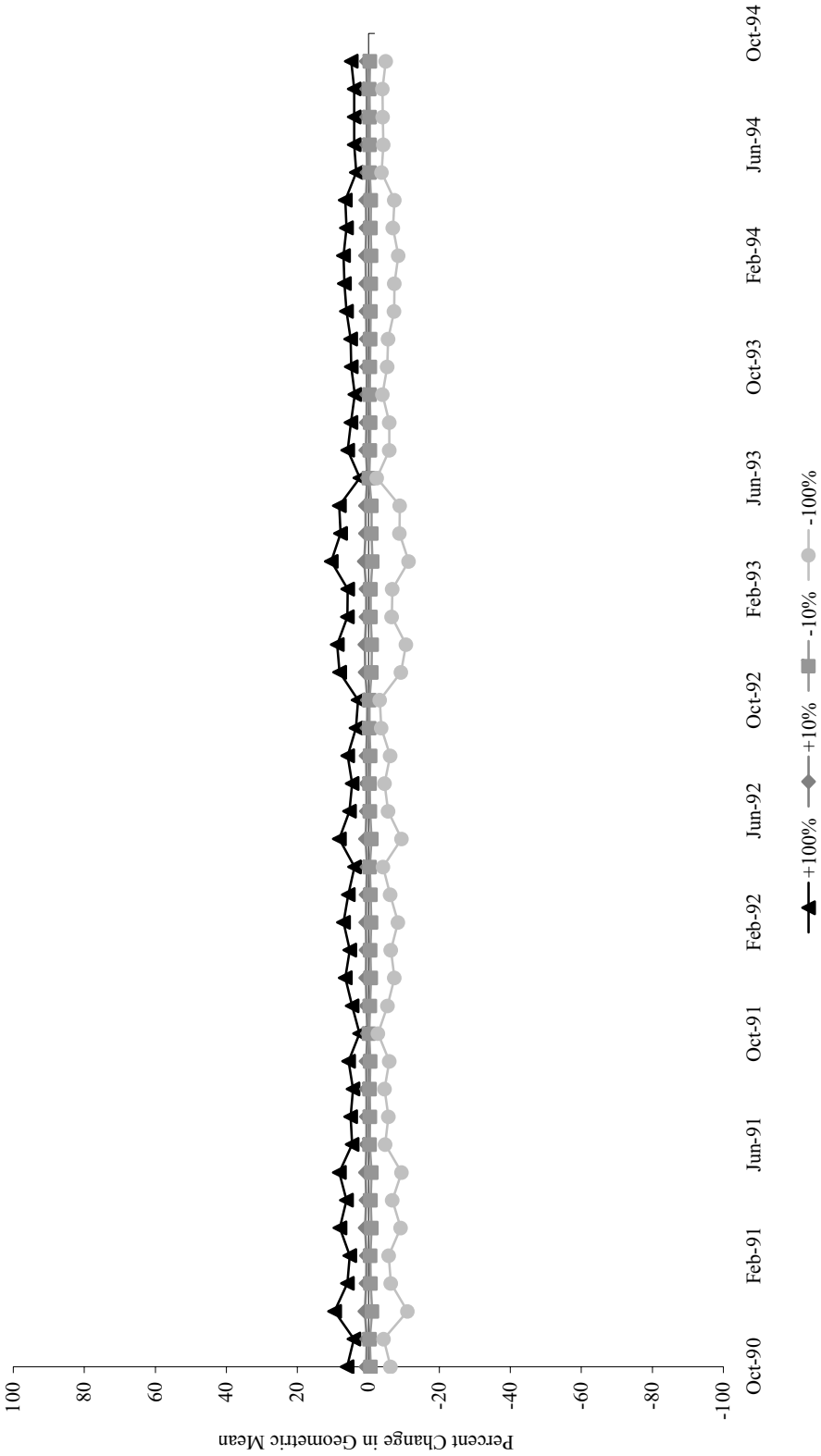

Figure 4.11 Results of sensitivity analysis on monthly geometric-mean concentrations in the Straight Creek watershed, as affected by changes in land-based loadings.

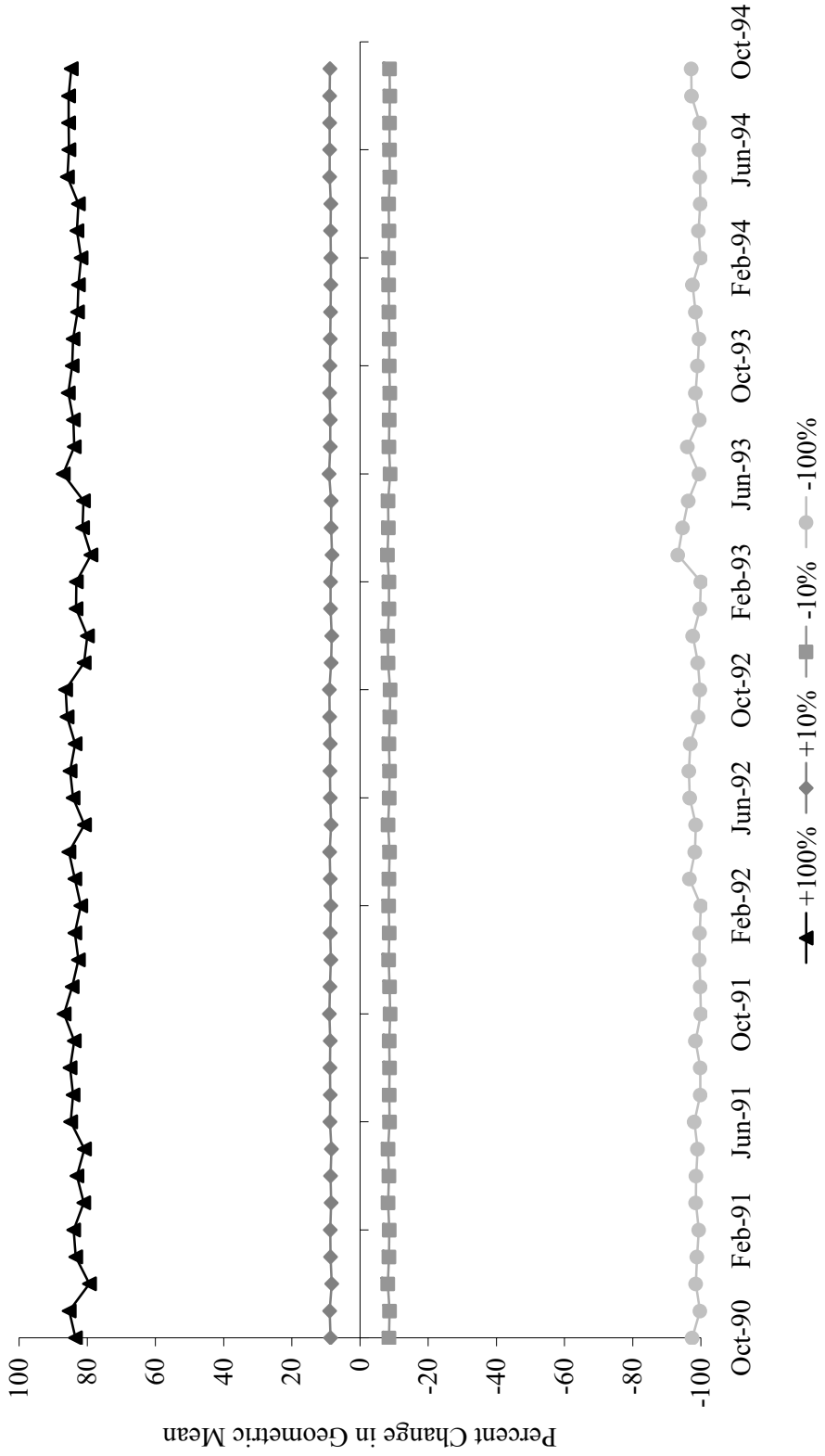

Figure 4.12 Results of sensitivity analysis on monthly geometric-mean concentrations in the Straight Creek watershed, as affected by changes in loadings from direct nonpoint sources.

4.7 Model Calibration Process

Calibration is performed in order to ensure that the model accurately represents the hydrologic and water quality processes in the watershed. The model's hydrologic parameters were set based on available soils, land use, and topographic data. Through calibration, these parameters were adjusted within appropriate ranges until the model performance was deemed acceptable. Calibration is the process of comparing modeled data to observed data and making appropriate adjustments to model parameters to minimize the error between observed and simulated events. Using observed data that is reported at a shorter time-step improves this process and subsequently the performance of a time-dependent model.

4.7.1 Hydrologic Calibration

Parameters that were adjusted during the hydrologic calibration represented the amount of evapotranspiration from the root zone (MON-LZETP), the recession rates for groundwater (AGWRC), the amount of soil moisture storage in the upper zone (MON-UZSN) and lower zone (MON-LZSN), the infiltration capacity (INFILT), baseflow PET (potential evapotranspiration) (BASETP), direct ET from shallow groundwater (AGWETP), and Manning's *n* for overland flow plane (MON-MAN). Although HSPF is not a physically based model, and thus parameters are adjusted during calibration in order to match observed data, guidelines are provided by the EPA as to typically encountered values.

The Straight Creek model was initially calibrated for hydrologic accuracy using continuous stream flow data at USGS Station #03530500 on the North Fork Powell River (subwatershed 5). The results of hydrology calibration for the North Fork Powell River are presented in Table 4.10 and Figures 4.12 through Figure 4.14. Table 4.10 shows the percent difference (or error) between observed and modeled data for total in-stream flows, -9.62%, upper 10% flows, -9.60%, and lower 50% flows, 8.33% during model calibration.

Table 4.10 Hydrology calibration criteria and model performance for the North Fork Powell River at the outlet of subwatershed 5 for the period 10/01/1991 through 3/31/1995.

Criterion	Observed	Modeled	Error
Total In-stream Flow:	106.71	96.44	-9.62%
Upper 10% Flow Values:	58.70	53.07	-9.60%
Lower 50% Flow Values:	9.15	9.91	8.33%
Winter Flow Volume	58.18	43.78	-24.75%
Spring Flow Volume	18.36	20.55	11.96%
Summer Flow Volume	4.82	5.20	7.86%
Fall Flow Volume	25.34	26.91	6.16%
Total Storm Volume	100.70	86.17	-14.43%
Winter Storm Volume	56.48	40.87	-27.63%
Spring Storm Volume	17.07	18.35	7.52%
Summer Storm Volume	3.53	3.01	-14.96%
Fall Storm Volume	23.61	23.94	1.39%

MapTech received additional data from Biological Monitoring Inc. (BMI) on January 10, 2005. The data consisted of flow measurements recorded by BMI at seven locations on Straight Creek and tributaries from 11/8/2004 to 12/30/2004. There was not enough data to extrapolate an entire year of data to use in hydrology calibration. This data was used qualitatively to ensure that the hydrologic model was accurate. The Straight Creek hydrologic model produced flow values within the min and max of the observed flow measured by BMI.

All final calibrated parameters were within the typical values (Table 4.11). The distribution of flow volume between groundwater interflow, surface runoff was 50%, 32%, and 18%, respectively.

Table 4.11 Model parameters utilized for hydrologic calibration of the Straight Creek and North Fork Powell River watersheds.

Parameter	Units	Typical Range of Parameter Value	Initial Parameter Estimate	Calibrated Parameter Value
FOREST	---	0.0 – 0.95	1.0	1.0
LZSN	in	2.0 – 15.0	0.108 – 11.041	2.0
INFILT	in/hr	0.001 – 0.50	0.001 – 0.3845	0.001 – 0.1154
LSUR	ft	100 – 700	7.12 – 782.8	7.12 – 615.09
SLSUR	---	0.001 – 0.30	0.0315 – 0.3537	0.0315 – 0.30
KVARY	1/in	0.0 – 5.0	0.0	0.0
AGWRC	1/day	0.85 – 0.999	0.980	0.945 – 0.980
PETMAX	deg F	32.0 – 48.0	40.0	40.0
PETMIN	deg F	30.0 – 40.0	35.0	35.0
INFEXP	---	1.0 – 3.0	2.0	2.0
INFILD	---	1.0 – 3.0	2.0	2.0
DEEPFR	---	0.0 – 0.50	0.010	0.0 – 0.5
BASETP	---	0.0 – 0.20	0.010	0.035
AGWETP	---	0.0 – 0.20	0.0	0.0 – 0.2
INTFW	---	1.0 – 10.0	1.0	1.0 – 1.3
IRC	1/day	0.30 – 0.85	0.5	0.5 – 0.6
MON-INTERCEP	in	0.01 - 0.40	0.01 – 0.2	0.01 – 0.2
MON-UZSN	in	0.05 – 2.0	0.05 – 9.952	0.05 – 2.0
MON-LZETP	---	0.10 – 0.90	0.01 – 0.8	0.1 – 0.17
MON-MANNING	---	0.05 – 0.50	0.1	0.05
RETSC	in	0.01 – 0.30	0.1	0.1
KS	---	0.0 – 0.99	0.5	0.5

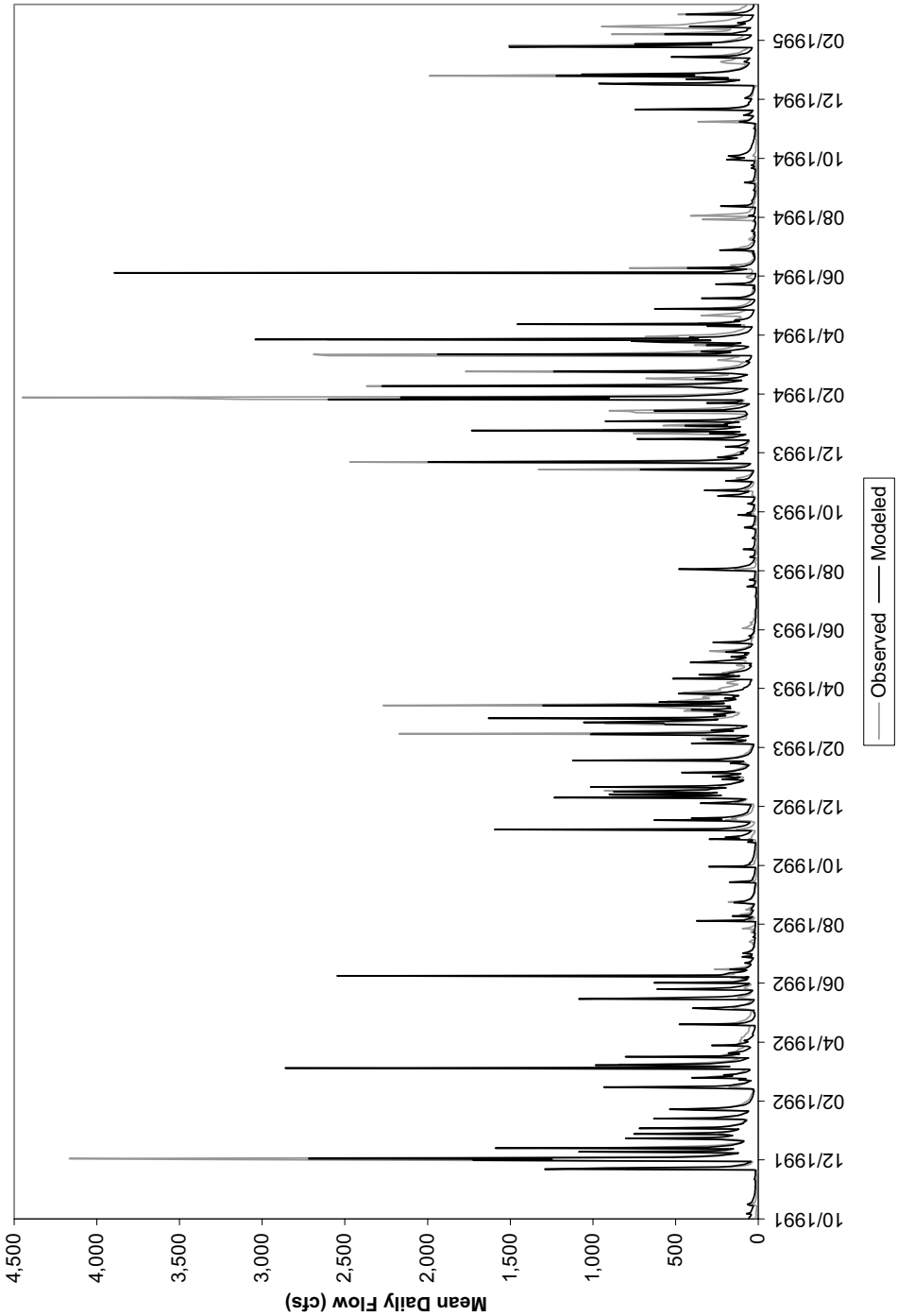

Figure 4.13 Hydrology calibration results for the North Fork Powell River at subwatershed 5 (10/01/1991 through 3/31/1995).

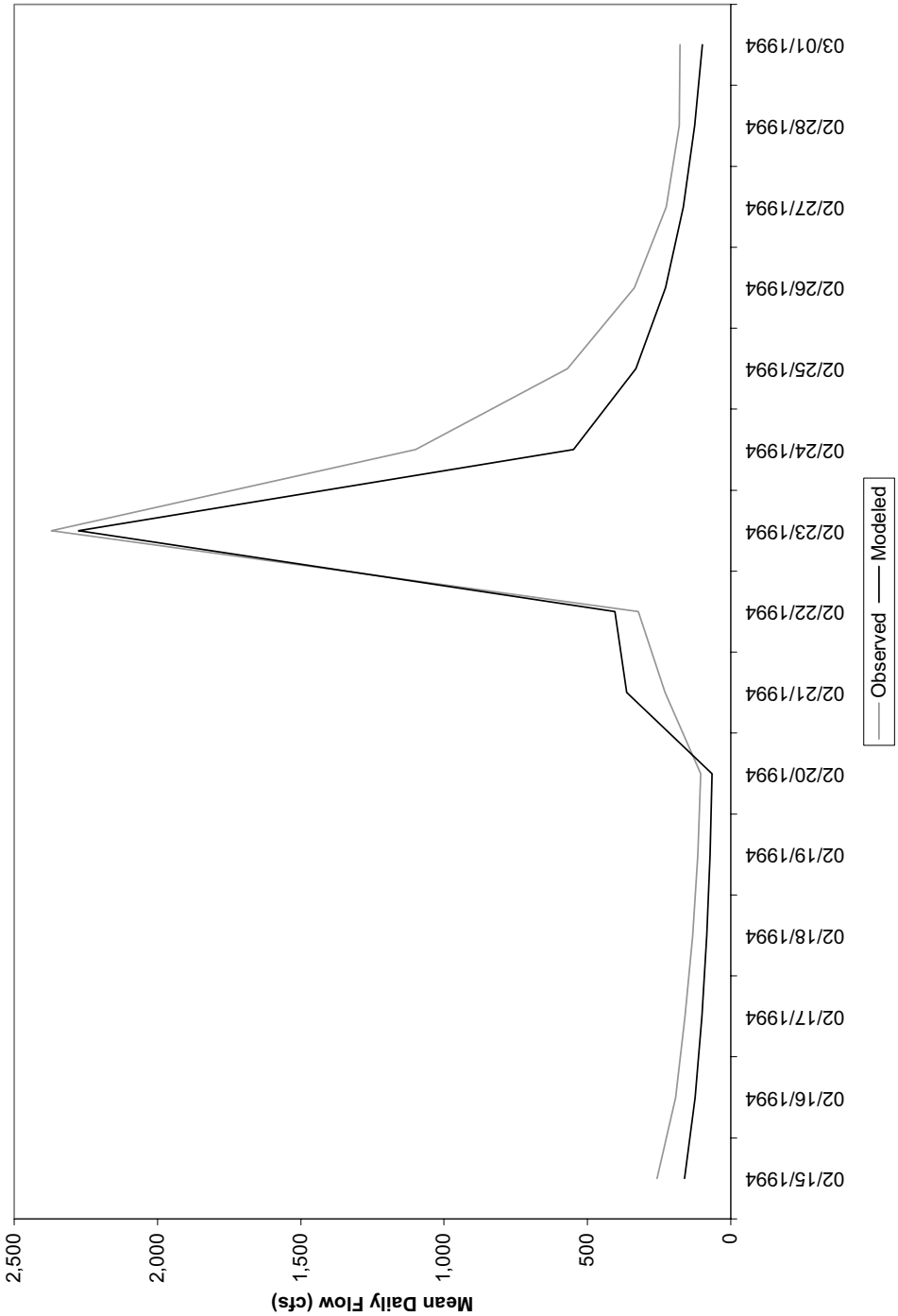

Figure 4.14 Hydrology calibration results for a single storm for the North Fork Powell River at subwatershed 5 (02/15/1994– 03/01/1994).

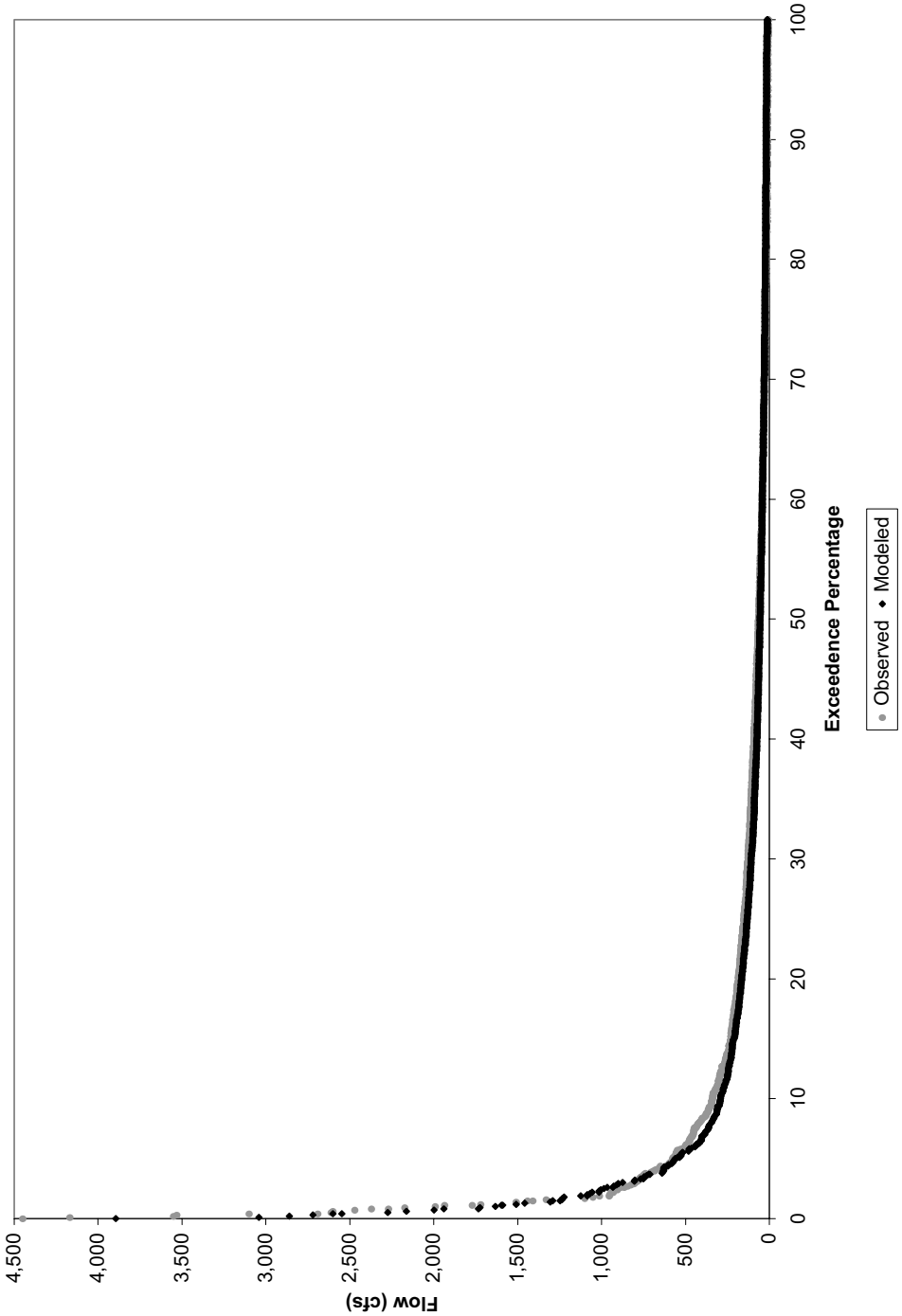

Figure 4.15 North Fork Powell River flow duration at subwatershed 5 (10/01/1991 through 3/31/1995).

4.7.2 Water Quality Calibration

Water quality calibration is complicated by a number of factors, some of which are described here. First, water quality concentrations (*e.g.*, fecal coliform concentrations) are highly dependent on flow conditions. Any variability associated with the modeling of stream flow compounds the variability in modeling water quality parameters such as fecal coliform concentration. Second, the concentration of fecal coliform is particularly variable. Variability in location and timing of fecal deposition, variability in the density of fecal coliform bacteria in feces (among species and for an individual animal), environmental impacts on regrowth and die-off, and variability in delivery to the stream all lead to difficulty in measuring and modeling fecal coliform concentrations. Additionally, the limited amount of measured data for use in calibration and the practice of censoring both high (typically 8,000 or 16,000 cfu/100 mL) and low (typically under 100 cfu/100 mL) concentrations impede the calibration process.

Three parameters were utilized for model adjustment: in-stream first-order decay rate (FSTDEC), maximum accumulation on land (SQOLIM), and rate of surface runoff that will remove 90% of stored fecal coliform per hour (WSQOP). All of these parameters were initially set at expected levels for the watershed conditions and adjusted within reasonable limits until an acceptable match between measured and modeled fecal coliform concentrations was established.

The Straight Creek fecal coliform water quality model was calibrated against observed values from 10/1/1990 to 9/29/1994. Table 4.12 shows the results of fecal coliform calibration for Straight Creek. All parameters used in the calibration were within typical ranges (the PERLND Water had a WSQOP value of 0.0). Figure 4.15 shows the modeled daily average fecal coliform concentration versus observed data in Straight Creek. As the fecal coliform sensitivity analysis shows, the model is driven by direct deposition. Direct deposits cause in-stream fecal coliform concentrations to spike and fall rapidly during a day. Figure 4.15 is a graph of the average daily fecal coliform concentration; the model was also evaluated on the daily minimum and maximum to account for the variations during the day. The model was calibrated to include the monitored values in the daily maximum and minimum.

Table 4.12 Model parameters utilized for fecal coliform water quality calibration of the Straight Creek watershed.

Parameter	Units	Typical Range of Parameter Value	Initial Parameter Estimate	Calibrated Parameter Value
MON-ACCUM	FC/ac*day	0.0 – 1.0E+20	0.0 – 1.6E+10	0.0 – 1.6E+10
MON-SQOLIM	FC/ac	0.01 – 1.0E+30	0.0 – 1.6E+10	0.0 – 3.2E+11
WSQOP	in/hr	0.05 – 3.00	0.0 – 2.8	0.0 – 1.4
IOQC	FC/ft^3	0.0 – 1.0E+06	0.0	0.0
AOQC	FC/ft^3	0 – 10	0.0	0.0
DQAL	FC/100mL	0 – 1,000	200	200
FSTDEC	1/day	0.01 – 10.00	1.0	0.8
THFST	---	1.0 – 2.0	1.07	1.07

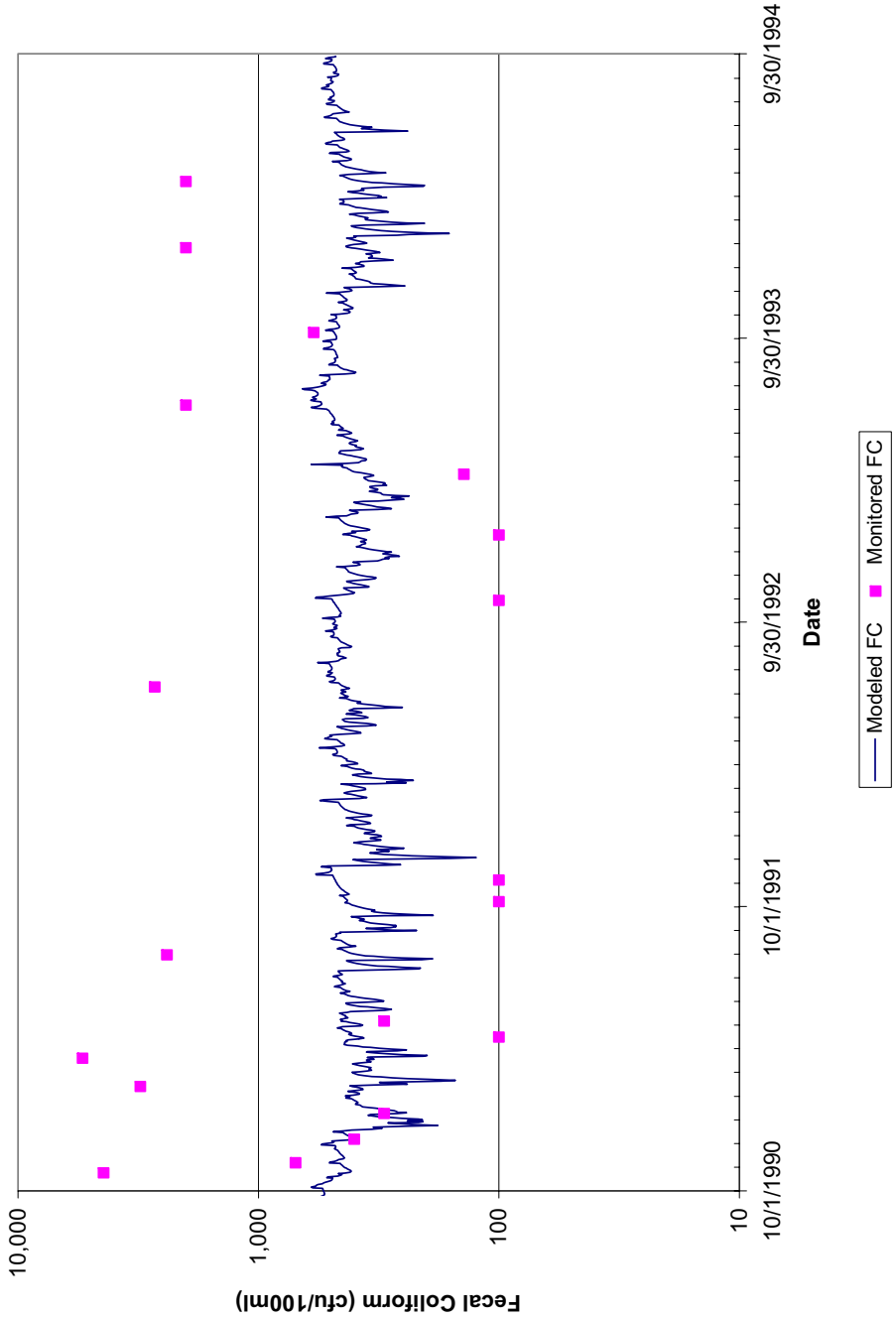

Figure 4.16 Mean daily modeled fecal coliform concentrations compared to instantaneous observed fecal coliform concentrations in the Straight Creek impairment at 6BSRA001.11 during calibration.

4.7.2.1 Water Quality Calibration Statistics

Careful inspection of graphical comparisons between continuous simulation results and limited observed points was the primary tool used to guide the calibration process. To provide a quantitative measure of the agreement between modeled and measured data while taking the inherent variability of fecal coliform concentrations into account, each observed value was compared with modeled concentrations in a 2-day window surrounding the observed data point. Standard error in each observation window was calculated as follows:

$$Standard\ Error = \frac{\sqrt{\dfrac{\sum_{i=1}^{n}\left(observed - modeled_i\right)^2}{\left(n-1\right)}}}{\sqrt{n}}$$

where

$$\begin{aligned} observed &= \text{an observed value of fecal coliform} \\ modeled_i &= \text{a modeled value in the 2 - day window surrounding the observation} \\ n &= \text{the number of modeled observations in the 2 - day window} \end{aligned}$$

This is a non-traditional use of standard error, applied here to offer a quantitative measure of model accuracy. In this context, standard error measures the variability of the sample mean of the modeled values about an instantaneous observed value. The use of limited instantaneous observed values to evaluate continuous data introduces error and, therefore, increases standard error. The mean of all standard errors for each station analyzed was calculated. Additionally, the maximum concentration values observed in the simulated data were compared with maximum values obtained from uncensored data and found to be at reasonable levels (Tables 4.13).

The standard error in the Straight Creek model was 128.0 (Table 4.13). The high standard error values can be considered quite reasonable when one takes into account the censoring of maximum values that is practiced in the taking of actual water quality samples. The standard error will be biased upwards when an observed high value

censored at 8,000 cfu is compared to a simulated high value that may be an order of magnitude or more above the censor limit. Considering the data in Table 4.13, it is evident that the higher standard errors coincide with the higher simulated maximum values as expected. Thus, the standard errors calculated for these impairments are considered an indicator of strong model performance.

Table 4.13 Results of analyses on fecal coliform calibration for Straight Creek.

Station	Mean Standard Error (cfu/100 mL)	Maximum Simulated Value (cfu/100 mL)	Simulated FC Instantaneous Violations (%)	Monitored FC Instantaneous Violations (%)
6BSRA001.11	128	737	62.7	57.9

4.8 Existing Loadings

All appropriate inputs were updated to 2004 conditions. All model runs were conducted using precipitation data during hydrologic calibration. Figure 4.16 shows the monthly geometric mean of *E. coli* concentrations in relation to the 126-cfu/100mL standard for Straight Creek. Figure 4.17 shows the instantaneous values of *E. coli* concentrations in relation to the 235-cfu/100 mL standard for Straight Creek. These figures show that there are violations of both standards at the impairment outlet during the calibration periods. Appendix B contains tables with monthly loadings to the different land use areas in each subwatershed.

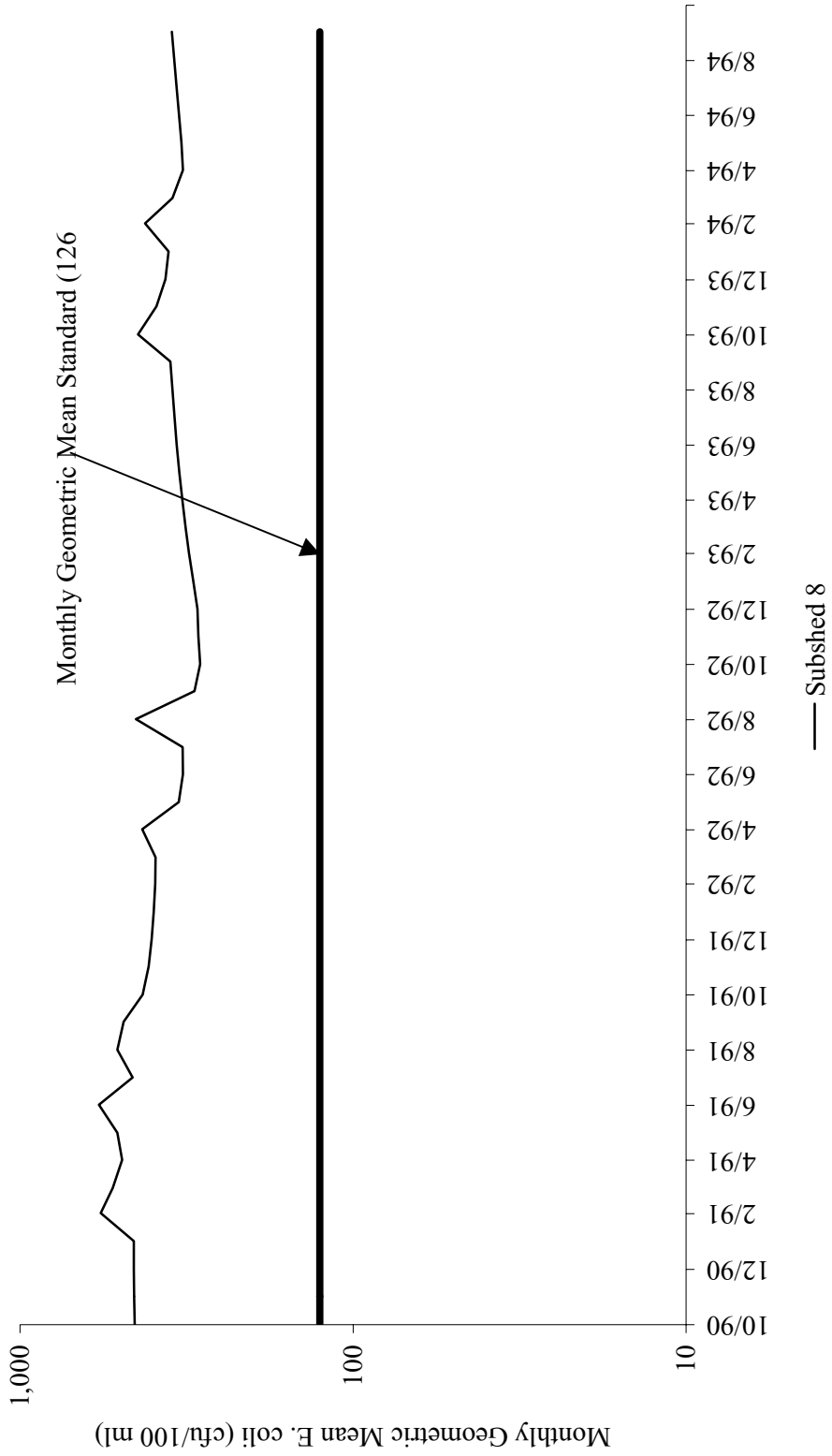

Figure 4.17 Existing conditions (*i.e.*, monthly geometric-mean) of *E. coli* concentrations at the outlet of the Straight Creek impairment (subwatershed 8+9).

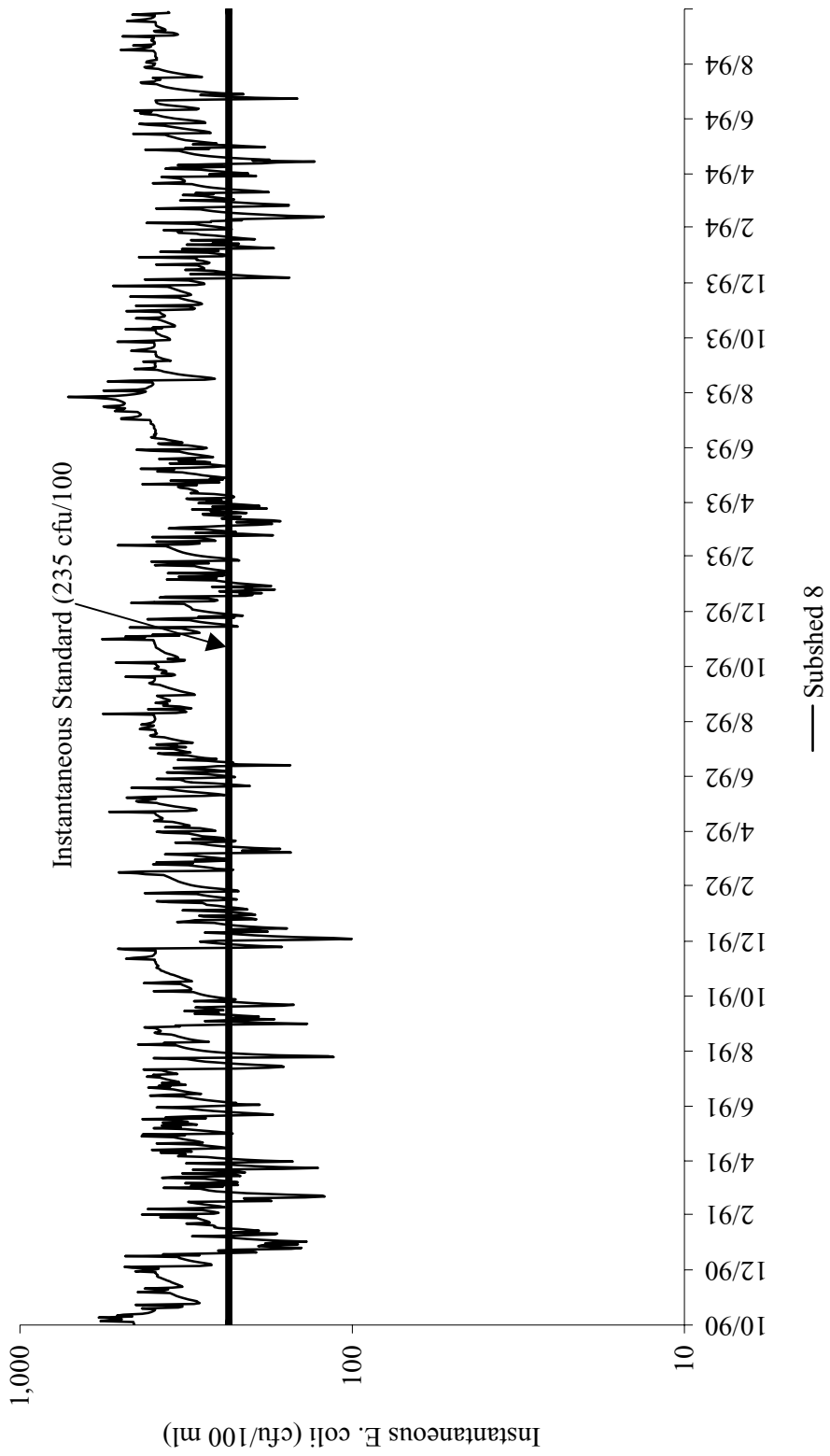

Figure 4.18 Existing conditions (*i.e.*, mean daily) of *E. coli* concentrations at the outlet of the Straight Creek impairment (subwatershed 8+9).

5. ALLOCATION

TMDLs consist of waste load allocations (WLAs, permitted sources) and load allocations (LAs, nonpoint/non-permitted sources) including natural background levels. Additionally, the TMDL must include a margin of safety (MOS) that either implicitly or explicitly accounts for the uncertainties in the process (*e.g.,* accuracy of wildlife populations). The definition is typically denoted by the expression:

$$TMDL = WLAs + LAs + MOS$$

The TMDL becomes the amount of a pollutant that can be assimilated by the receiving waterbody and still achieve water quality standards. For fecal bacteria, TMDL is expressed in terms of colony forming units (or resulting concentration).

5.1 Incorporation of a Margin of Safety

In order to account for uncertainty in modeled output, an MOS was incorporated into the TMDL development process. Individual errors in model inputs, such as data used for developing model parameters or data used for calibration, may affect the load allocations in a positive or a negative way. A margin of safety can be incorporated implicitly in the model through the use of conservative estimates of model parameters, or explicitly as an additional load reduction requirement. The intention of a MOS in the development of a fecal coliform TMDL is to ensure that the modeled loads do not under-estimate the actual loadings that exist in the watershed. An implicit MOS was used in the development of this TMDL. By adopting an implicit MOS in estimating the loads in the watershed, it is insured that the recommended reductions will, in fact, succeed in meeting the water quality standard. Examples of implicit MOS used in the development of this TMDL were:

- Allocating permitted point sources at the maximum allowable fecal coliform concentration
- The selection of a modeling period that represented the critical hydrologic conditions in the watershed

5.2 Scenario Development

Allocation scenarios were modeled using HSPF. Existing conditions were adjusted until the water quality standard was attained. The TMDL developed for the Straight Creek watershed was based on the Virginia State Standard for *E. coli*. As detailed in Section 2.1, the *E. coli* standard states that the calendar month geometric-mean concentration shall not exceed 126 cfu/100 mL, and that a maximum single sample concentration of *E. coli* not exceed 235 cfu/100 mL. According to the guidelines put forth by VADEQ (VADEQ, 2003) for modeling *E. coli* with HSPF, the model was set up to estimate loads of fecal coliform, then the model output was converted to concentrations of *E. coli* through the use of the following equation (developed from a dataset containing n-493 paired data points):

$$\log_2(C_{ec}) = -0.0172 + 0.91905 \cdot \log_2(C_{fc})$$

Where C_{ec} is the concentration of *E. coli* in cfu/100 mL, and C_{fc} is the concentration of fecal coliform in cfu/100 mL.

Pollutant concentrations were modeled over the entire duration of a representative modeling period, and pollutant loads were adjusted until the standard was met. The development of the allocation scenario was an iterative process that required numerous runs with each run followed by an assessment of source reduction against the water quality target.

5.2.1 Wasteload Allocations

There is one non-mining point sources currently permitted to discharge in the Straight Creek watershed (Figure 3.2 and Table 3.2). This permitted discharge is not permitted for fecal control. For water quality modeling this discharge was modeled at its design flow with zero cfu/100mL of fecal coliform.

5.2.2 Load Allocations

Load allocations to nonpoint sources are divided into land-based loadings from land uses and directly applied loads in the stream (*e.g.,* livestock, and wildlife). Source reductions include those that are affected by both high and low flow conditions. Land-based NPS

loads had their most significant impact during high-flow conditions, while direct deposition NPS had their most significant impact on low flow concentrations. Bacterial source tracking during 2003-2004 sampling periods confirmed the presence of human, pet, livestock and wildlife contamination.

Model results indicate that human direct deposits, and urban and agricultural nonpoint sources are significant in all areas of the watershed. This is in agreement with the results of BST analysis presented in Chapter 2. Allocation scenarios for Straight Creek are shown in Table 5.1. Scenario 1 describes a baseline scenario that corresponds to the existing conditions in the watershed.

The first objective of reduction scenarios was to explore the role of anthropogenic sources in standards violations. First, scenarios were explored to determine the feasibility of meeting standards without wildlife reductions. Following this theme, Scenario 2 resulted from 100% reductions in uncontrolled residential discharges (*i.e.,* straight pipes). This scenario greatly improved conditions in the stream, but failed to eliminate exceedances.

Scenario 3 had a 90% reduction in direct livestock deposition, and 50% reductions to land loads from urban and agricultural lands, as well as a 100% reduction of straight pipes. Direct loads from wildlife were not addressed. Again while it showed improved conditions, it still did not meet the instantaneous standard.

Scenario 4 shows 100% reductions to anthropogenic sources; however, exceedances still persisted with the instantaneous standard. This scenario shows that reductions to wildlife loads must be made.

Scenarios 5 and 6 had fewer reductions to agricultural and urban nonpoint source loads to provide more obtainable scenarios. Scenario 5 shows that reductions in direct wildlife loads had little impact on the percent violations; however, Scenario 6 shows that the same percent reduction in land-based wildlife loads lowered the instantaneous violations. This shows that reductions in land-based wildlife loads were necessary to lower the violation percentage whereas reductions in direct wildlife loads are not required.

Additional scenarios were made by iteratively reducing nonpoint source wildlife loads until a scenario was found that resulted in zero exceedances of both standards (Scenario 7, Table 5.1). Next, the scenario with the least reductions was found by decreasing the reductions of direct livestock, nonpoint agricultural and urban loads while maintaining zero percent violations of both standards (Scenario 8, Table 5.1).

Table 5.1 Allocation scenarios for bacterial concentration with current loading estimates in the Straight Creek impairment.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture/ Livestock	NPS Residential/ Urban	Straight Pipes	GM >126 cfu/ 100mL	Single Sample >235 cfu/ 100mL
1	0	0	0	0	0	0	100.0	84.29
2	0	0	0	0	0	100	0.0	2.19
3	0	0	90	50	50	100	0.0	1.44
4	0	0	100	100	100	100	0.0	0.82
5	10	0	100	99	99	100	0.0	0.82
6	0	10	100	99	99	100	0.0	0.55
7	0	32	100	99	99	100	0.0	0.0
8	0	32	0	80	99	100	0.0	0.0

5.2.2.1 Final bacteria TMDL

Figure 5.1 shows graphically the existing and allocated conditions for the geometric-mean *E. coli* concentrations in Straight Creek. Figure 5.2 shows the existing and allocated conditions of the instantaneous *E. coli* concentration in Straight Creek. The figures for Straight Creek are for the *E. coli* concentrations at the outlet (subwatershed 8).

Table 5.2 indicates the land-based and direct load reductions resulting from the final allocations. Table 5.3 shows the final TMDL loads for the Straight Creek impairment.

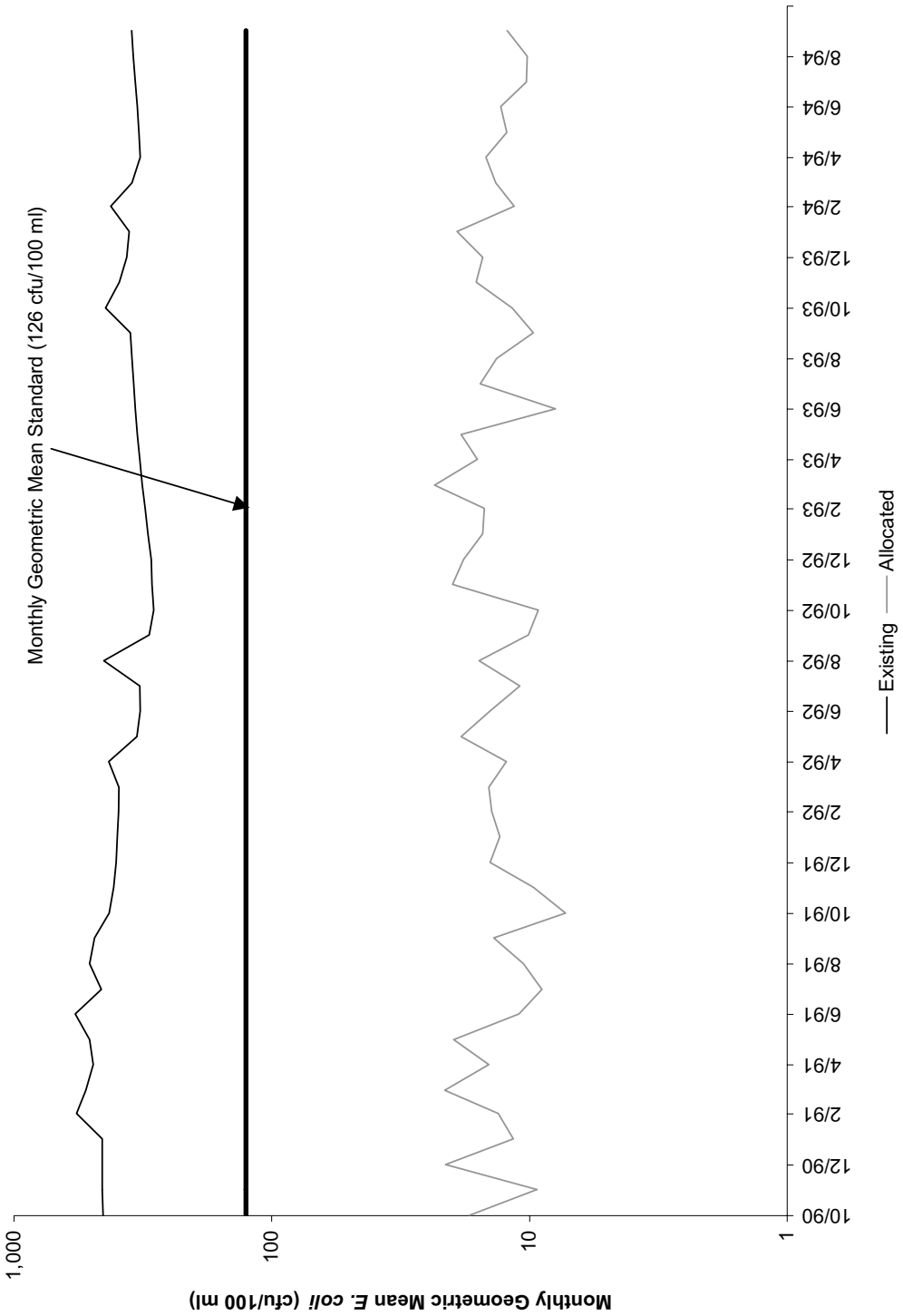

Figure 5.1 Monthly geometric mean *E. coli* concentrations for Straight Creek at the outlet under existing and allocated conditions.

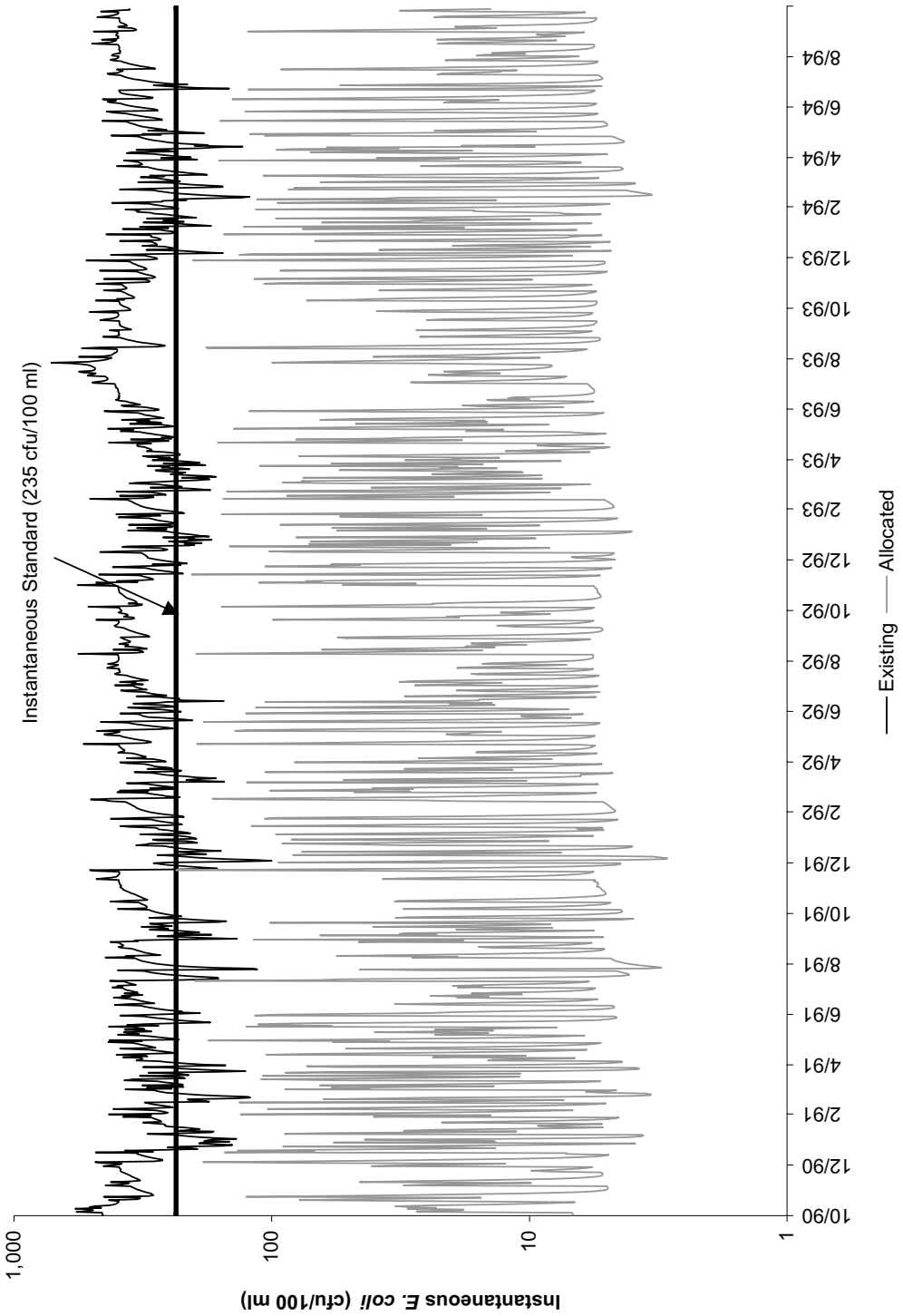

Figure 5.2 Instantaneous *E. coli* concentrations for Straight Creek at the outlet under existing and allocated conditions.

Table 5.2 Land-based and direct *E. coli* loads in the Straight Creek impairment for existing conditions and the final allocation.

Source	Total Annual Loading for Existing Run (cfu/yr)	Total Annual Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Abandoned Mine Land	3.11E+13	2.11E+13	32%
Active Mining	6.07E+12	6.07E+10	99%
Barren	5.64E+10	5.64E+08	99%
Commercial	8.69E+11	8.69E+09	99%
Cropland	2.32E+11	4.64E+10	80%
Forest	2.24E+14	1.52E+14	32%
Livestock Access	3.33E+11	6.66E+10	80%
Pasture	7.57E+12	1.51E+12	80%
Reclaimed	4.38E+13	2.98E+13	32%
Residential	6.60E+13	6.60E+11	99%
Roads	4.66E+12	4.66E+10	99%
Water	0.00E+00	0.00E+00	0%
Wetland	2.46E+11	1.67E+11	32%
Direct			
Livestock	3.55E+10	3.55E+10	0%
Wildlife	5.70E+12	5.70E+12	0%
Straight Pipes	4.96E+14	0.00E+00	100%

Table 5.3 Average annual *E. coli* loads (cfu/year) modeled after allocation in the Straight Creek watershed.

Impairment	WLA (cfu/year)	LA (cfu/year)	MOS	TMDL (cfu/year)
Straight Creek (FC)	0.00E+00	1.81E+13	*Implicit*	1.81E+13

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PART III: GENERAL STANDARD (BENTHIC) TMDLS

6. WATER QUALITY ASSESSMENT

6.1 Applicable Criterion for Benthic Impairment

The General Standard**,** as defined in Virginia state law 9 VAC 25-260-20, states:

> *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.*

The General Standard is implemented by VADEQ through application of the modified Rapid Bioassessment Protocol II (RBP II). Using the modified RBP II, the health of the benthic macroinvertebrate community is typically assessed through measurement of 8 biometrics (Table 6.1), which measure different aspects of the community's overall health. Surveys of the benthic macroinvertebrate community performed by VADEQ are assessed at the family taxonomic level (Barbour, 1999).

Each biometric measured at a target station is compared to the same biometric measured at a reference (not impaired) station to determine each biometric score. These scores are then summed and used to determine the overall bioassessment (*e.g.,* not impaired, slightly impaired, moderately impaired, or severely impaired).

Table 6.1 Components of the modified RBP II Assessment.

Biometric	Benthic Health [1]
Taxa Richness	↑
Modified Family Biotic Index (MFBI)	↓
Scraper to Filtering Collector Ratio (SC/CF)	↑
EPT / Chironomid Ratio (EPT/CHI ABUND)	↑
% Contribution of Dominant Family (% DOM)	↓
EPT Index	↑
Community Loss Index (COMM. LOSS INDEX)	↓
Shredder to Total Ratio (SH/TOT)	↑

[1] An upward arrow indicates a positive response in benthic health when the associated biometric increases.

6.2 Benthic Assessment

All biological and ambient water quality monitoring stations on Straight Creek are shown in Table 6.2 and Figure 6.1. Modified RBP II benthic surveys were performed by VADEQ on four sites on Straight Creek. Table 6.2 relates the station number to the station type and river mile location. The results of these surveys are presented in Tables 6.3, 6.4 and 6.5. The tables indicate that the majority of the surveys found moderately impaired conditions. The primary difference between Straight Creek and the reference stations was the absence of pollution sensitive organisms such as mayflies, stoneflies and caddisflies.

Table 6.2 Benthic and ambient monitoring stations on Straight Creek.

Station	Station Type[1]	River Mile
6BSRA000.10	VADEQ Ambient	0.10
6BSRA000.11	VADEQ Bio	0.11
SC	ECI_Ambient,Bio	0.19
6BSRA000.40	VADEQ _Bio	0.40
6BSRA000.54	VADEQ SS	0.54
6BSRA001.10	VADEQ SS	1.10
6BSRA001.11	VADEQ Ambient	1.11
6BSRA001.34	VADEQ _FT	1.34
0003102*	DMME monitoring site	2.12
SB	ECI_Ambient,Bio	2.40
6BSRA002.48	VADEQ Bio	2.48
6BSRA003.22	VADEQ Ambient	3.22
1020127	DMME monitoring site	3.26
6BSRA003.62	VADEQ Bio	3.62
SA	ECI_Ambient,Bio	3.84
0002877	DMME monitoring site	4.87
1020209	DMME monitoring site	5.32
1020237	DMME monitoring site	5.37
1020241	DMME monitoring site	5.57
1020226	DMME monitoring site	5.64
1020225	DMME monitoring site	6.06

[1]Bio: Biological, SS: Special study, Ambient: Ambient water quality, FT: Fish Tissue
*Station with less than nine data points.

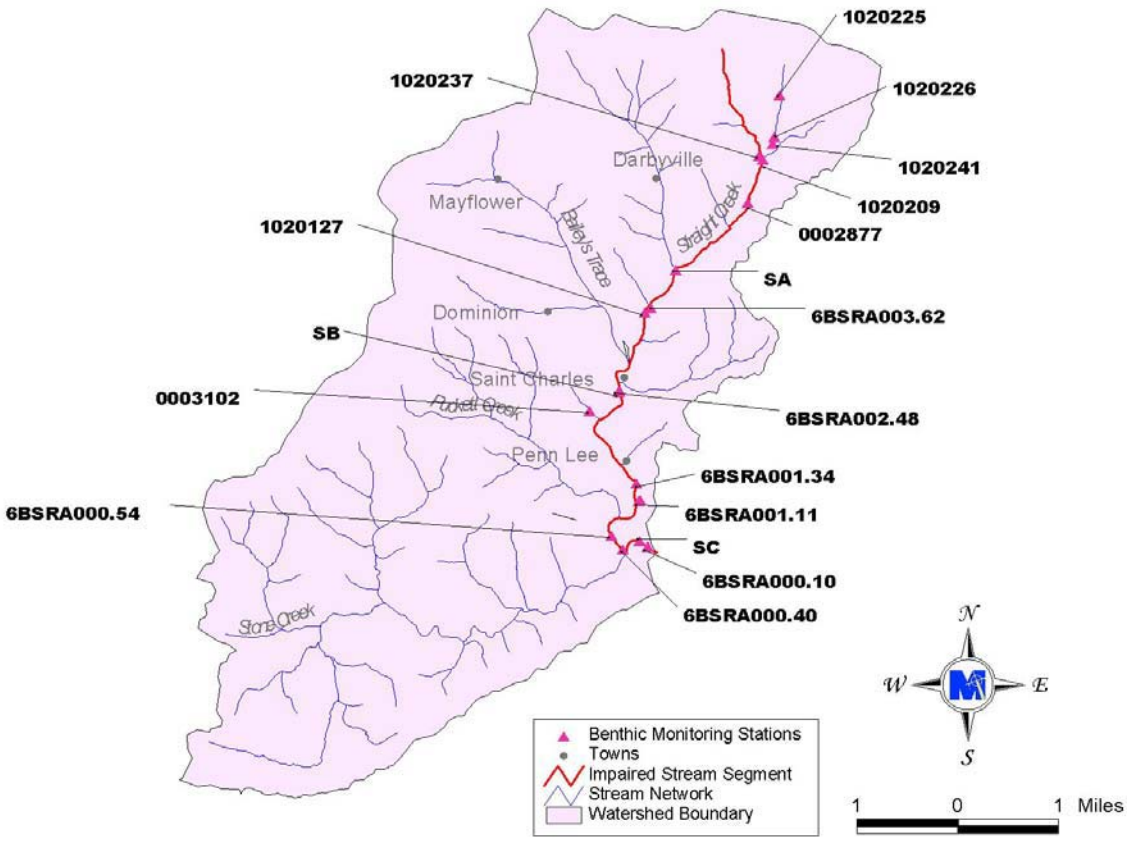

Figure 6.1 Biological and ambient water quality monitoring stations on Straight Creek.

Table 6.3 RBP II biological monitoring data for VADEQ station 6BSRA000.40 on Straight Creek.

Station:	6CWLC009.63	6BSRA000.40	6CWLC009.63	6BSRA000.40	6CWLC009.63	6BSRA000.40	6ADIS002.80	6BSRA000.40	6ADIS002.80	6BSRA000.40
Metric	**3/91**	**5/91**	**11/91**	**11/91**	**4/92**	**5/92**	**12/92**	**12/92**	**12/93**	**11/93**
Taxa Rich	15	7	23	10	17	9	10	10	12	9
MFBI	4	6	3	5	4	7	4	6	4	6
SC/CF	9	0	1	0.30	4	0	0.54	0.05	0.70	0.01
EPT/Chi Abund	25	0.83	24	0.84	10	0.03	50	3	16	12
% Dom	48	42	24	47	40	58	30	59	21	66
EPT Index	9	2	13	4	9	2	7	4	7	3
Comm. Loss Index	0	2	0	2	0	1	0	0.60	0	0.56
SH/Tot	0.01	0	0.15	0.10	0.02	0.01	0.09	0.02	0.14	0.00
Bio Cond Score	42	6	46	14	44	12	46	14	46	18
RBP II Score	100%	14%	100%	30%	100%	27%	100%	30%	100%	39%
Assessment*	Ref	SV	Ref	MI	Ref	MI	Ref	MI	Ref	MI

*Ref = Reference, SV = Severely Impaired, MI = Moderately Impaired, SI = Slightly Impaired

Table 6.4 RBP II biological monitoring data for 4 VADEQ stations on Straight Creek.

Station:	6BPLL006.50	6BSRA000.40	6AMCR000.55	6BSRA000.11	6BPLL006.50	6BSRA002.48	6BPLL006.50	6BSRA003.62	6BNFH085.31	6BSRA000.11	6CMFH045.83	6BSRA003.62
Metric:	**9/99**	**9/99**	**10/99**	**9/99**	**9/99**	**9/99**	**9/99**	**9/99**	**11/03**	**12/03**	**11-03**	**12-03**
Taxa Rich	13	8	14	7	13	12	13	11	14	8	11	10
MFBI	4.078	5.66	3.75	5.65	4.078	4.941	4.078	5.08	3.87	4.59	4.69	5.39
SC/CF	2.923	0	1.75	0	2.923	0.088	2.923	1.1111	1.17	0.39	0.50	0.16
EPT/Chi Abund	2.9	1.84	92	1.24	2.9	2.643	2.9	0.88	36.50	4.00	12.29	2.89
% Dom	33.01	50	29	36.6	33.01	37.25	33.01	30	30.43	33.33	43.52	53.33
EPT Index	7	3	7	2	7	5	7	3	8	5	8	5
Comm. Loss Index	0	1	0	1	0	1	0	0.73	0	1	0	0.3
SH/Tot	0.01	0	0.01	0.01	0.01	0.03	0.01	0.02	0.01	0.18	0.03	0.09
Bio Cond Score	44	16	46	16	44	30	44	28	44	20	42	26
RBP II Score (%)	100%	36%	100%	35%	100%	68%	100%	63%	100%	45%	100%	62%
Assessment*	Ref	MI	Ref	MI	Ref	SI	Ref	SI	Ref	MI	Ref	SI

*Ref = Reference, SV = Severely Impaired, MI = Moderately Impaired, SI = Slightly Impaired

Table 6.5 RBP II biological monitoring data for VADEQ stations on Straight Creek, Spring 2004.

Station:	6CSFH098.10	6BSRA000.11	6CPSM017.73	6BSRA003.62
Metric:	**5/11/2004**	**6/7/2004**	**4/29/2004**	**6/7/2004**
Taxa Rich	12	8	15	8
MFBI	4.2	5.01	3.98	4.76
SC/CF	1.7	0.05	2.25	0.05
EPT/Chi Abund	3.07	0.83	6.64	3.67
% Dom	28.04	46.67	37.74	52
EPT Index	6	3	9	6
Comm. Loss Index	0.00	0.88	0.00	1.25
SH/Tot	0.04	0.13	0.09	0.03
Bio Cond Score	46	20	44	16
RBP II Score	100	43.48	100	36.36
Assessment*	Ref	MI	Ref	MI

*Ref = Reference, SV = Severely Impaired, MI = Moderately Impaired, SI = Slightly Impaired

An alternative method, the Virginia Stream Condition Index (VASCI), has been developed and shows promise. Data is being collected to calibrate and further validate the VASCI method. The advantage of the VASCI is that the score does not depend on values from a reference station. The VASCI has an impairment threshold of 61.3. The VASCI scores for the VADEQ surveys are presented in Tables 6.6, 6.7 and 6.8. The VASCI scores for all nine VADEQ surveys on Straight Creek were below the impairment threshold of 61.3 (Figure 6.2).

Table 6.6 VASCI data for VADEQ station 6BSRA000.40 on Straight Creek and reference stations.

Station:	6CWLC009.63	6BSRA000.40	6CWLC009.63	6BSRA000.40	6CWLC009.63	6BSRA000.40	6ADIS002.80	6BSRA000.40	6ADIS002.80	6BSRA000.40
Metric	**3/91**	**5/91**	**11/91**	**11/91**	**4/92**	**5/92**	**12/92**	**12/92**	**12/93**	**11/93**
Richness Score	68.18	31.82	100	45.45	77.27	40.91	45.45	45.45	54.55	40.91
EPT Score	81.82	18.18	100	36.36	81.82	18.18	63.64	36.36	63.64	27.27
% Ephem. Score	100	40.07	94.69	25.68	100	1.60	72.50	8.68	33.29	15.43
%PT-H* Score	41.61	0.00	39.29	7.80	21.87	2.75	52.02	0.00	65.93	0.00
%Scraper Score	80.65	0.00	47.37	17.92	48.29	1.58	53.76	6.86	60.90	27.24
%Chironomidae Score	96.30	57.89	96.50	52.78	92.22	42.16	98.15	75.53	95.92	93.92
%2Dominant Score	44.09	48.10	83.75	45.43	57.03	16.98	62.80	24.56	85.40	28.28
%MFBI Score	91.91	61.92	96.57	70.81	91.49	49.02	89.46	63.83	88.99	65.08
VASCI Score	75.57	32.25	82.27	37.78	71.25	21.65	67.22	32.66	68.58	37.27

*%PT – Hydropsychidae

Table 6.7 VASCI data for 4 VADEQ stations on Straight Creek and reference stations.

Station:	6BPLL006.50	6BSRA000.40	6BPLL006.50	6BSRA000.11	6BPLL006.50	6BSRA002.48	6BPLL006.50	6BSRA00 3.62	6CNFH085.31	6BSRA000.11	6CMFH045.83	6BSRA003.62
Metric	**9/99**	**9/99**	**9/99**	**9/99**	**9/99**	**9/99**	**9/99**	**9/99**	**11/03**	**12/03**	**11//03**	**12/03**
Richness Score	59.09	36.36	59.09	31.82	59.09	54.55	59.09	50.00	63.64	36.36	50	45.45
EPT Score	63.64	27.27	63.64	18.18	63.64	45.45	63.64	27.27	72.73	45.45	72.73	45.45
% Ephem. Score	34.84	7.55	34.84	20.39	34.84	11.20	34.84	13.05	62.42	28.07	49.85	10.88
%PT-H* Score	5.45	0.00	5.45	0.00	5.45	0.00	5.45	0.00	14.66	51.35	15.61	3.12
%Scraper Score	100	22.40	100	15.84	100	64.83	100	62.90	77.14	24.28	40.32	14.34
%Chironomidae Score	90.29	70.37	90.29	63.39	90.29	86.27	90.29	75.00	98.26	82.80	93.52	78.89
%2Dominant Score	71.45	29.39	71.45	43.81	71.45	48.10	71.45	64.94	70.27	69.82	62.80	36.88
%MFBI Score	87.09	63.86	87.09	63.94	87.09	74.39	87.09	72.35	90.15	79.54	78.16	67.81
VASCI Score	63.98	32.15	63.98	32.17	63.98	48.10	63.98	45.69	68.66	52.21	57.87	37.85

*%PT – Hydropsychidae

Table 6.8 VASCI data for 4 VADEQ stations on Straight Creek and reference stations.

Station:	6CSFH098.10	6BSRA000.11	6CPSM017.73	6BSRA003.62
Metric	**5/11/2004**	**6/7/2004**	**4/29/2004**	**6/7/2004**
Richness Score	72.73	36.36	59.09	36.36
EPT Score	90.91	54.55	63.64	27.27
% Ephem. Score	88.43	88.09	43.40	16.31
%PT-H* Score	28.88	8.43	33.50	21.85
%Scraper Score	45.22	4.84	69.55	12.54
%Chironomidae Score	89.72	79.00	86.24	53.33
%2Dominant Score	74.17	38.96	79.43	46.5
%MFBI Score	88.79	77.06	85.81	73.37
VASCI Score	72.35	48.40	65.08	35.94

*%PT – Hydropsychidae

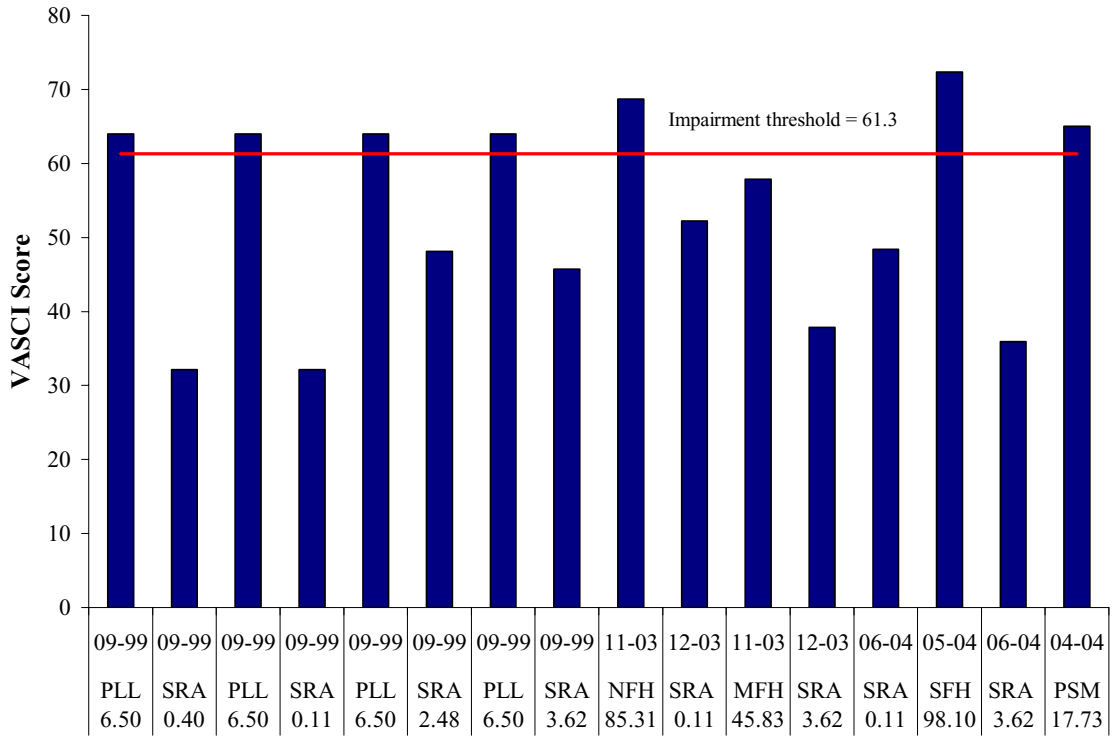

Figure 6.2 VASCI scores for VADEQ benthic surveys on Straight Creek.

On July 18, 2002 and November 7, 2002, Environmental Concepts, Inc. (ECI) performed additional benthic surveys at three sites on Straight Creek under contract from Virginia Division of Mines, Minerals, and Energy (DMME). Detailed results of the surveys are shown in Table 6.9 and 6.10 and Figure 6.3. The VASCI scores for all six surveys are below the impairment threshold of 61.3. Scores improved slightly from upstream to downstream.

Table 6.9 ECI benthic monitoring stations on Straight Creek.

Station	River Mile	Location
SC	0.19	Below Stone Creek
SB	2.40	Below Big Branch
SA	3.84	Just above Gin Creek

Table 6.10 VASCI data for the ECI benthic surveys on Straight Creek.

Metric	Station					
	SA 7/02	SA 11/02	SB 7/02	SB 11/02	SC 7/02	SC 11/02
Tot Taxa	12	16	15	16	13	19
EPT Tax	3	3	5	5	4	4
%Ephem	4	7	6	24	36	12
%PT-Hydropsychidae*	1		1	0	2	
%Scrap	2	5	3	6	9	26
%Chiro	3	2	7	0	11	7
%2Dom	77	57	73	80	52	61
HBI	5	5	5	5	4	5
VASCI	37.31	43.08	41.63	46.89	51.96	50.18

*%PT – Hydropsychidae

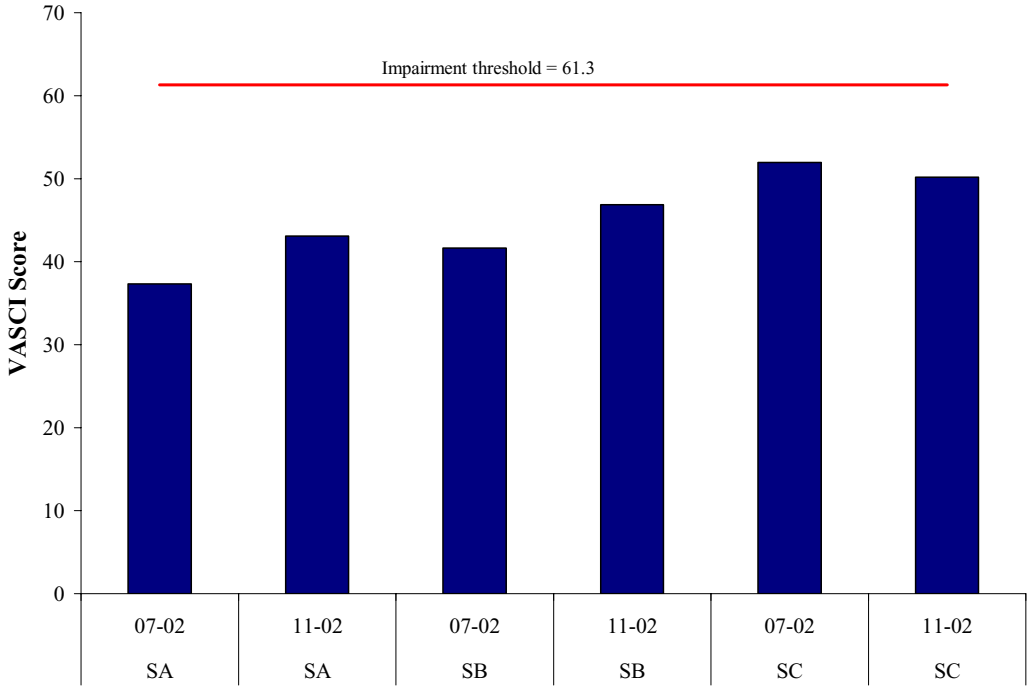

Figure 6.3 VASCI scores for ECI monitoring sites on Straight Creek.

In 1998 the United States Army Corps of Engineers (USACE) began multiyear Powell River Ecosystem Restoration Project which includes water quality monitoring and water quality studies. The Virginia Tech Biology Department was contracted to conduct an integrative bioassessment study in the watershed that resulted in the collection of benthic organisms in the Straight Creek watershed (Table 6.11). The study provided an

ecotoxicological restoration potential (ETR) for five watersheds in the Powell River Basin. Based on the ETR score for the Straight Creek watershed this study concluded that it was more influenced by urban land uses than past and present mining activities. It should be noted the worst of these influences, uncontrolled discharges from single family homes, are being addressed by the fecal coliform TMDL. The maximum conductivity value reported was 774 µmhos/cm at station SC2. Data collected by the regulatory agencies and additional data collected by the USACE contractors at these sites in Straight Creek show numerous conductivity values above 1,000 µmhos/cm with a maximum value of 5,800 µmhos/cm. Conductivities above 1,000 µmhos/cm are inconsistent with the type urban land use found in Straight Creek, but are consistent with mining land uses. This indicates that mining impacts on water quality in the Straight Creek watershed are much more pronounced than the Virginia Tech study found (Cherry, D.S 2001). All three results were well below the VASCI impairment threshold of 61.3.

Table 6.11 VASCI data for benthic surveys on Straight Creek performed by the Virginia Tech Biology Department in 2000.

Metric	Station		
	SC2 River Mile 4.16	**SC6C River Mile 3.63**	**SW 19 River Mile 0.54**
Tot Taxa	54.55	54.55	72.73
EPT Tax	18.18	27.27	45.45
%Ephem	0.73	12.25	14.42
%PT-Hydropsychidae*	0.00	0.00	2.61
%Scrap	4.32	14.39	15.00
%Chiro	57.59	77.46	71.63
%2Dom	31.57	42.68	44.97
HBI	66.64	68.83	67.72
VASCI	29.2	37.18	41.82

*%PT – Hydropsychidae

6.3 Habitat Assessments

Benthic impairments have two general causes: input of pollutants to streams and alteration of habitat in either the stream or the watershed. Habitat can be altered directly (*e.g.,* by channel modification), indirectly (because of changes in the riparian corridor leading to conditions such as streambank destabilization), or even more indirectly (*e.g.,* due to land use changes in the watershed such as clearing large areas).

Habitat assessments are normally carried out as part of the benthic sampling. The overall habitat score is the sum of ten individual metrics, each metric ranging from 0 to 20. The classification schemes for both the individual habitat metrics and the overall habitat score for a sampling site are shown in Table 6.12.

Table 6.12 Classification of habitat metrics based on score.

Habitat Metric	Optimal	Sub-optimal	Marginal	Poor
Embeddedness	16 - 20	11 – 15	6 - 10	0 - 5
Epifaunal Substrate	16 - 20	11 – 15	6 - 10	0 - 5
Pool Sediment	16 - 20	11 – 15	6 - 10	0 - 5
Flow	16 - 20	11 – 15	6 - 10	0 - 5
Channel Alteration	16 - 20	11 – 15	6 - 10	0 - 5
Riffles	16 - 20	11 – 15	6 - 10	0 - 5
Velocity	16 - 20	11 – 15	6 - 10	0 - 5
Bank Stability	18 - 20	12 – 16	6 - 10	0 - 4
Bank Vegetation	18 - 20	12 – 16	6 - 10	0 - 4
Riparian Vegetation	18 - 20	12 – 16	6 - 10	0 - 4

6.3.1 Habitat Assessment at Biological Monitoring Stations

Habitat assessment for Straight Creek will include an analysis of habitat scores recorded by the VADEQ biologist and the ES&C benthic surveys. The VADEQ habitat assessments at Straight Creek monitoring station 6BSRA000.40 are displayed in Table 6.13. The habitat metrics related to sediment, embeddedness and sediment deposition had median scores of 7 and 8, respectively. This is indicative of large-scale movements of sediment in the stream and an unstable environment for the macroinvertebrate population. A marginal score for embeddedness indicates that 50 to 75% of the hard substrate in a riffle is surrounded by fine sediment which greatly affects the amount of habitat available to aquatic organisms. Marginal sediment deposition scores indicate that 30 to 50% of the pool bottom is covered with fine sediment. In addition, bank stability scores were marginal indicating that 30 to 60% of the streambank has areas of erosion which contribute to the sediment problems previously discussed. Riparian vegetation scored in the marginal category. A healthy riparian zone acts as a buffer for pollutants running off the land, helps prevent erosion, and provides habitat. Bank vegetation also scored in the marginal category. The lack of proper streambank vegetation is another indication of erosion potential. Another metric that had marginal scores was velocity. Streams with the best habitat have four distinct velocity/depth patterns that provide a

diverse habitat for macroinvertebrates. A marginal score indicates that only two different patterns were present. Channel flow is a metric that describes how much of the available substrate is covered by water. Straight Creek had marginal scores for this metric which means that only 25 to 75% of the available substrate was covered by water. The frequency of riffles is also an important measure of available habitat. Straight Creek had marginal scores for this metric, which indicates the stream is characterized by occasional riffles or bend areas.

Table 6.13 Habitat scores at VADEQ benthic monitoring station 6BSRA000.40 on Straight Creek.

Metric	05-91	11-91	05-92	12-92	11-93	09-99	Median
ALTERATION	11	12	6	13	13	16	12.5
BANK STABILITY	5	8	8	8	4	7	7.5
BANK VEGETATION	5	10.5	9	8	5.5	14	8.5
EMBEDDEDNESS	7	7	7	9	6	6	7
FLOW	12	11.5	7.5	8.5	4	7	8
RIFFLES	10	8	6	9	7	7	7.5
RIPARIAN VEGETATION	7	10.5	9	9	2	6	8
SEDIMENT DEPOSITION	9	8	8	8	8	6	8
EPIFAUNAL SUBSTRATE	17	17	17	17	16	17	17
VELOCITY	8	7	7	7	11	6	7

A special benthic survey was performed on Straight Creek by VADEQ in September of 1999 and three additional sites were monitored. The results of those surveys are presented in Table 6.14.

Table 6.14 Habitat scores at three additional VADEQ benthic monitoring stations on Straight Creek (9/22/1999).

Metric	6BSRA000.11	6B SRA002.48	6B SRA003.62
ALTERATION	14	18	14
BANK STABILITY	8	5	3
BANK VEGETATION	15	5	9
EMBEDDEDNESS	13	9	10
FLOW	7	7	7
RIFFLES	7	7	10
RIPARIAN VEGETATION	5	5	5
SEDIMENT DEPOSITION	5	10	10
EPIFAUNAL SUBSTRATE	16	9	6
VELOCITY	6	8	7

The habitat scores for these stations are very consistent with those for station 6BSRA000.40. The most striking difference was for the epifaunal substrate metric at stations 6BSRA002.48 and 6BSRA003.62. This metric is a measure of how stable the available substrate is. Marginal scores indicate that it is subject to frequent disturbance and/or removal. The most recent benthic monitoring performed in Straight Creek by the VADEQ was in the fall of 2003 and spring of 2004. Those results are shown in Table 6.15.

Table 6.15 Fall 2003 and Spring 2004 habitat scores at VADEQ benthic monitoring stations on Straight Creek.

Metric	6BSRA000.11	6B SRA003.62	6BSRA000.11	6B SRA003.62
	12/09/2003	12/09/2003	06/07/2004	06/07/2004
ALTERATION	15	15	18	18
BANK STABILITY	6	9	6	11
BANK VEGETATION	6	13	10	13
EMBEDDEDNESS	17	15	14	13
FLOW	15	18	15	18
RIFFLES	16	11	16	17
RIPARIAN VEGETATION	6	9	8	12
SEDIMENT DEPOSITION	11	13	9	10
EPIFAUNAL SUBSTRATE	18	18	15	17
VELOCITY	16	17	10	13

The more recent monitoring shows improvements in many of the habitat parameters at these two monitoring stations. Embeddedness and sediment deposition showed considerable improvement at station 6ASRA000.11. Scores for bank stability, bank vegetation and riparian vegetation remained in the marginal category. Embeddedness scores were much better at station 6ASRA003.62 but sediment deposition, bank stability and riparian vegetation scores remain in the marginal category.

The ECI habitat scores are presented in Table 6.16. Station SC, located near the VADEQ monitoring station 6BSRA000.11, had marginal scores for most of the same metrics that the VADEQ station had in 1999. Unfortunately, embeddedness was not reported. Station SB, located near the VADEQ station 6BSRA002.48, had marginal scores for riparian vegetation and bank stability. Sediment deposition scores were suboptimal.

Station SA, located just above the confluence with Gin Creek, is close to the VADEQ station 6BSRA003.62. This station reported no marginal habitat scores. This could indicate some improvement in conditions in this portion of the stream since 1999, but the two sites are at different locations and it is possible that the ECI site had better habitat.

Table 6.16 Habitat scores for the three ECI benthic stations on Straight Creek.

Metric	SA 7/18/02	SA 11/7/02	SB 7/18/02	SB 11/7/02	SC 7/18/02	SC 11/7/02
ALTERATION	17	17	16	16	13	13
BANK STABILITY	16	16	6	6	10	10
BANK VEGETATION	14	14	12	12	13	13
FLOW	11	11	12	12	9	9
RIPARAIN VEGETATION	15	15	8	8	10	10
SEDIMENT DEPOSITION	17	17	13	13	9	9
EPIFAUNAL SUBSTRATE	15	15	17	17	13	13

6.4 Discussion of In-stream Water Quality

This section provides an inventory of available observed in-stream monitoring data throughout the Straight Creek watershed. An examination of data from water quality stations used in the Section 305(b) assessment and data collected during TMDL development were analyzed. Sources of data and pertinent results are discussed.

6.4.1 Inventory of Water Quality Monitoring Data

The primary sources of available water quality information for Straight Creek are:

- Data collected at nine VADEQ stations,
- Data collected at nine sites monitored by private coal mining companies for mining permit application or compliance and supplied by DMME, and
- Data collected at nine sites by Engineering Concepts, Inc (ECI) and supplied by DMME.

Each station included in the DMME permit-monitoring database has been assigned unique monitoring point identification (MPID) number.

6.4.1.1 VADEQ Water Quality Monitoring

VADEQ has monitored water quality recently at nine sites on Straight Creek (Table 6.17). The locations of these stations are shown in Figure 6.1. Only stations with at least

nine data points were used in the stressor identification evaluation unless extreme values were reported. This was done for statistical accuracy and to ensure that data was collected in every season. The data for the stations is summarized in Tables 6.18 through 6.27. Conductivity values are high throughout all stations.

Table 6.17 VADEQ monitoring stations on the Straight Creek watershed from January 1990 through March 2004.

Station	Type	Data Record	# Samples
6BSRA000.10	Ambient	8/03 - 3/04	4
6BSRA000.11	Special Study	10/00	1
6BSRA000.40	Special Study	8/03	1
6BSRA000.54	Special Study	10/00	1
6BSRA001.10	Special Study	10/00	1
6BSRA001.11	Ambient	1/90 - 3/04	66
6BSRA003.22	Ambient/ Special Study	7/03 - 3/04	9
6BSRA003.62	Special Study	8/03	1
6BSRA004.16	Ambient	7/03 - 3/04	9

Table 6.18 In-stream water quality data at 6BSRA000.10 on Straight Creek (8/03-2/04).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
DO	12	12.505	14.5	7.98	3	4	--
PH	8.08	8.0	8.5	7.8	0.33	4	--
TEMP (C)	10.40	9.2	19.2	4.0	6.91	4	--
TP (mg/L AS P)	0.010	0.01	0.010	0.01	0.00	4	--
Nitrite + Nitrate (mg/L AS N)	0.35	0.36	0.39	0.3	0.04	4	--
TN (mg/L AS N)	0.6	0.501	0.8	0.4	0.2	4	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.19 In-stream water quality data at 6BSRA000.11 on Straight Creek (10/31/00).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
Al DISSOLVED (µg/L)	4.8	4.8	4.8	4.8	--	1	--
Sb DISSOLVED (µg/L)	0.11	0.11	0.11	0.11	--	1	--
As DISSOLVED (µg/L)	0.21	0.21	0.21	0.21	--	1	--
Ca DISSOLVED (mg/L)	47.60	47.60	47.60	47.60	--	1	--
Cl, TOTAL (mg/L)	13.6	13.6	13.6	13.6	--	1	--
Conductivity (µmho/cm)	770	770	770	770	--	1	--
Cu, DISSOLVED (µg/L)	0.49	0.49	0.49	0.49	--	1	--
PH	8.57	8.57	8.57	8.57	--	1	--
Mg DISSOLVED (mg/L)	18.8	18.8	18.8	18.8	--	1	--
Mn DISSOLVED (mg/L)	6.28	6.28	6.28	6.28	--	1	--
Ni DISSOLVED (mg/L)	0.55	0.55	0.55	0.55	--	1	--
Nitrite + Nitrate (mg/L AS N)	0.52	0.5	0.76	0.4	0.04	4	--
TEMP (C)	9.86	9.86	9.86	9.86	--	1	--
TP (mg/L AS P)	0.01	0.01	0.01	0.01	0.01	4	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.20 In-stream water quality data at 6BSRA000.40 on Straight Creek (8/6/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
Conductivity (µmho/cm)	936	936	936	936	--	1	--
DO	8.02	8.02	8.02	8.02	--	1	--
PH	8.21	8.21	8.21	8.21	--	1	--
TEMP (C)	19.1	19.1	19.1	19.1	--	1	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.21 In-stream water quality data at 6BSRA000.54 on Straight Creek (10/31/00).

Water Quality Constituent	Mean	Median	Max	Min	SD1	N2	Trend3
Al DISSOLVED (µg/L)	3.5	3.5	3.5	3.5	--	1	--
Sb DISSOLVED (µg/L)	0.12	0.12	0.12	0.12	--	1	--
As DISSOLVED (µg/L)	0.20	0.20	0.20	0.20	--	1	--
Cd DISSOLVED (mg/L)	0.24	0.24	0.24	0.24	--	1	--
Ca DISSOLVED (mg/L)	38.5	38.5	38.5	38.5	--	1	--
Cl TOTAL (mg/L)	15.2	15.2	15.2	15.2	--	1	--
Conductivity (µmho/cm)	847	847	847	847	--	1	--
Cu DISSOLVED (µg/L)	0.53	0.53	0.53	0.53	--	1	--
PH	8.60	8.60	8.60	8.60	--	1	--
Mg DISSOLVED (mg/L)	14.5	14.5	14.5	14.5	--	1	--
Mn DISSOLVED (mg/L)	2.35	2.35	2.35	2.35	--	1	--
Ni DISSOLVED (mg/L)	0.61	0.61	0.61	0.61	--	1	--
TEMP (C)	9.32	9.32	9.32	9.32	--	1	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.22 In-stream water quality data at 6BSRA001.10 on Straight Creek (10/31/00).

Water Quality Constituent	Mean	Median	Max	Min	SD1	N2	Trend3
Al, DISSOLVED (µg/L)	16.2	16.2	16.2	16.2	--	1	--
Sb DISSOLVED (µg/L)	0.14	0.14	0.14	0.14	--	1	--
As DISSOLVED (µg/L)	0.23	0.23	0.23	0.23	--	1	--
Cd DISSOLVED (mg/L)	0.24	0.24	0.24	0.24	--	1	--
Ca DISSOLVED (mg/L)	37.8	37.8	37.8	37.8	--	1	--
Cl, TOTAL (mg/L)	11.1	11.1	11.1	11.1	--	1	--
Conductivity (µmho/cm)	834	834	834	834	--	1	--
Cu, DISSOLVED (µg/L)	0.55	0.55	0.55	0.55	--	1	--
PH	8.69	8.69	8.69	8.69	--	1	--
Mg DISSOLVED (mg/L)	14.0	14.0	14.0	14.0	--	1	--
Mn DISSOLVED (mg/L)	4.41	4.41	4.41	4.41	--	1	--
Ni DISSOLVED (mg/L)	1.15	1.15	1.15	1.15	--	1	--
TEMP (C)	8.58	8.58	8.58	8.58	--	1	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.23 In-stream water quality data at 6BSRA001.11 on Straight Creek (7/90—3/04), Part 1.

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
Al DISSOLVED (µg/L)	148.00	148.00	148.00	148.00	--	1	--
Al SEDIMENT (mg/kg DRY WGT)	10,818	10,300	15,600	4,480	3913	7	--
AMMONIA, TOTAL (mg/L AS N)	0.09	0.06	0.22	0.04	0.05	19	—
Sb DISSOLVED (µg/L)	0.17	0.17	0.17	0.17	--	1	--
Sb SEDIMENT (mg/kg DRY WGT)	9.0	9.0	11	7	2.83	2	--
As DISSOLVED (µg/L)	0.33	0.33	0.33	0.33	--	1	--
As SEDIMENT (mg/kg DRY WGT)	7.43	6.7	12	5.0	2.62	7	--
Be SEDIMENT (mg/kg DRY WGT)	1.0	1.0	1.0	1.0	--	1	--
BOD (mg/L)	1.55	1.0	6.0	1.0	1.1	28	—
Ca DISSOLVED (mg/L)	41.0	41.0	41.0	41.0	--	1	--
Cl, TOTAL (mg/L)	8.08	7.3	20.8	1.3	4.84	53	—
Cr DISSOLVED (mg/L)	0.25	0.25	0.25	0.25	--	1	--
Cr SEDIMENT (mg/kg DRY WGT)	15.02	14.85	20.0	9.0	3.55	10	--
COD (mg/L)	27.5	7.0	410	1.0	72.5	34	—
Conductivity (µmho/cm)	1079	651	10269	40.1	1747	66	—
Cu, DISSOLVED (µg/L)	1.18	1.18	1.18	1.18	--	1	--
Cu SEDIMENT (mg/kg DRY WGT)	29.0	26.7	46.7	16.0	10.3986	10	--
Cu, TOTAL (µg/L)	10.0	10.0	10.0	10.0	--	1	--
DO	10.66	10.65	15.06	7.23	1.87	64	—
PH	8.06	8.10	8.57	7.42	0.28	66	—
FIXED SOLIDS (mg/L)	495	398	1800	189	290	55	—
FIXED SUSPENDED SOLIDS (mg/L)	84	6.0	1280	1.0	252	33	—
F, TOTAL (mg/L)	0.19	0.16	0.65	0.12	0.13	16	—
HARDNESS (mg/L AS $CaCO_3$)	191	161	1500	90	202	56	—
Fe, SEDIMENT (mg/kgG AS DRY WT)	30547	26500	48900	19800	11445	7	--
Pb, SEDIMENT (mg/kg DRY WT)	24.929	26.35	43	10	10.8068	10	--
Mg DISSOLVED (mg/L)	16	16	16	16	--	1	--
Mg TOTAL (mg/L)	16264	15660	21510	10480	4182	5	--
Mn DISSOLVED (mg/L)	93	93	93	93	--	1	--
Mn SEDIMENT (mg/kg DRY WGT)	898	756	1630	452	413.515	7	--
Ni DISSOLVED (mg/L)	5.66	5.66	5.66	5.66	--	1	--
Ni SEDIMENT (mg/kg DRY WGT)	41.0	43.0	64.5	19.0	16.7	10	--
Ni TOTAL (mg/L)	31.75	31.75	31.75	31.75	--	1	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.24 In-stream water quality data at 6BSRA001.11 on Straight Creek (7/90—3/04), Part 2.

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
NITRATE, TOTAL (mg/L AS N)	0.57	0.55	1.38	0.18	0.24	55	—
Nitrite + Nitrate (mg/L AS N)	0.52	0.5	0.76	0.4	0.10	9	--
Nitrite, TOTAL (mg/L AS N)	0.022	0.010	0.130	0.010	0.027	22	—
TKN (mg/L AS N)	0.34	0.2	3.6	0.1	0.55	52	—
N, TOTAL (mg/L)	0.644	0.636	0.86	0.53	0.10312	9	--
ORTHOPHOSPHORUS (mg/L AS P)	0.09	0.015	0.40	0.01	0.15	10	--
TP (mg/L AS P)	0.052	0.020	0.60	0.01	0.11	49	—
Se, DISSOLVED (µg/L)	1.5	1.5	1.5	1.5	--	1	--
Se, SEDIMENT (mg/kgDRY WT)	4.5	1.7	16	1	6.4	5	--
Se, TOTAL (µg/L)	10	10	10	10	--	1	--
TANNIN AND LIGNIN (mg/L)	1.62	1.62	1.62	1.62	--	1	--
TEMP (C)	13.6	13.2	26.5	2.6	6.4	67	--
THALLIUM, SEDIMENT (mg/kg DRY WT)	5.0	5.0	5.0	5.0	--	1	--
TOTAL ORGANIC CARBON (mg/L)	2.31	1.65	6.54	1	1.44	31	—
TOTAL SOLIDS (mg/L)	544	447	1860	212	305	55	—
VOLATILE SOLIDS (mg/L)	48.5	44	200	16	26.6	55	—
VOLATILE SUSPENDED SOLIDS (mg/L)	15.6	3	180	1	37.6	29	—
Zn, DISSOLVED (ug/L)	1.95	1.95	1.95	1.95	--	1	--
Zn, SEDIMENT (mg/kgDRY WT)	161.0	179	231	72	56.9	10	--
Zn, TOTAL (µg/L)	21.1	11.7	51.0	10	--	1	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.25 In-stream water quality data at 6BSRA003.22 on Straight Creek (7/03—3/04).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
Al, DISSOLVED (µg/L)	0.15	0.10	0.40	0.040	0.14	5	--
Conductivity (µmho/cm)	1345	1234	2251	582	551	9	--
DO	11.2	11.4	14.7	8.18	2.3	9	--
PH	8.42	8.43	8.74	8.21	0.17	9	--
Nitrite + Nitrate (mg/L AS N)	0.56	0.57	0.85	0.27	0.15	9	--
N, TOTAL (mg/L)	0.78	0.75	0.97	0.62	0.12	9	--
TEMP (C)	11.2	11.8	20.6	2.1	6.5	10	--
TP (mg/L AS P)	0.014	0.010	0.02	0.01	0.005	8	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.26 In-stream water quality data at 6BSRA003.62 on Straight Creek (8/6/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
Conductivity (µmho/cm)	521	521	521	521	--	1	--
DO	8.06	8.06	8.06	8.06	--	1	--
PH	8.20	8.20	8.20	8.20	--	1	--
TEMP (C)	18.30	18.30	18.30	18.30	--	1	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.27 In-stream water quality data at 6BSRA004.16 on Straight Creek (7/03—3/04).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
Conductivity (µmho/cm)	425	320	1059	253.0	248	9	--
DO	11.16	12.31	13.86	7.87	2.36	9	--
PH	8.18	8.09	9.28	7.555	0.48	9	--
Nitrite + Nitrate (mg/L AS N)	0.74	0.68	1.9	0.14	0.49	9	--
TEMP (C)	11.1	11.9	20.9	1.4	6.9	10	--
TP (mg/L AS P)	0.017	0.020	0.03	0.01	0.01	9	--
N, TOTAL (mg/L)	0.90	0.81	2.06	0.30	0.48	9	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

There have been a number of pollution response (PReP) incidents in the Straight Creek watershed over the past nine years. The major incidents that VADEQ has responded to are summarized below by pollution compliant number.

PC 95-0478 – 3/14/95

Polymer was added to a roadside settling basin owned by Lone Mountain Processing, Inc. (LMPI) to improve settling. The basin was not totally sealed and an unknown quantity reached state waters including Straight Creek. The result was 4,320 dead fish, including minnows and suckers. The spill impacted fish all the way to the mouth of Straight Creek.

PC 97-0135 – 10/24/1996

Subsidence in a LMPI impoundment caused coal slurry to reach a network of underground mines. Coal slurry consists of coal fines, water, and a variety of chemicals used to wash coal. The majority of the contaminants are considered PAHs (Polynuclear aromatic hydrocarbons). The slurry entered state surface

waters at Gin Creek and killed 11,240 fish in 8.5 miles involving Straight Creek and the North Fork Powell River. A consent decree between LMPI and the US Department of the Interior was entered into. The consent decree requires that LMPI pay the Department's Natural Resource Damage Assessment and Restoration Program (NRDAR) $2.45 million. This money is supposed to be earmarked for past natural resource damage, assessment costs, restoration, replacement of endangered species or acquisition of habitats which support them, and planning, implementation, oversight and monitoring. No implementation or reclamation work has been done.

PC 98-0001 – 7/1/1997

There was a blowout when water from the abandoned mine broke out of a hillside and flowed into Straight Creek. This occurred 0.4 miles north of St. Charles, VA. This mine was abandoned circa 1925. The wastewater was a low pH (3.5) and contained an extremely high concentration of iron, which precipitated in Straight Creek. The amount of water that flowed into Straight Creek is not known, but the level of water in the stream did rise because of the iron deposits on the banks. The fish kill totaled 3,133 including minnows, suckers, red-eye bass, smallmouth bass, brown trout and carp. The incident was declared an emergency in order that corrective action could be expedited. DMME dewatered the abandoned mine and put in mine seals where necessary.

A special benthic survey was carried out by VADEQ on August 7 to 9, 1997. A severe impact was found at station SRA002.69 just downstream of St. Charles. Only 49 organisms were found, less than half the minimum expected. A station further downstream, SRA000.50, compared favorably to the control station on Straight Creek, SRA003.84.

PC 2004-S-0153 – 10/9/2003

A sediment pond owned by Ghermal Coal Company breached, causing wastewater to leak into Straight Creek just upstream of St. Charles, VA. The fish

kill extended to the Bailey's Trace confluence (2,479 fish were killed). The fish killed were predominantly minnows (98%).

6.4.1.2 Mine Permit Application/Compliance Monitoring

In addition to the VADEQ stations, DMME in-stream monitoring data is shown in Table 6.28 and Figure 6.1. The data from these stations were used in the stressor identification in Chapter 7.

Table 6.28 Monitoring stations on Straight Creek from data supplied by DMME.

MPID	River Mile	Data Record	
		Begin	End
0003102*	2.12	04/99	05/99
1020127	3.26	11/95	12/04
0002877	4.87	03/98	12/04
1020209	5.32	01/95	12/04
1020237	5.37	01/95	12/04
1020241	5.57	01/95	03/98
1020226	5.64	01/95	12/04
1020180	5.97	01/95	12/04
1020225	6.06	01/95	12/04

*Only two data points, this station was not shown in the median graphs. There were no extreme values.

Tables 6.29 through 6.36 show summaries of the water quality data collected at each of the in-stream monitoring locations. Sample timing varied based on the mine permit that the sample was intended to support. Abbreviations used in these tables include: Fe (Total Iron), Mn (Total Manganese), TDS (Total Dissolved Solids), and TSS (Total Suspended Solids). All flow values that contributed to these summaries were estimated.

Conductivity and total dissolved solids are consistently high throughout the watershed, while total iron and total manganese spike at certain points in the stream and quickly return to lower levels.

Table 6.29 In-stream water quality data at MPID 0003102 (4/99—12/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	72	20.0	500	0.0	106	57	0.50
TEMP (C)	15	15.0	15	15.0	0	2	--
PH	7.8	7.8	8.3	7.2	0.8	2	--
Fe (mg/L)	1.1	1.1	1.6	0.6	0.7	2	--
Mn (mg/L)	0.1	0.1	0.1	0.1	0.0	2	--
TSS (mg/L)	14.5	14.5	20.0	9.0	7.8	2	--
ACIDITY (mg/L)	3.0	3.0	3.0	3.0	--	1	--
ALKALINITY (mg/L)	14.0	14.0	16.0	12.0	2.8	2	--
CONDUCTIVITY (µmhos/cm)	170	170	220	120	71	2	--
TDS (mg/L)	88	88	122.0	54	48.1	2	--
SULFATE (mg/L)	63	63	89.0	36.0	37.5	2	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.30 In-stream water quality data at MPID 1020127 (11/95—12/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	107	78	400	0	96	102	—
TEMP (C)	12.2	12.0	22.0	3.0	5.5	92	0.167
PH	7.5	7.6	8.7	6.2	0.44	97	-0.075
Fe (mg/L)	0.44	0.20	6.9	0.10	0.85	88	—
Mn (mg/L)	0.37	0.10	9.0	0.10	1.2	53	—
TSS (mg/L)	13.1	7.5	112	2.0	18.4	96	—
ACIDITY (mg/L)	0	0	0	0	0	97	—
ALKALINITY (mg/L)	80	62	296	15.0	63	97	-6.0
CONDUCTIVITY (µmhos/cm)	862	450	5,800	130	1,188	97	—
TDS (mg/L)	698	338	5,122	30.0	1,064	97	—
SULFATE (mg/L)	278	156	2,132	8.0	346	97	—

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.31 In-stream water quality data at MPID 0002877 (3/98—12/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	505	500	1,400	100	213	67	40.0
TEMP (C)	12.1	11.0	21.0	2.0	5.1	67	—
PH	7.9	8.0	8.5	6.8	0.29	67	—
Fe (mg/L)	0.34	0.10	7.0	0.10	0.96	52	-0.02
Mn (mg/L)	0.11	0.10	0.3	0.10	0.04	24	-0.02
TSS (mg/L)	10.2	4.0	284	2.0	34.6	67	—
ACIDITY (mg/L)	0	0	0	0	0	67	—
ALKALINITY (mg/L)	141	136	385	16	65	67	—
CONDUCTIVITY (µmhos/cm)	542	510	1,580	180	234	67	—
TDS (mg/L)	354	350	918	108	132	67	—
SULFATE (mg/L)	117	116	215	42.0	46.4	67	—

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.32 In-stream water quality data at MPID 1020209 (1/95—12/95).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	405	325	1,200	40	340	12	--
TEMP (C)	12.0	14.0	18.0	2.0	5.9	12	--
PH	7.7	7.9	8.3	7.0	0.42	12	--
Fe (mg/L)	0.43	0.25	1.2	0.10	0.33	12	--
Mn (mg/L)	0.23	0.25	0.40	0.10	0.12	6	--
TSS (mg/L)	18.8	19.5	43	4.0	13.2	12	--
ACIDITY (mg/L)	0	0	0	0	0	12	--
ALKALINITY (mg/L)	142	116	333	79	72	12	--
CONDUCTIVITY (µmhos/cm)	533	485	1,300	320	257	12	--
TDS (mg/L)	394	351	855	236	157	12	--
SULFATE (mg/L)	122	119	177	64	31.1	12	--

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.33 In-stream water quality data at MPID 1020237 (1/95—12/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	337	300	2,000	30	251	105	12.5
TEMP (C)	11.5	12.0	21.0	1.0	5.4	104	—
PH	8.0	8.0	8.5	7.0	0.32	105	—
Fe (mg/L)	0.85	0.20	33.8	0.10	3.65	90	-0.035
Mn (mg/L)	0.14	0.10	1.0	0.10	0.14	55	-0.006
TSS (mg/L)	23.8	7.0	930	2.0	96	105	-0.08
ACIDITY (mg/L)	0	0	0	0	0	105	—
ALKALINITY (mg/L)	170	140	674	14	108	105	2.41
CONDUCTIVITY (µmhos/cm)	651	535	2,620	270	355	105	12.0
TDS (mg/L)	471	387	1,596	35	259	105	—
SULFATE (mg/L)	166	138	530	35	85	105	—

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.34 In-stream water quality data at MPID 1020241 (1/95—3/98).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	164	75	800	10	195	39	-32.5
TEMP (C)	10.4	12.0	19.0	1.0	5.2	39	—
PH	7.8	7.9	8.2	7.0	0.30	39	0.1
Fe (mg/L)	2.0	0.40	46.0	0.10	7.5	39	—
Mn (mg/L)	0.14	0.10	0.50	0.10	0.09	37	—
TSS (mg/L)	58.6	11.0	1610	4.0	256	39	—
ACIDITY (mg/L)	0	0	0	0	0	39	—
ALKALINITY (mg/L)	123	120	213	72	42.9	39	—
CONDUCTIVITY (µmhos/cm)	407	420	630	8.0	121	39	—
TDS (mg/L)	321	308	668	156	95	39	—
SULFATE (mg/L)	95	91	202	38.0	37.8	39	—

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.35 In-stream water quality data at MPID 1020226 (1/95—12/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	103	75	800	10.0	131	105	-5.0
TEMP (C)	11.5	12.0	19.0	1.0	4.9	105	0.167
PH	7.8	7.9	8.2	7.0	0.25	105	—
Fe (mg/L)	0.6	0.20	12.9	0.10	1.69	99	-0.033
Mn (mg/L)	0.1	0.10	0.5	0.1	0.09	73	—
TSS (mg/L)	31.4	7.0	1,610	2.0	160	105	-1.0
ACIDITY (mg/L)	0	0	0	0	0	105	—
ALKALINITY (mg/L)	131	126	222	69	43.1	105	—
CONDUCTIVITY (µmhos/cm)	466	460	914	120	126	105	—
TDS (mg/L)	343	329	1,175	136	124	105	—
SULFATE (mg/L)	111	102	258	38.0	46.3	105	—

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

Table 6.36 In-stream water quality data at MPID 1020225 (1/95—12/03).

Water Quality Constituent	Mean	Median	Max	Min	SD[1]	N[2]	Trend[3]
FLOW (gpm)	78	50.0	600	5.0	101	105	-4.17
TEMP (C)	11.7	13.0	20.0	1.0	5.1	105	—
PH	7.7	7.9	8.3	0.0	0.81	105	-0.025
Fe (mg/L)	0.66	0.20	13.2	0.10	1.85	97	-0.025
Mn (mg/L)	0.11	0.10	0.40	0.10	0.05	44	—
TSS (mg/L)	24.2	8.0	590	2.0	72	105	-0.5
ACIDITY (mg/L)	0	0	0	0	0	105	—
ALKALINITY (mg/L)	108	107	354	58	41.4	105	—
CONDUCTIVITY (µmhos/cm)	421	410	700	120.0	100	105	5.0
TDS (mg/L)	293	290	505	55	79	105	-6.33
SULFATE (mg/L)	104	102	225	27.0	41.3	105	—

[1]SD: standard deviation, [2]N: number of sample measurements, [3]A number in the significant trend column represents the Seasonal-Kendall estimated slope, "--": insufficient data, "—" no trend

6.4.1.3 Water Quality Monitoring Conducted by DMME

ECI performed additional water quality monitoring during July 2002 through June 2003 under contract from DMME. Three sites were selected on Straight Creek (Figure 6.1). The results of the chemical sampling are presented in Tables 6.37 and 6.38.

Table 6.37 Results of ECI chemical monitoring in the Straight Creek watershed.

Station	Date	Flow (cfs)	Alkalinity, $CaCO_3$ (mg/L)	Conductivity (µmho/cm)	Dissolved Fe (mg/L)	Total Fe (mg/L)	Dissolved Mn (mg/L)	Total Mn (mg/L)
SA	7/18/2002	2.85	153	370	0	0.57	0	0
SA	11/7/2002	6.38	119	350	0	0.11	0	0
SA	6/5/2003	4.79	103	337	0	0.09	0	0
SB	7/18/2002	4.16	174	510	0.06	0.58	0	0
SB	11/8/2002	10	114	470	0	0.12	0	0
SB	6/5/2003	13.6	1,144	597	0	0.41	0.1	0.07
SC	7/18/2002	17.4	156	530	0.09	1.35	0	0.12
SC	11/7/2002	41.8	58	230	0	0.2	0	0
SC	6/5/2003	30.8	81	427	0	0.3	0.07	0

Table 6.38 Results of ECI chemical monitoring in the Straight Creek watershed.

Station	Date	Flow (cfs)	pH	Temp ^{0}C	DO (mg/L)	SO4 (mg/L)	TDS (mg/L)	TSS (mg/L)
SA	7/18/2002	2.85	6.3	16.8	7	53	326	44
SA	11/7/2002	6.38	6.7	8.7	8	112	250	11
SA	6/5/2003	4.79	8.1	18	7	79	299	10
SB	7/18/2002	4.16	6.1	18.9	7	164	503	25
SB	11/8/2002	10.01	6.4	12	8	204	290	13
SB	6/5/2003	13.56	7.9	16	7	262	488	8
SC	7/18/2002	17.35	6.3	24	7	314	532	29
SC	11/7/2002	41.76	6.4	8.9	8	88	155	10
SC	6/5/2003	30.76	8	16	9	151	347	7

6.4.1.4 Water Quality Monitoring Conducted by United States Army Corp of Engineers (USACOE)

The USACOE has an ongoing data collection process for the Powell River Ecosystem Restoration Project. Water quality data was collected from December 1998 through September 2003 at 12 monitoring stations on the mainstem of Straight Creek. Table 6.39 provides descriptive statistics for all of the data collected at the 12 sites. Data was also collected at a 13th site, SC6D (river mile 3.41), but it was inconsistent with other data collected for Straight Creek by the regulatory agencies or independent contractors. It was obvious that this data was either not collected from the mainstem or was collected in the plume of seep and did not represent typical Straight Creek stream conditions. The data for this station is not represented in Table 6.39.

Table 6.39 Results of USACOE chemical monitoring in Straight Creek.

Parameter	Mean:	Median:	Max:	Min:	SD[1]	N[2]
Temperature (C °)	13.3	12.3	25.3	0.6	6.2	217
pH (std units)	8.1	8.2	9.7	6.1	0.6	221
Dissolved Oxygen (mg/L)	10.9	10.6	17.1	7.6	2.1	83
Alkalinity, Total field (mg/L)	123	123	253	48	50	76
Aluminum, Total (mg/L)	0.93	0.22	23.90	0.05	3.44	62
Calcium (mg/L)	30.48	27.25	99.10	11.30	16.23	70
Copper (mg/L)	0.02	0.02	0.04	0.00	0.02	8
Iron, Dissolved (mg/L)	0.06	0.05	0.11	0.03	0.02	34
Iron, Total (mg/L)	0.56	0.18	11.10	0.03	1.50	70
Manganese, Total (mg/L)	0.14	0.05	1.65	0.03	0.30	39
Zinc (mg/L)	0.02	0.01	0.07	0.01	0.02	7
Specific Conductance (µmhos/cm)	781	620	4,773	144	643	219
Sulfate, (mg/L)	204	127	1,400	42	263	76
Sodium (mg/L)	117	55	939	6	174	68
Total Dissolved Solids (mg/L)	498	324	3,294	30	580	76
Total Suspended Solids (mg/L)	13	5	219	1	31	73
Flow (gpm)	4,076	1,100	46,100	9	6,992	222

[1]SD: standard deviation, [2]N: number of sample measurements

6.4.2 Trend and Seasonal Analyses

In order to improve TMDL allocation scenarios and, therefore, the success of implementation strategies, trend and seasonal analyses were performed on flow and water quality results. A Seasonal Kendall Test was used to examine long-term trends. The Seasonal Kendall Test ignores seasonal cycles when looking for long-term trends. This improves the chances of finding existing trends in data that are likely to have seasonal patterns. Additionally, trends for specific seasons can be analyzed. For instance, the Seasonal Kendall Test can identify the trend (over many years) in discharge levels during a particular season or month. A seasonal analysis of water chemistry results was conducted using the Mood Median Test. This test was used to compare median values of flow and water quality in each month.

6.4.2.1 Water Chemistry Results

There are some consistent trends for stations on Straight Creek, which show decreasing trends for Fe, Mn and TSS (Table 6.40). The four upstream stations show a downward trend for flow, while three of the five downstream stations show an increasing trend. No trends were observed in the VADEQ water quality data.

The Mood Median test results on water quality data from VADEQ station 6BSRA001.11 showed significant differences between months for conductivity, dissolved oxygen (DO), fixed solids (FS), hardness, pH, total solids (TS), and volatile solids (VS). The Mood Median test results from the DMME stations are shown in Tables 6.41 through 6.74.

Table 6.40 Trend Analysis results for DMME supplied water quality data for Straight Creek.

Constituent	Station			
	0003102	**1020127**	**0002877**	**1020209**
FLOW (gpm)	0.50	—	40.0	--
TEMP (C)	--	0.167	—	--
PH	--	-0.075	—	--
FE (mg/L)	--	—	-0.02	--
MN (mg/L)	--	—	-0.02	--
TSS (mg/L)	--	—	—	--
ACIDITY (mg/L)	--	—	—	--
ALKALINITY (mg/L)	--	-6.0	—	--
CONDUCTIVITY (µmhos/cm)	--	—	—	--
TDS (mg/L)	--	—	—	--
SULFATE (mg/L)	--	—	—	--

A number in station column represents the Seasonal-Kendall estimated slope.
"--": insufficient data, "—" no trend

Table 6.40 Trend Analysis results for DMME supplied water quality data for Straight Creek (continued).

Constituent	Station			
	1020237	1020241	1020226	1020225
FLOW (gpm)	12.5	-32.5	-5.0	-4.17
TEMP (C)	—	—	0.167	
PH	—	0.1	—	-0.025
FE (mg/L)	-0.033	—	-0.033	-0.025
MN (mg/L)	-0.017	—	-0.013	—
TSS (mg/L)	-0.08	—	-1.0	-0.5
ACIDITY (mg/L)	—	—	—	—
ALKALINITY (mg/L)	2.41	—	—	—
CONDUCTIVITY (µmhos/cm)	12.0	—	—	5.0
TDS (mg/L)	—	—	—	-6.33
SULFATE (mg/L)	—	—	—	—

A number in station column represents the Seasonal-Kendall estimated slope.
"--": insufficient data, "—" no trend

Table 6.41 Summary of Moods Median Test on mean monthly conductivity at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (µmhos/cm)	Minimum (µmhos/cm)	Maximum (µmhos/cm)	Median Groups[1]	
January	437	185	696	A	
February	698	405	901		
March	484	301	767	A	
April	457	40.1	836	A	B
May	622	404	885	A	B
June	10,214	428	20,000		
July	898	501	1,376		B
August	3,682	538	20,000		B
September	1,292	588	2,700		B
October	1,521	457	8,500		B
November	870	600	1,123		B
December	504	397	610		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.42 Summary of Moods Median Test on mean monthly DO at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]		
January	12.7	10.63	15.06		B	C
February	12.5	11.67	12.9			C
March	11.1	9.7	11.9		B	C
April	10.8	9.78	12.19		B	C
May	9.6	8.45	10.8	A	B	
June	8.6	8.6	8.6			
July	8.8	7.23	10.02	A	B	
August	8.2	7.7	8.62	A		
September	9.3	7.99	11.5	A	B	
October	10.5	9.43	12.91		B	
November	12.4	11.31	13.37			C
December	13.4	12.2	14.62			C

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.43 Summary of Moods Median Test on mean monthly fixed solids at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	315.6	219	471	A	
February	222.0	222	222		
March	270.3	189	403	A	B
April	317.7	210	483	A	B
May	403.3	300	608	A	B
June	1,120.0	1,120	1,120		
July	560.6	340	870		B
August	1,139.5	479	1,800		B
September	674.8	370	972		B
October	630.6	277	1,008		B
November	559.8	376	686		B
December	237.0	237	237		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.44 Summary of Moods Median Test on mean monthly hardness (mg/L AS CACO3) at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]		
January	264.6	94.9	1,500	A	B	C
February	108.0	108	108			
March	97.0	90	105	A		
April	116.6	101	172	A	B	
May	135.3	114	160		B	
June	240.0	240	240			
July	177.0	142	222			C
August	473.0	146	800		B	C
September	183.8	152	195			C
October	202.0	156	268			C
November	171.4	148	189		B	C
December	144.0	144	144			

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.45 Summary of Moods Median Test on mean monthly pH at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean	Minimum	Maximum	Median Groups[1]	
January	7.9	7.42	8.57	A	B
February	8.0	7.87	8.22	A	B
March	8.2	7.99	8.5		B
April	7.8	7.7	8.0	A	
May	7.9	7.48	8.28	A	B
June	8.3	8.32	8.32		
July	8.1	7.8	8.36	A	B
August	7.9	7.48	8.17	A	B
September	8.2	7.88	8.45	A	B
October	8.2	7.71	8.47	A	B
November	8.3	8.13	8.37		B
December	8.0	7.91	8.11	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.46 Summary of Moods Median Test on mean monthly temperature (C) at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]			
January	5.8	2.6	9.7	A	B		
February	5.4	4.9	6.2	A			
March	10.7	7.4	12.4		B		
April	12.9	8.9	18.9		B	C	
May	15.4	13.7	18.2				D
June	17.9	17.9	17.9				
July	21.6	19.4	26.5				D
August	19.2	18.1	20.9				D
September	20.2	17.3	23.4				D
October	13.8	9.4	18.3		B	C	
November	8.5	5.1	12.2	A	B		
December	5.7	4.1	7.3	A			

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.47 Summary of Moods Median Test on mean monthly total solids at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	355	258	530	A	
February	250	250	250		
March	300	212	447	A	B
April	355	246	527	A	B
May	445	335	661	A	B
June	1,320	1,320	1,320		
July	618	391	941		B
August	1,187	514	1,860		B
September	721	412	1,008		B
October	689	309	1,092		B
November	611	402	742		B
December	272	272	272		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.48 Summary of Moods Median Test on mean monthly volatile solids at VADEQ station 6BSRA001.11 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	39.7	21.0	71.0	A	B
February	28.0	28.0	28.0		
March	30.0	23.0	44.0	A	
April	37.6	30.0	47.0	A	B
May	42.0	33.0	53.0	A	B
June	200	200	200		
July	56.9	16.0	82.0		B
August	47.5	35.0	60.0	A	B
September	46.0	34.0	76.0	A	B
October	58.3	32.0	84.0		B
November	51.0	26.0	68.0	A	B
December	35.0	35.0	35.0		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.49 Summary of Moods Median Test on mean monthly flow at DMME MPID 0003102 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	54	1	100	A	B
February	68	15	125		B
March	113	50	225		B
April	234	45	500		B
May	113	20	250		B
June	51	0	200	A	B
July	68	2	300	A	B
August	15	5	25	A	B
September	5	0	20	A	
October	5	0	15	A	
November	49	0	200	A	B
December	91	0	150	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.50 Summary of Moods Median Test on mean monthly temperature (C) at DMME MPID 1020127 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]			
January	4.5	3.0	7.0	A			
February	5.0	3.0	8.0	A			
March	7.0	4.0	11.0	A	B		
April	10.0	7.0	16.0		B	C	
May	14.0	11.0	16.0			C	
June	16.6	15.0	18.0			C	D
July	18.6	17.0	20.0				D
August	19.3	18.0	20.0				D
September	18.4	17.0	22.0				D
October	13.8	11.0	17.0			C	
November	9.8	8.0	13.0		B		
December	7.6	3.0	10.5	A	B		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.51 Summary of Moods Median Test on mean monthly temperature (C) at DMME MPID 0002877 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	6.5	2.0	9.0	A	
February	7.3	5.0	10.0	A	
March	6.8	4.0	10.0	A	
April	9.7	8.0	11.0	A	B
May	15.7	14.0	17.0		B
June	15.3	11.0	18.0		B
July	18.5	17.0	21.0		B
August	18.5	17.0	20.0		B
September	15.5	12.0	19.0		B
October	12.3	9.0	18.0	A	B
November	8.0	4.0	12.0	A	B
December	7.0	3.0	12.0	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.52 Summary of Moods Median Test on mean monthly alkalinity at DMME MPID 0002877 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	76	57	104	A	
February	124	81	176	A	B
March	81	54	116	A	
April	87	56	117	A	
May	119	16	181	A	B
June	144	101	231	A	B
July	173	116	270		B
August	204	130	345		B
September	193	104	385	A	B
October	162	146	188		B
November	154	108	217		B
December	135	65	223	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.53 Summary of Moods Median Test on mean monthly conductivity at DMME MPID 0002877 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	305	180	390	A	
February	514	410	734		B
March	346	220	480	A	B
April	357	233	498	A	B
May	505	370	580		B
June	507	380	710		B
July	640	490	1,118		B
August	725	520	1,200		B
September	742	380	1,580		B
October	655	510	800		B
November	583	390	880		B
December	510	240	907	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.54 Summary of Moods Median Test on mean monthly flow at DMME MPID 0002877 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	719	600	825		B
February	650	600	800		B
March	620	500	800		B
April	621	500	800		B
May	598	500	800		B
June	458	350	600	A	B
July	434	225	580	A	B
August	515	150	1,400	A	B
September	347	125	580	A	B
October	268	100	400	A	
November	388	275	600	A	B
December	583	350	900		B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.55 Summary of Moods Median Test on mean monthly TDS at DMME MPID 0002877 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups1	
January	266	182	385	A	B
February	312	195	441	A	B
March	247	188	305	A	
April	253	206	300	A	
May	357	264	432	A	B
June	355	219	544	A	B
July	398	343	521		B
August	471	342	733		B
September	440	230	918	A	B
October	406	323	511		B
November	366	276	503		B
December	321	108	630	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.56 Summary of Moods Median Test on mean monthly temperature (C) at DMME MPID 1020237 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	6.4	2.0	10.0	A	
February	5.4	1.0	9.0	A	
March	7.4	3.0	12.0	A	B
April	10.3	7.0	17.0	A	B
May	15.4	12.0	18.0		B
June	15.4	11.0	18.0		B
July	17.7	13.0	21.0		B
August	18.4	15.0	20.0		B
September	15.1	11.0	19.0		B
October	12.2	9.0	17.0		B
November	6.2	2.0	11.0	A	B
December	5.6	2.0	13.0	A	

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.57 Summary of Moods Median Test on mean monthly alkalinity at DMME MPID 1020237 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	140	71	226	A	B
February	120	83	222	A	
March	115	14	325	A	B
April	135	82	246	A	B
May	174	92	310	A	B
June	160	84	324	A	B
July	197	43	510		B
August	215	137	632		B
September	232	121	674		B
October	163	127	207		B
November	179	122	354		B
December	197	82	474	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.58 Summary of Moods Median Test on mean monthly flow at DMME MPID 1020237 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	594	150	2,000	A	B
February	428	200	1,000		B
March	416	300	900		B
April	379	150	600		B
May	487	300	1,200		B
June	332	225	465		B
July	278	100	400	A	B
August	197	50	400	A	
September	195	30	375	A	
October	151	40	300	A	
November	301	80	950	A	B
December	336	200	600	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.59 Summary of Moods Median Test on mean monthly pH at DMME MPID 1020237 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	7.9	7.0	8.3	A	B
February	8.1	7.2	8.5	A	B
March	8.1	7.6	8.4		B
April	8.2	7.8	8.4		B
May	7.9	7.2	8.2	A	B
June	7.9	7.2	8.2	A	B
July	8.0	7.4	8.3	A	B
August	8.1	7.9	8.4	A	B
September	7.9	7.5	8.3	A	B
October	7.8	7.3	8.1	A	
November	8.0	7.2	8.5	A	B
December	8.1	7.4	8.5	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.60 Summary of Moods Median Test on mean monthly temperature (C) at DMME MPID 1020241 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]		
January	5.3	2.0	8.0	A	B	
February	4.0	1.0	7.0	A		
March	8.8	4.0	13.0	A	B	
April	10.3	6.0	17.0	A	B	C
May	13.7	12.0	15.0		B	
June	15.7	13.0	18.0		B	C
July	16.7	15.0	19.0			C
August	16.0	15.0	17.0			C
September	14.0	12.0	16.0		B	C
October	14.0	13.0	15.0		B	
November	5.7	4.0	7.0	A		
December	5.3	3.0	9.0	A	B	

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.61 Summary of Moods Median Test on mean monthly alkalinity at DMME MPID 1020241 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]		
January	105.5	72.0	135	A	B	
February	87.5	74	97	A	B	
March	76.5	72	84	A		
April	93.0	78	106	A	B	
May	92.3	76	103	A	B	
June	112.0	80	128	A	B	
July	134.7	112	160		B	
August	169.7	142	188		B	C
September	176.7	134	213		B	C
October	196.7	190	208			C
November	145.0	122	180		B	C
December	122.3	87	160		B	

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.62 Summary of Moods Median Test on mean monthly conductivity at DMME MPID 1020241 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	332.5	290.0	380	A	
February	320.0	120	460	A	B
March	345.0	320	380	A	
April	380.0	360	420	A	B
May	380.0	280	460	A	B
June	433.3	300	500	A	B
July	476.7	440	510		B
August	486.7	460	540		B
September	563.3	460	630		B
October	356.0	8	620	A	B
November	470.0	410	540		B
December	413.3	340	480	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.63 Summary of Moods Median Test on mean monthly Fe at DMME MPID 1020241 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	3.6	0.1	12.9	A	B
February	0.2	0.1	0.3	A	
March	0.7	0.2	1.7	A	B
April	0.2	0.1	0.2	A	
May	16.7	0.3	46		B
June	0.5	0.5	0.6		B
July	0.6	0.5	0.8		B
August	0.7	0.4	0.9		B
September	0.8	0.2	1.3	A	B
October	0.2	0.2	0.2	A	
November	0.4	0.1	0.9	A	B
December	0.2	0.1	0.3	A	

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.64 Summary of Moods Median Test on mean monthly TSS at DMME MPID 1020241 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	414.5	7.0	1,610	A	B
February	6.8	4.0	9	A	
March	32.3	12.0	52		B
April	9.7	8.0	11	A	
May	29.3	20.0	48		B
June	25.3	19.0	29		B
July	17.7	4.0	33	A	B
August	15.3	4.0	33	A	B
September	40.0	11.0	82	A	B
October	4.3	4.0	5	A	
November	11.3	5.0	20	A	B
December	4.3	4.0	5	A	

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.65 Summary of Moods Median Test on mean monthly alkalinity at DMME MPID 1020226 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]			
January	97	72	135	A	B	C	
February	92	69	124	A	B		
March	82	71	118	A			
April	90	73	110	A	B		
May	102	76	118		B		
June	127	80	172		B	C	D
July	143	112	163			C	
August	167	130	196			C	D
September	182	126	222			C	D
October	197	162	217				D
November	153	102	192			C	D
December	123	87	160		B	C	

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.66 Summary of Moods Median Test on mean monthly temperature (C) at DMME MPID 1020226 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]			
January	5.9	2.0	10.0	A			
February	5.8	1.0	10.0	A	B		
March	7.6	3.0	13.0	A	B		
April	10.4	6.0	17.0		B		
May	14.6	12.0	18.0			C	
June	15.0	11.0	18.0		B	C	D
July	17.0	15.0	19.0			C	D
August	16.9	15.0	18.0				D
September	14.9	12.0	19.0			C	D
October	13.7	11.0	18.0		B	C	
November	8.4	4.0	14.0	A	B		
December	6.4	3.0	13.0	A	B		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.67 Summary of Moods Median Test on mean monthly conductivity at DMME MPID 1020226 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	380	240	540	A	B
February	374	120	491	A	B
March	379	320	460	A	B
April	377	280	434	A	
May	398	280	460	A	B
June	464	300	700	A	B
July	490	440	530		B
August	537	390	690		B
September	596	460	800		B
October	606	440	914		B
November	532	380	737		B
December	435	340	668	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.68 Summary of Moods Median Test on mean monthly flow at DMME MPID 1020226 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	203	50	800		B
February	139	75	400		B
March	147	75	400		B
April	87	30	100		B
May	172	20	800		B
June	96	40	300		B
July	84	25	280	A	B
August	43	20	75	A	B
September	43	10	75	A	B
October	33	10	75	A	
November	114	20	600	A	B
December	96	35	275		B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.69 Summary of Moods Median Test on mean monthly TDS at DMME MPID 1020226 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	285	136	542	A	B
February	258	187	314	A	
March	266	199	346	A	
April	281	235	338	A	B
May	318	203	439	A	B
June	341	212	450	A	B
July	341	265	420		B
August	359	257	475		B
September	403	290	668		B
October	427	305	629		B
November	400	249	608		B
December	415	204	1175	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.70 Summary of Moods Median Test on mean monthly temperature (C) at DMME MPID 1020225 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]			
January	5.9	1.0	10.0	A			
February	6.1	1.0	11.0	A			
March	7.8	3.0	13.0	A	B		
April	10.7	6.0	19.0		B		
May	14.6	13.0	18.0			C	
June	15.6	10.0	18.0			C	D
July	17.7	16.0	20.0				D
August	17.8	17.0	20.0				D
September	15.3	13.0	19.0			C	D
October	13.2	10.0	17.0		B	C	
November	8.0	4.0	13.0	A	B		
December	6.0	2.0	13.0	A	B		

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.71 Summary of Moods Median Test on mean monthly alkalinity at DMME MPID 1020225 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	104	72	264	A	B
February	77	58	100	A	B
March	69	59	81	A	
April	76	64	88	A	
May	87	72	109	A	B
June	102	76	127		B
July	118	110	124		B
August	133	107	228		B
September	134	112	167		B
October	165	120	354		B
November	120	84	168		B
December	102	82	123		B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.72 Summary of Moods Median Test on mean monthly conductivity at DMME MPID 1020225 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	336	260	430	A	B
February	340	120	450	A	B
March	340	270	440	A	
April	354	260	400	A	
May	363	280	478	A	B
June	438	300	580	A	B
July	436	350	484		B
August	489	420	600		B
September	514	410	620		B
October	532	400	700		B
November	460	360	638	A	B
December	418	310	569	A	B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.73 Summary of Moods Median Test on mean monthly flow at DMME MPID 1020225 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]	
January	164	30	600		B
February	118	50	350		B
March	111	50	300		B
April	72	40	100		B
May	132	30	600		B
June	74	30	275		B
July	54	20	150		B
August	33	15	50	A	B
September	26	5	50	A	B
October	19	5	40	A	
November	76	5	400	A	B
December	75	30	250		B

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

Table 6.74 Summary of Moods Median Test on mean monthly TDS at DMME MPID 1020225 on Straight Creek.

Month	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Median Groups[1]		
January	273	55	495	A	B	C
February	229	150	287	A		
March	256	185	416	A	B	
April	243	186	290	A		
May	283	180	470	A	B	C
June	293	196	363	A	B	C
July	277	163	350	A	B	
August	314	265	366		B	
September	325	268	440		B	C
October	385	279	505			C
November	335	251	409		B	C
December	295	199	403	A	B	C

[1]Months with the same median group letter are not significantly different from each other at the 95% level of significance.

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7. TMDL ENDPOINT: STRESSOR IDENTIFICATION

7.1 Stressor Identification

There are no water quality standards or recommended screening levels for many of the water quality parameters sampled in the Straight Creek watershed. In order to assess the potential impact of water quality on the macroinvertebrate population in Straight Creek, a suitable watershed was selected for comparison. The McClure River is a fourth order stream in the same ecoregion as Straight Creek and there are mining related land uses in the watershed. Recent biological monitoring at VADEQ station 6AMCR000.55 indicates a healthy macroinvertebrate population. Therefore, for water quality parameters without established standards or screening levels, the 90th percentile for the parameters available from the McClure River (6AMCR000.20) were used to evaluate the water quality data in this stressor analysis. When a parameter exceeded the 90th percentile more than 10% of the time it was considered excessive, and a scatter graph is shown for the parameter at that monitoring station. Depending on the habitat and benthic metrics, additional chemical evidence, and references documenting potential problems for aquatic life, a parameter with excessive values may be considered a possible or probable stressor. In addition summary graphs depicting the median values at multiple VADEQ and DMME MPIDs for each parameter that had more than nine data points are also shown. The presence of nine values was selected as a cut off in order to avoid using data from stations that were not sampled during different seasons of the year or different flow regimes of Straight Creek. However, all data collected on Straight Creek was carefully reviewed to ensure it was consistent with expected values and to document any extreme values. The monitoring data supplied by DMME was collected from 1/1995 to 12/2003 and there was considerable variation in the amount of data collected at each monitoring site. For example, data at some sites was collected very early in the sampling period and at other sites near the end of the sampling period. In the graphs that follow the entire sampling period is reported to show when the data was collected and to compare values between stations. Table 7.1 shows the 90th percentile values used as screening values from the McClure River (6AMCR000.20) data. Graphs for parameters with more than

one data point and less than nine are shown in Appendix C. The monitoring sites are ordered from downstream to upstream in each stressor section.

Table 7.1 McClure River (6AMCR000.20) 90th percentile screening values.

Parameter	90th Percentile
Conductivity (µmhos/cm)	800
Total dissolved solids (mg/L)	525
Total suspended solids, (mg/L)	25
Sulfate (mg/L)	150
Alkalinity (mg/L)	200
Iron sediment (mg/Kg)	23,947
Manganese sediment (mg/Kg)	897
Selenium sediment (mg/Kg)	1.0
Nitrate-nitrogen (mg/L)	0.41
BOD_5 (mg/L)	2.0
COD (mg/L)	12.5
Volatile solids (mg/L)	68
Volatile suspended solids (mg/L)	3.4
Turbidity (FORMAZIN TU)	28
Total iron (mg/L)	1.45
Total manganese (mg/L)	0.10*

*0.10 mg/L was used because this value represents the minimum detection value in the majority of the available data.

TMDLs must be developed for a specific pollutant(s). Benthic assessments are very good at determining if a particular stream segment is impaired or not but they usually do not provide enough information to determine the cause(s) of the impairment. The process outlined in the Stressor Identification Guidance Document (EPA, 2000) was used to separately identify the most probable stressor(s) for Straight Creek. A list of candidate causes was developed from published literature, VADEQ, and DMME staff input. Chemical and physical monitoring data provided evidence to support or eliminate potential stressors. Individual metrics for the biological and habitat evaluation were used to determine if there were links to a specific stressor(s). Land use data as well as a visual assessment of conditions along the stream provided additional information to eliminate or support candidate stressors. The potential stressors are: sediment, toxics, low dissolved oxygen, nutrients, pH, metals, conductivity, temperature, and organic matter.

The results of the stressor analysis for Straight Creek are divided into three categories:

Non-Stressors: Those stressors with data indicating normal conditions, without water quality standard violations, or without the observable impacts usually associated with a specific stressor, were eliminated as possible stressors. Table 7.2 lists the parameters and where they are located in the document.

Possible Stressors: Those stressors with data indicating possible links, but inconclusive data, were considered to be possible stressors. Table 7.7 lists the parameters and where they are located in the document.

Most Probable Stressor: The stressor(s) with the most consistent information linking it with the poorer benthic and habitat metrics was considered to be the most probable stressor(s). Table 7.10 lists the parameters and where they are located in the document.

7.2 Non-Stressors

Table 7.2 Non-Stressors in Straight Creek.

Parameter	Location in Document
Dissolved oxygen	Section 7.2.1
Temperature	Section 7.2.2
Nutrients	Section 7.2.3
Ammonia	Section 7.2.4
Chloride	Section 7.2.4
Sediment organics[1]	Section 7.2.4 & Appendix C, Table C.1
Sediment pesticides	Section 7.2.4 & Appendix C, Table C.2
Sediment metals[2]	Section 7.2.5
Total & Dissolved metals	Section 7.2.5

[1]except as noted in section 1.3.1, [2]except as noted in section 1.3.4

7.2.1 Low dissolved oxygen

Dissolved oxygen (DO) concentrations remained well above the water quality standard at the VADEQ monitoring stations. Median values for three VADEQ monitoring stations are shown in Figure 7.1. In addition, there were no low DO concentrations in the three measurements made by ECI at three sites on Straight Creek. Low DO concentration is considered a non-stressor.

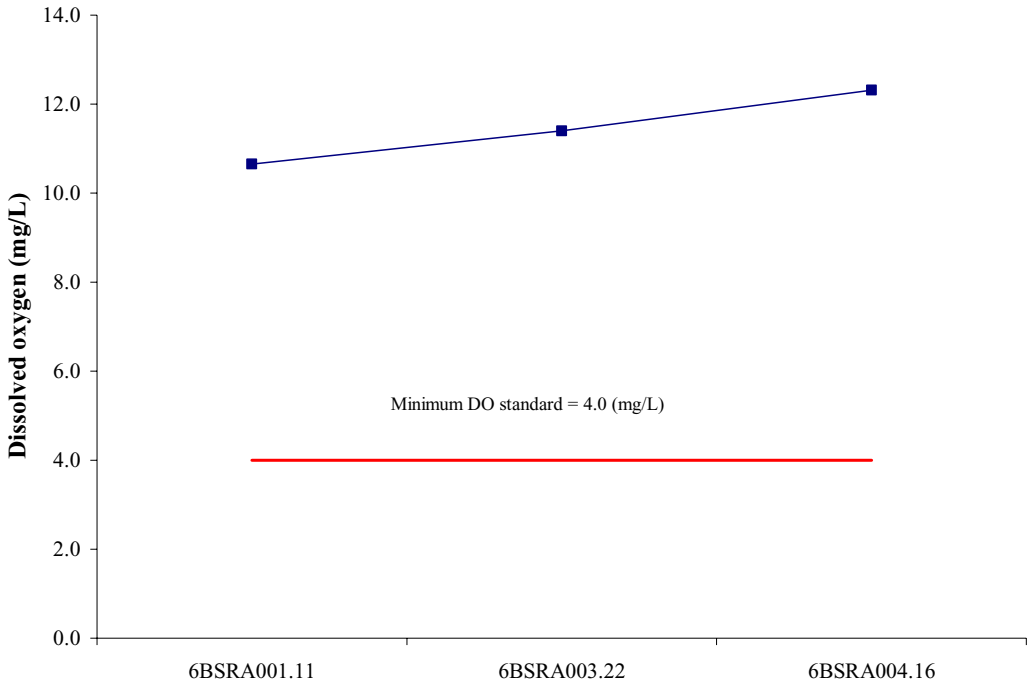

Figure 7.1 Median DO concentrations at VADEQ monitoring stations on Straight Creek.

7.2.2 Temperature

The maximum temperature recorded in Straight Creek was at VADEQ station 6BSRA001.11 (26.5^{o}C), which is well below the state standard of 31°C for the mountain zone waters. Median values for three VADEQ monitoring stations are shown in Figure 7.2. The nine temperature measurements made by ECI were below the state standard. Temperature measurements at the seven DMME permitted monitoring sites were also below the state standard; median values are shown in Figure 7.3. Temperature is considered a non-stressor.

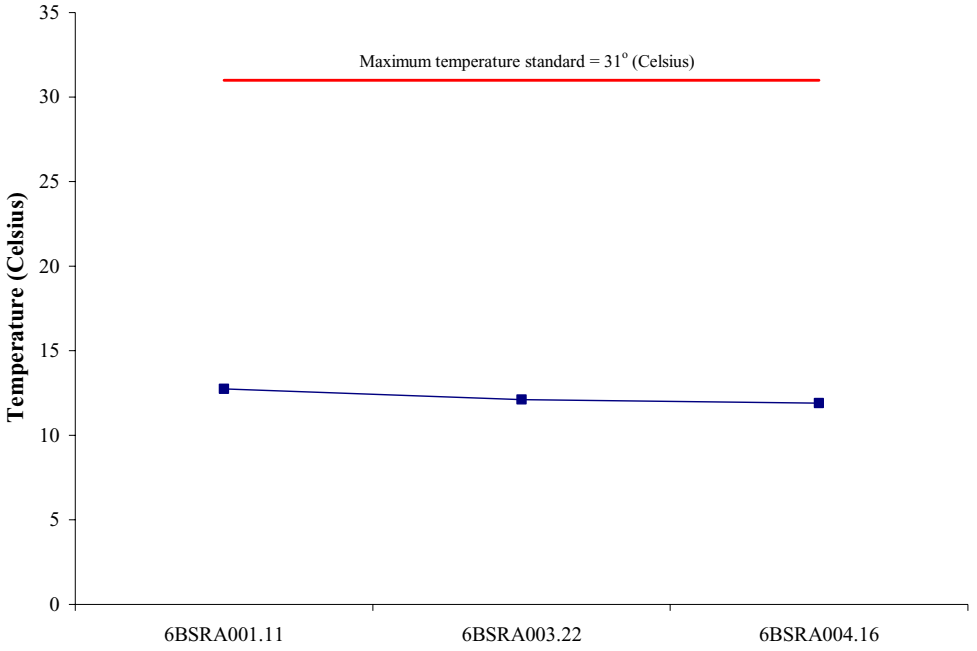

Figure 7.2 Median temperature measurements at VADEQ stations on Straight Creek.

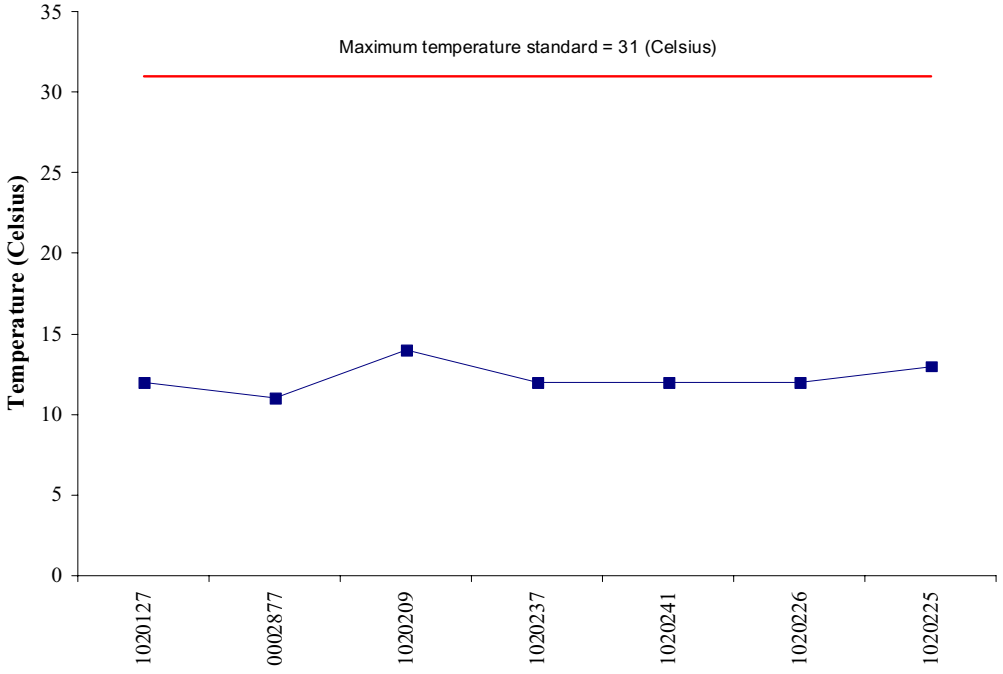

Figure 7.3 Median temperature measurements at DMME MPIDs on Straight Creek.

7.2.3 Nutrients

Median TP concentrations were below the VADEQ assessment screening value of 0.2 mg/L at all of the VADEQ stations (Figure 7.4). Only two values out of 49 samples at VADEQ station 6BSRA001.11 exceeded the screening value.

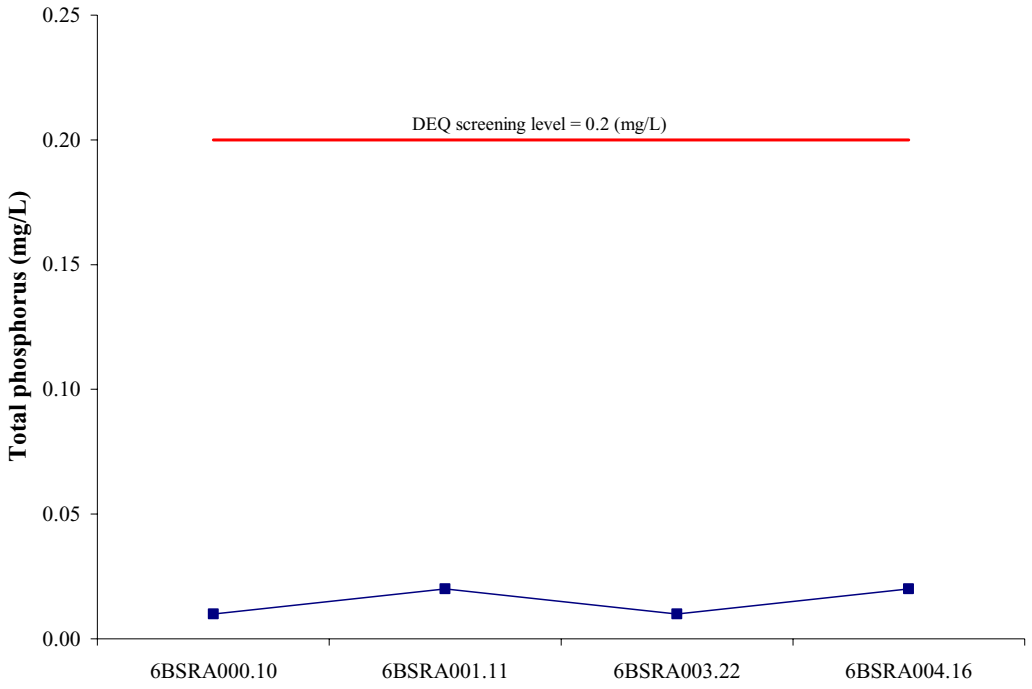

Figure 7.4 Median TP concentrations at VADEQ stations on Straight Creek.

Nitrate nitrogen (NO_3-N) concentrations exceeded the 90th percentile value of 0.41 mg/L in more than 10% of the samples collected at three VADEQ monitoring stations (Figures 7.5 through 7.7). Median NO_3-N concentrations also exceeded the 90th percentile value of 0.41 mg/L at these three VADEQ stations (Figure 7.8). A more thorough examination of nutrients was performed to try and determine the potential for eutrophication from the existing data at VADEQ station 6BSRA001.11. The criteria used can be found in Water quality assessment: A screening procedure for toxic and conventional pollutants in surface and ground water (Mills et al., 1985). The results indicated that TP was the most limiting nutrient 97% of the time. However, TP concentrations exceeded the PLE

threshold during the algal growing season only 10% of the time. Therefore, nutrients are considered non-stressors.

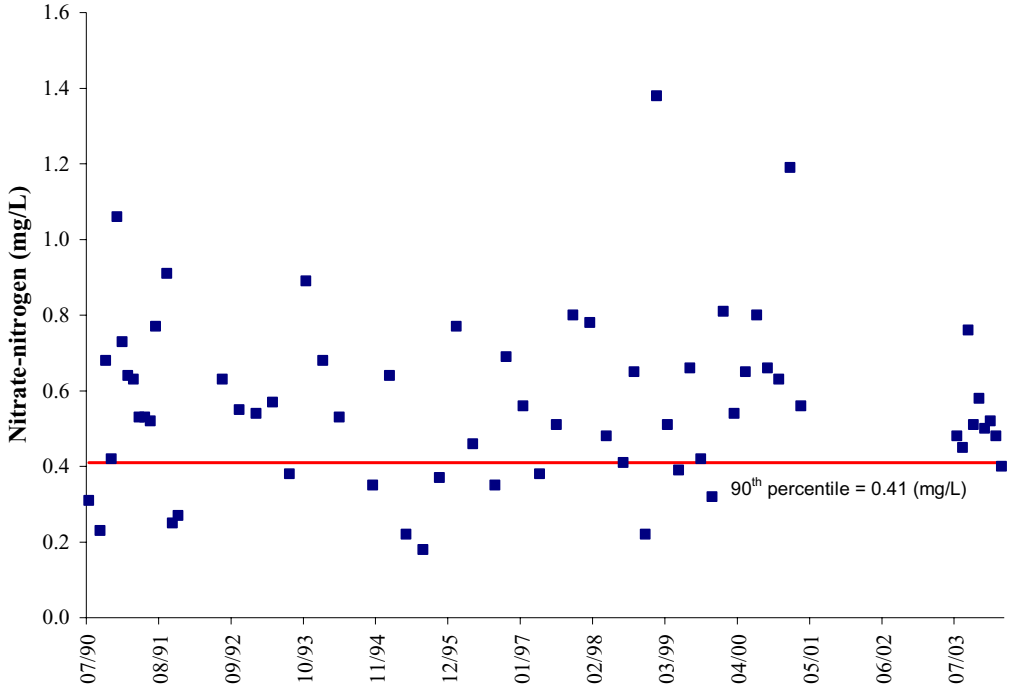

Figure 7.5 NO_3-N concentrations at VADEQ station 6BSRA001.11.

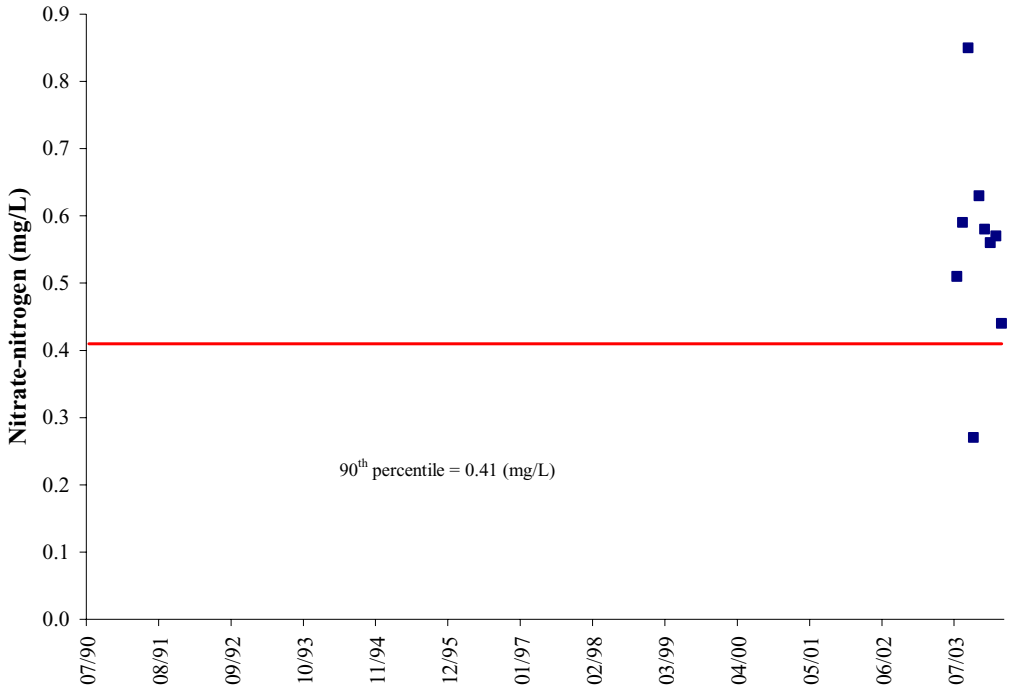

Figure 7.6 NO_3-N concentrations at VADEQ station 6BSRA003.22.

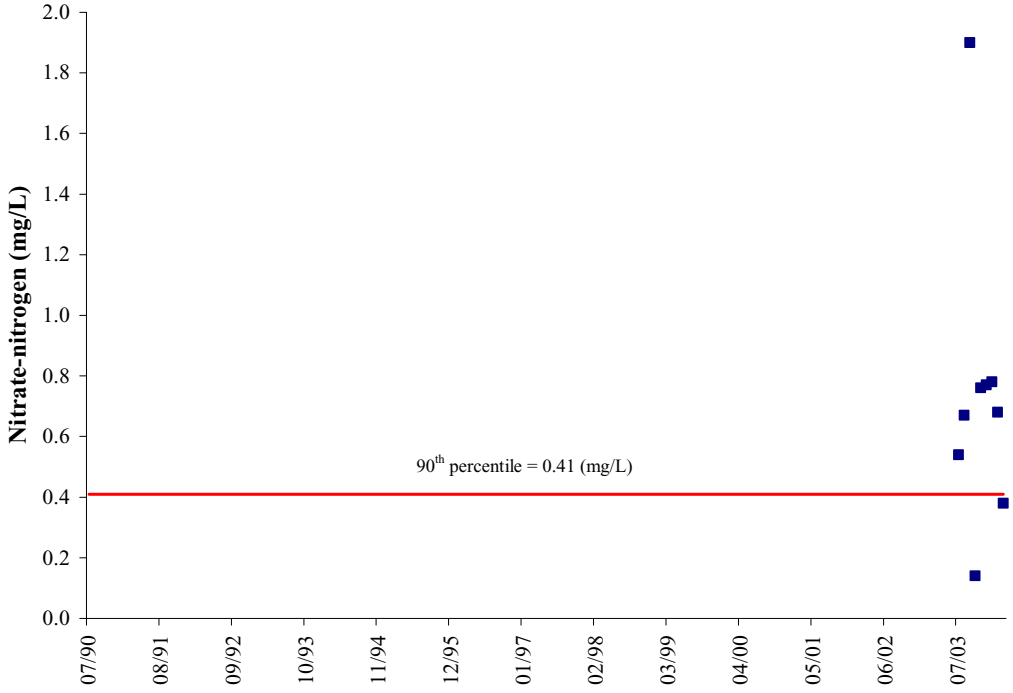

Figure 7.7 NO_3-N concentrations at VADEQ station 6BSRA004.16.

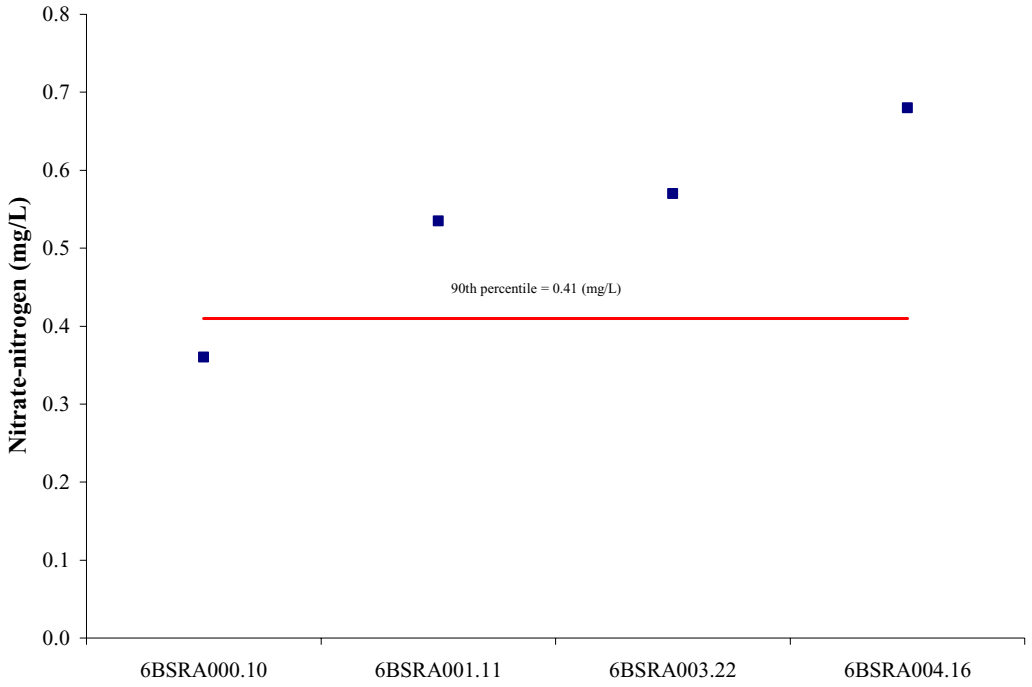

Figure 7.8 Median NO_3-N concentrations at VADEQ stations on Straight Creek.

7.2.4 Toxics

Most of the available total ammonia (NH_3/NH_4) data was below the detection level at VADEQ station 6BSRA001.11. The median value for this station is 0.06 mg/L. All ammonia values were well below the chronic water quality standard, which is temperature and pH dependent, at VADEQ stations 6BSRA001.11 and 6BSRA003.22 (Figures 7.9 and 7.10). Chloride values at 6BSRA001.11 are all below 230 mg/L, which is EPA's chronic water quality criterion (Figure 7.11). PCB's, organics and pesticides were collected at VADEQ stations 6BSRA001.11 and 6BSRA001.34 on June 18, 2002 and August 13, 1997, respectively, as part of VADEQ's fish tissue and sediment monitoring program. All sediment values at these two monitoring stations were below the established PEC (MacDonald et al., 2000) values. Toxic levels of these parameters in fish were low, with the exception of total PCBs. The state standard is 54 ppb and red-breasted sunfish had values of 105 ppb. The Virginia Department of Health has not issued a fish consumption advisory for Straight Creek. Total PCB levels in sediment

samples were extremely low. This data can be found in Tables C.1 and C.2 in Appendix C.

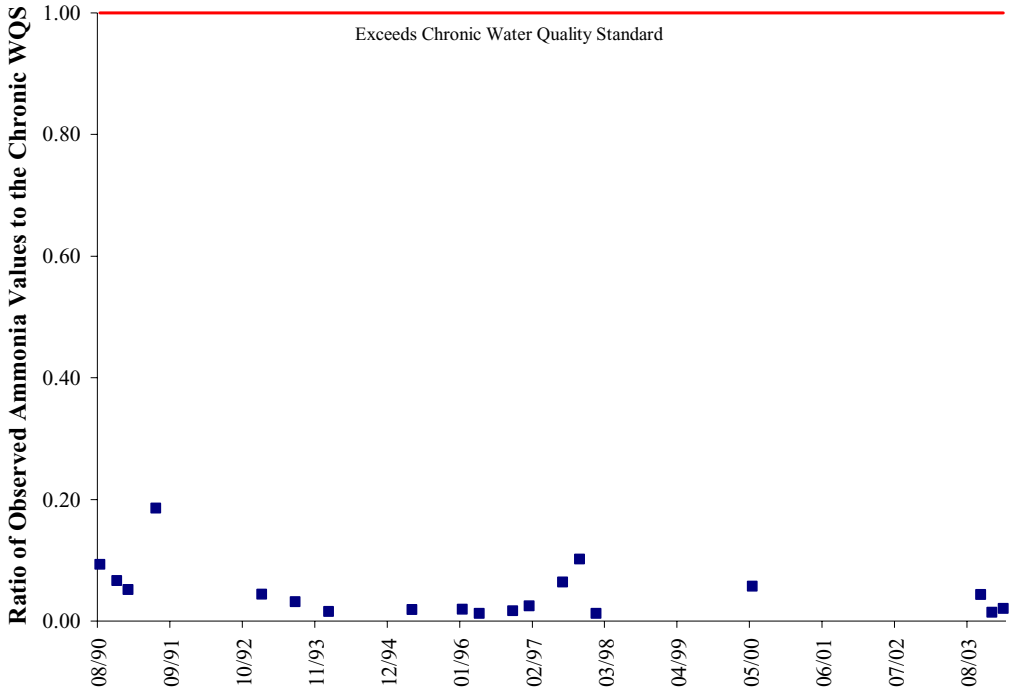

Figure 7.9 Ammonia ratio of observed values to the chronic water quality standard at VADEQ 6BSRA001.11.

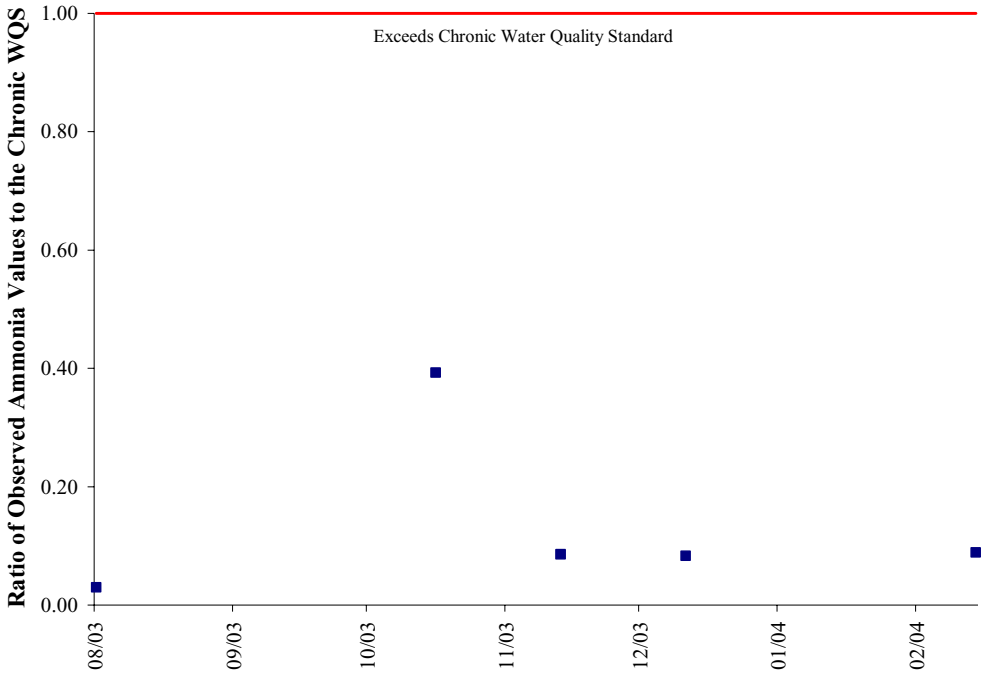

Figure 7.10 Ammonia ratio of observed values to the chronic water quality standard at VADEQ 6BSRA003.22.

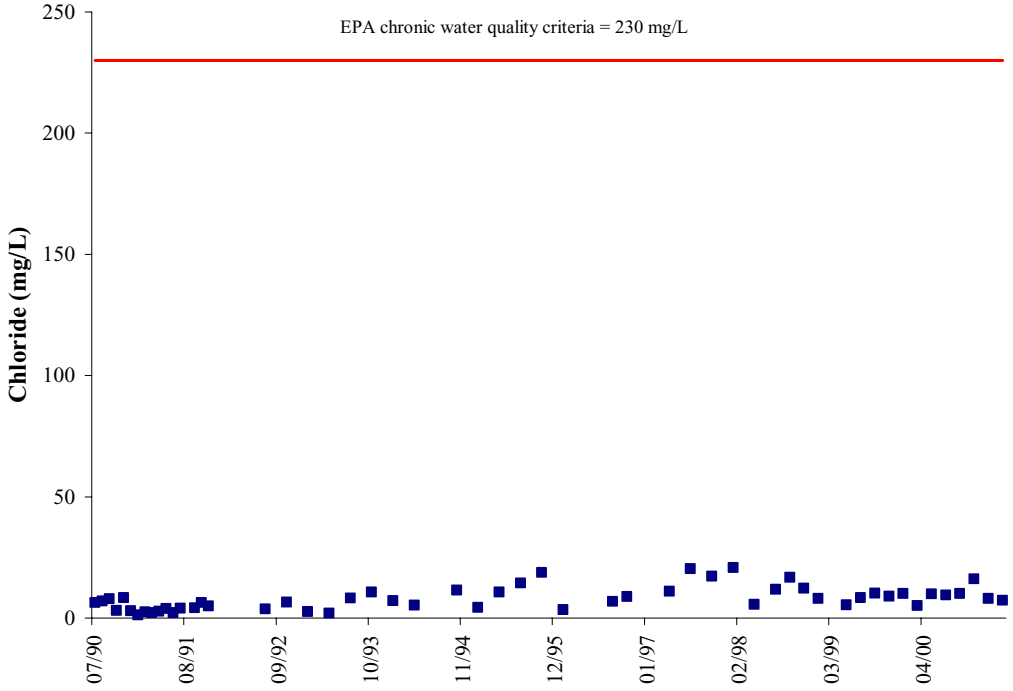

Figure 7.11 Chloride concentrations at VADEQ station 6BSRA001.11.

7.2.5 Metals

Total iron (Fe) is measured at DMME MPIDs. The toxic impacts from total iron are not well known because of the complexes iron forms with other compounds. A study by Soucek (2001) noted the potential for iron precipitates to have a smothering effect on benthic organisms. Total Fe concentrations were low and Straight Creek did not exceed the 90th percentile value of 1.45 mg/L in more than 10% of the samples collected at any DMME MPID. Median values for Straight Creek at all seven DMME MPIDs are shown in Figure 7.12.

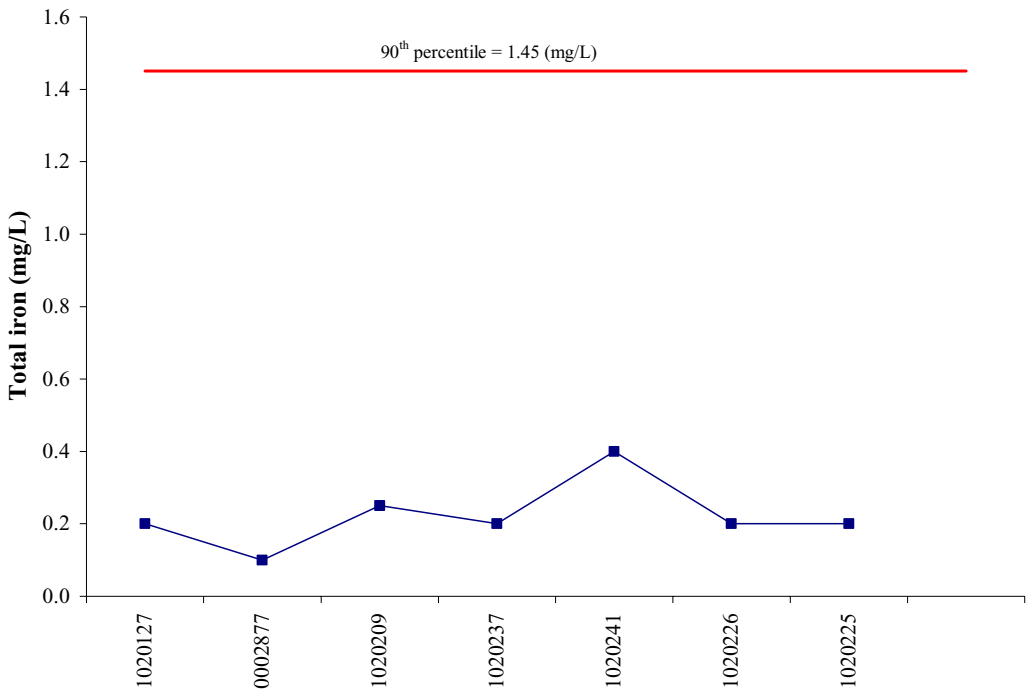

Figure 7.12 Median total Fe concentrations at DMME MPIDs on Straight Creek.

Water column dissolved metals were sampled by the VADEQ at 6BSRA001.11 on two occasions and the results were either at the minimum detection level or below the appropriate water quality standard (Table 7.3).

Table 7.3 Dissolved metals at VADEQ stations on Straight Creek (µg/L).

Metal	Date	6BSRA000.11	6BSRA000.54	6BSRA001.10	6BSRA001.11
	10/31/2000	4.8	3.45	16.2	
Aluminum	8/6/2003				148
	Standard	NA	NA	NA	NA
	10/31/2000	0.11	0.12	0.14	
Antimony	8/6/2003				0.17
	Standard	NA	NA	NA	NA
	10/31/2000	0.21	0.2	0.23	
Arsenic	8/6/2003				0.33
	Standard	NA	NA	NA	NA
	10/31/2000				
Barium	8/6/2003				35
	Standard	NA	NA	NA	NA
	10/31/2000	0.24	0.24	0.56	
Cadmium	8/6/2003				
	Standard	8.39	6.47	6.29	7.04
	10/31/2000				
Chromium	8/6/2003				1.11
	Standard	3,017	2,496.8	2,446.9	2,655.6
	10/31/2000	0.49	0.53	0.55	
Copper	8/6/2003				1.18
	Standard	33.46	26.92	26.3	28.9
	10/31/2000	6.28	2.35	4.41	
Manganese	8/6/2003				93
	Standard	NA	NA	NA	NA
	10/31/2000	0.55	0.61	1.15	
Nickel	8/6/2003				5.66
	Standard	323.3	265.9	260.4	283.4
	10/31/2000				
Selenium	8/6/2003				1.5
	Standard	NA	NA	NA	NA
	10/31/2000				
Zinc	8/6/2003				1.95
	Standard	207.2	170.4	166.9	181.6

NA - Virginia has no water quality standard

Total manganese (Mn) concentrations were high throughout Straight Creek relative to the 90th percentile value of 0.10 mg/L. Five of the seven DMME MPIDs had concentrations that exceeded 0.10 mg/L in more than 10% of the samples collected (Table 7.4 and Figures 7.13 through 7.17). There were two extreme values reported at DMME MPID 1020127 (9.0 mg/L) and DMME MPID 1020237 (1.0 mg/L). Median total Mn concentrations are shown in Figure 7.18. DMME MPID 1020127 had a median Mn concentration of 0.3 mg/L, which is above the 90th percentile concentration of 0.1 mg/L. Total Mn was sampled six times at the VADEQ station 6BSRA001.11 and none of the

concentrations exceeded the 90th percentile value. There was one exceedance in the Mn data collected by ECI at station SC, river mile 0.19 (0.12 mg/L). Dissolved Mn was measured at four VADEQ stations (Table 7.3). There was one extreme value of 93 mg/L reported at VADEQ station 6BSRA001.11. There are no known or established toxic levels for Mn and aquatic life so it is considered a non-stressor.

Table 7.4 DMME MPIDs with excessive total Mn concentrations.

MPID	River Mile	%Exceedances	Range (mg/L)
1020127	3.26	21	0.10 – 9.00
1020209	5.32	67	0.10 – 0.40
1020237	5.37	18	0.10 – 1.00
1020241	5.57	22	0.10 – 0.50
1020226	5.64	18	0.10 – 0.50

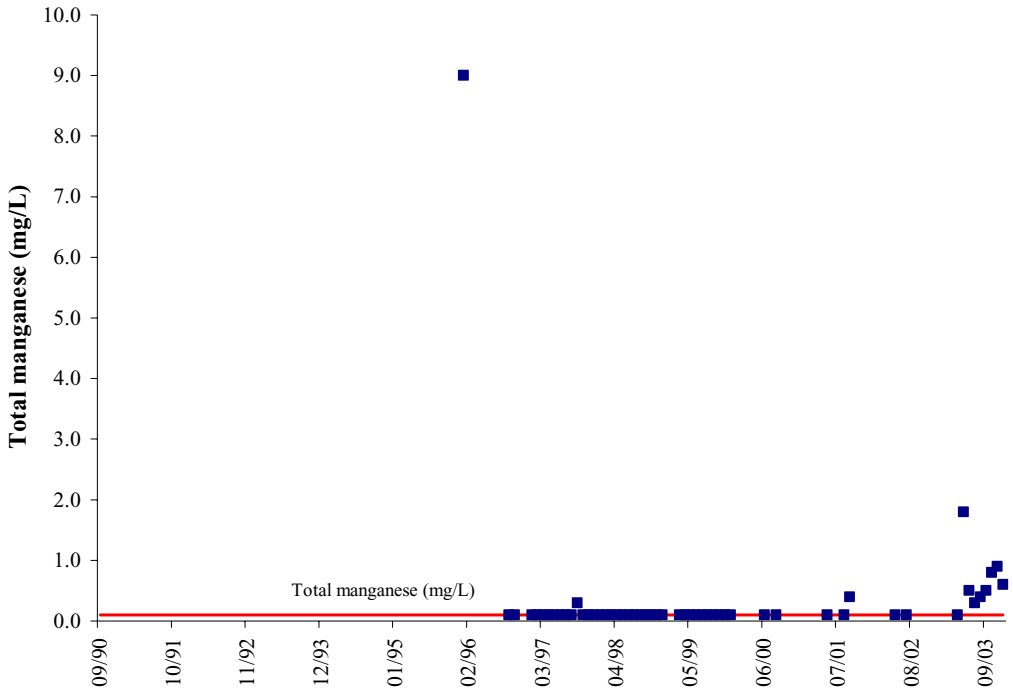

Figure 7.13 Total Mn concentrations at DMME MPID 1020127.

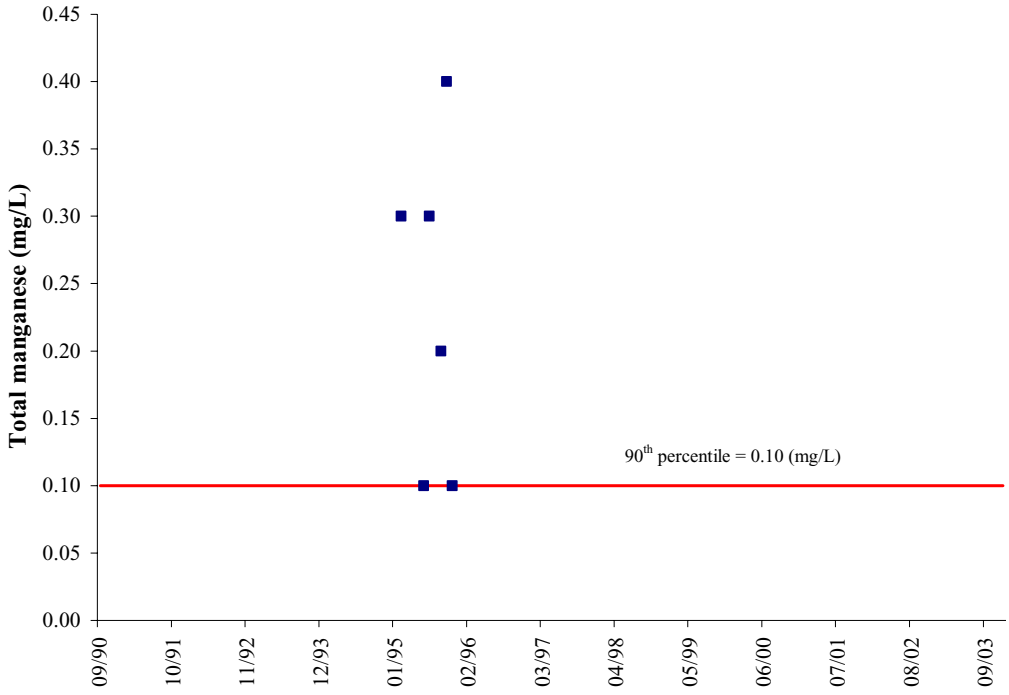

Figure 7.14 Total Mn concentrations at DMME MPID 1020209.

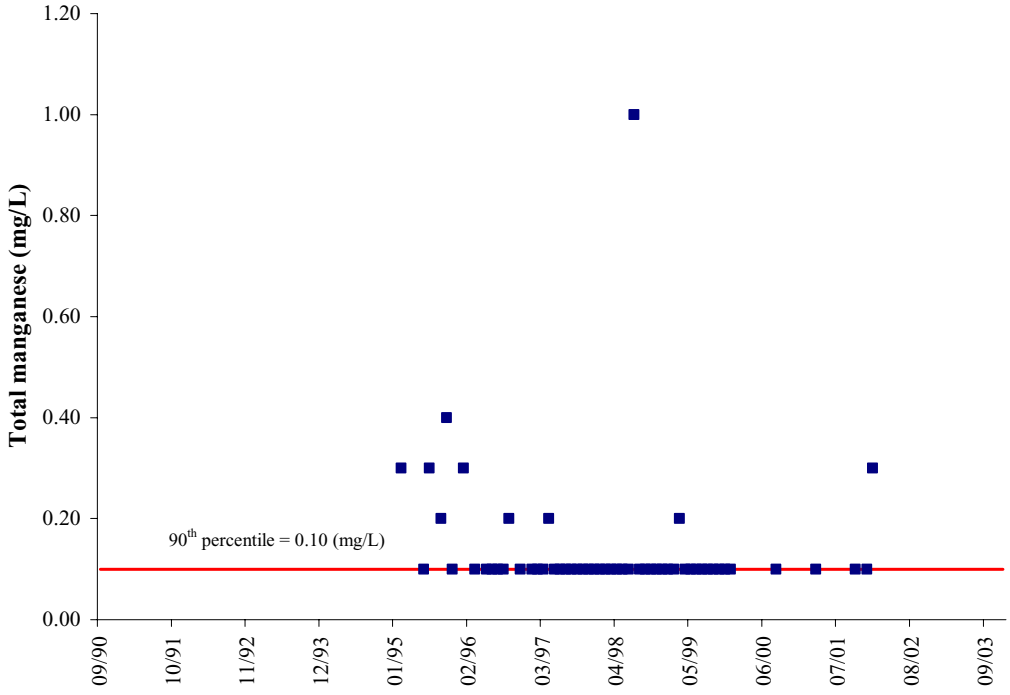

Figure 7.15 Total Mn concentrations at DMME MPID 1020237.

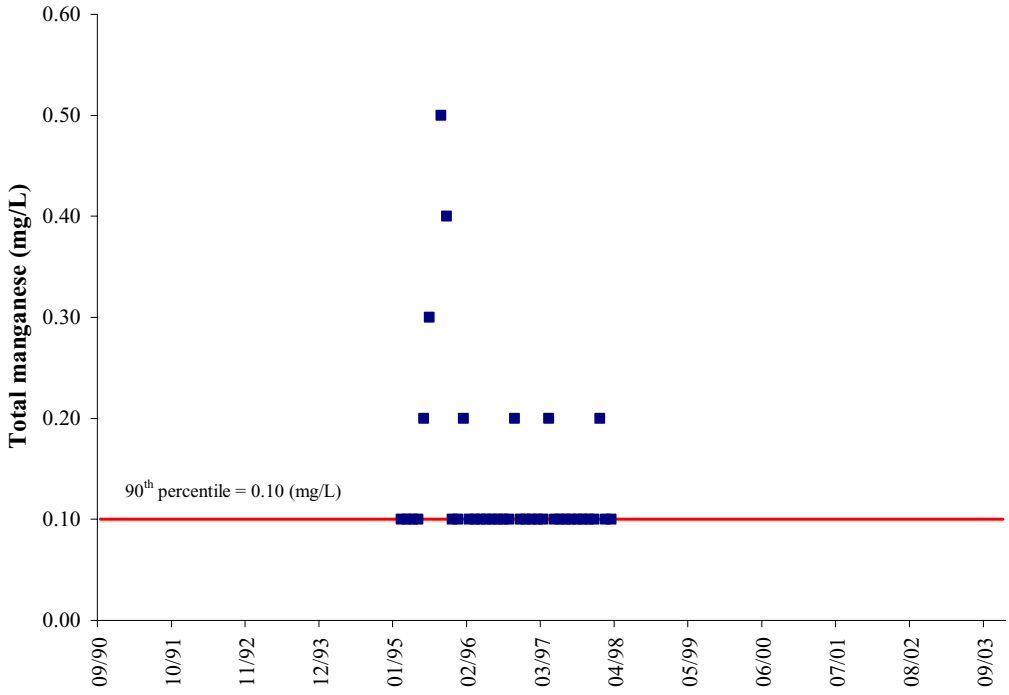

Figure 7.16 Total Mn concentrations at DMME MPID 1020241.

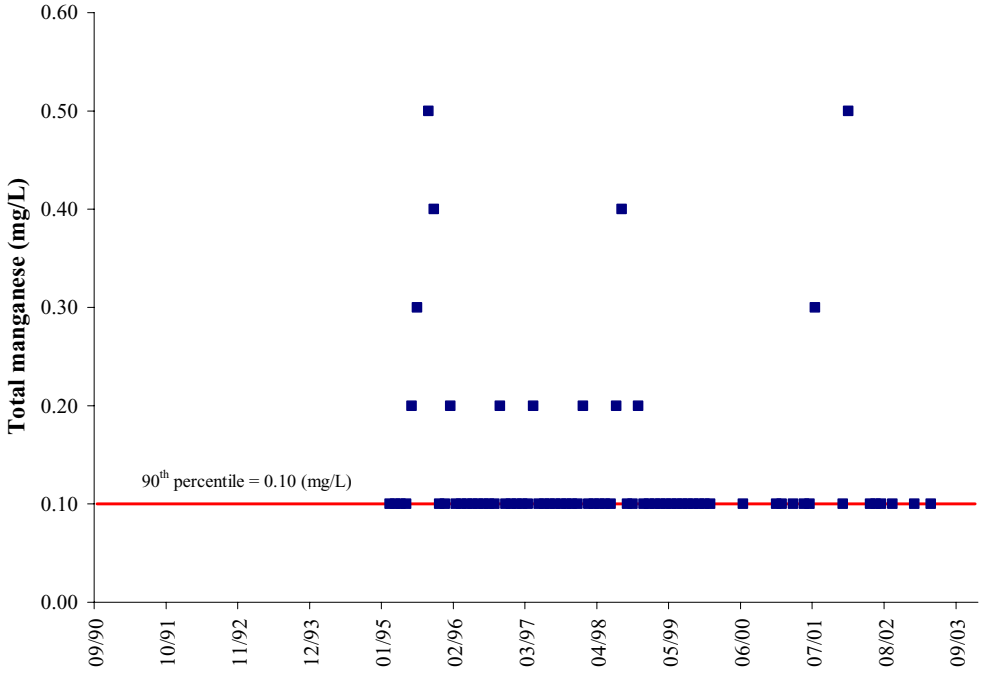

Figure 7.17 Total Mn concentrations at DMME MPID 1020226.

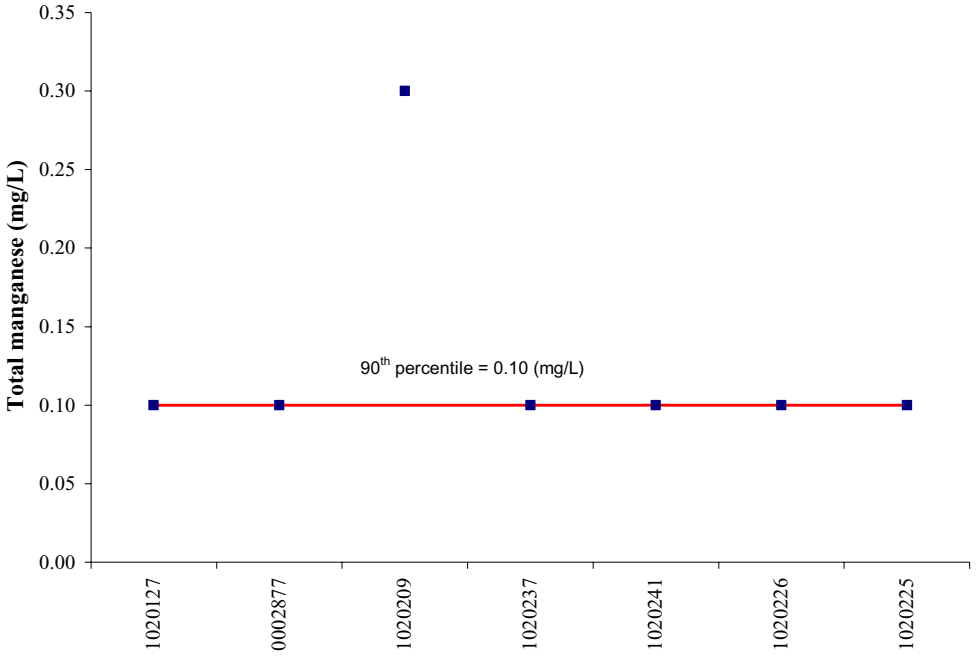

Figure 7.18 Median total Mn concentrations at DMME MPIDs on Straight Creek.

VADEQ sediment sampling indicated metals values were below the PEC values (Table 7.5), with the exception of nickel (discussed in section 7.3.4). Fish tissue and sediment metals were collected at VADEQ stations 6BSRA001.11 and 6BSRA001.34 on June 18, 2002 and August 13, 1997 respectively. No values for sediment metals exceeded PEC levels for these samples and levels were low in fish tissue as well. This sediment data is shown in Table 7.6. Baetidae, a family of mayflies, is extremely sensitive to metal pollutants and this family comprised four percent of the total assemblage from all of the benthic monitoring stations on Straight Creek.

Table 7.5 Sediment metals at VADEQ station 6BSRA001.11.

Metal (n)	Median (mg/kg)	Range (mg/kg)	PEC (mg/kg)
Aluminum (7)	10,300	4,480 – 15,600	NA
Arsenic (7)	6.70	5 – 12	33
Antimony (2)	9.0	7 – 11	NA
Beryllium (1)	NA	1.0	NA
Chromium (10)	14.85	9 – 20	111
Copper (10)	26.65	16 – 47.7	149
Iron (7)	26,500	19,800 – 48,900	NA
Lead (10)	26.35	10 – 43	128
Manganese (7)	756	452 – 1,630	NA
Nickel (10)	43.0	19.0 – 64.5	48.6
Selenium (5)	1.7	1.0 – 16.0	NA
Zinc (10)	179.00	72 – 231	459

NA - No value is available.

Table 7.6 Special study sediment metals at VADEQ stations on Straight Creek.

Parameter	PEC (mg/kg)	6BSRA001.34	6BSRA001.11
Aluminum	NA	0.19	3.6
Antimony	NA	<0.5	<0.5
Arsenic	33	5.4	7.8
Cadmium	4.98	0.15	0.31
Chromium	111	4.4	12
Copper	149	11	32
Lead	128	11	25
Mercury	1.06	0.1	0.086
Nickel	48.6	2.3	24
Selenium	NA		<0.5
Silver[1]	2.6	0.029	<0.02
Thallium	NA		<0.3
Zinc	459		84

[1] Virginia 99th percentile

7.3 Possible Stressors

Table 7.7 Possible Stressors in Straight Creek.

Parameter	Location in Document
Methylnapthelene, 2-	Section 7.3.1
Sulfate	Section 7.3.2
pH & alkalinity	Section 7.3.3
Nickel	Section 7.3.4
Organic matter	Section 7.3.5

7.3.1 Methylnapthalene, 2-

In the absence of a PEC value, Virginia has 99th percentile values for several parameters. The Virginia 99th percentile value for methylnapthalene, 2- is 83.0 µg/kg. A sediment sample collected on June 18, 2002 at VADEQ Station 6BSRA001.11 was 511.22 µg/kg. In the absence of sediment toxicity data confirming whether methylnaphthalene, -2 is bioavailable or not, it is considered a possible stressor.

7.3.2 Sulfate

Sulfate (SO_4) concentrations were excessive at six of the seven DMME MPIDs and at VADEQ station 6BSRA001.11 (Table 7.8 and Figures 7.19 through 7.25). Median SO_4 concentrations for all of the DMME MPIDs are shown in Figure 7.26. The median SO_4 concentration at VADMDLR MPID 1020127 exceeded the 90th percentile sulfate value of 150 mg/L. This site is the furthest downstream of the seven DMME MPIDs and is located at river mile 3.26, one half mile downstream of the Gin Creek confluence. All three samples collected by ECI at station SB (river mile 2.40) were above the 90th percentile value and two of the three samples collected at station SC (river mile 0.19) also exceeded the 90th percentile. The EPA used an SO_4 value of 1,000 mg/L as an indicator of impaired macroinvertebrate communities in mid-Atlantic highland streams (Klemm et al., 2001). DMME MPID 1020127 had six SO_4 values above 1,000 mg/L between May and December of 2003. Other studies note that SO_4 is a reliable indicator of mining activity and is often linked to depressed benthic health but, by itself, has not been shown to actually cause a reduction in the health of benthic communities (Merricks, 2003). However, large fluctuations in TDS can depress the health of benthic communities and sulfate is a component of TDS. Therefore, sulfate is considered a possible stressor.

Table 7.8 VADEQ stations and DMME MPIDs with excessive SO_4 concentrations.

MPID or VADEQ Station	River Mile	%Exceedances	Range (mg/L)
6BSRA001.11	1.11	66	71 – 500
1020127	3.26	51	8 – 2,132
0002877	4.87	25	42 – 215
1020209	5.32	17	64 – 177
1020237	5.37	46	35 – 530
1020226	5.64	16	38 – 258
1020225	6.06	12	27 – 225

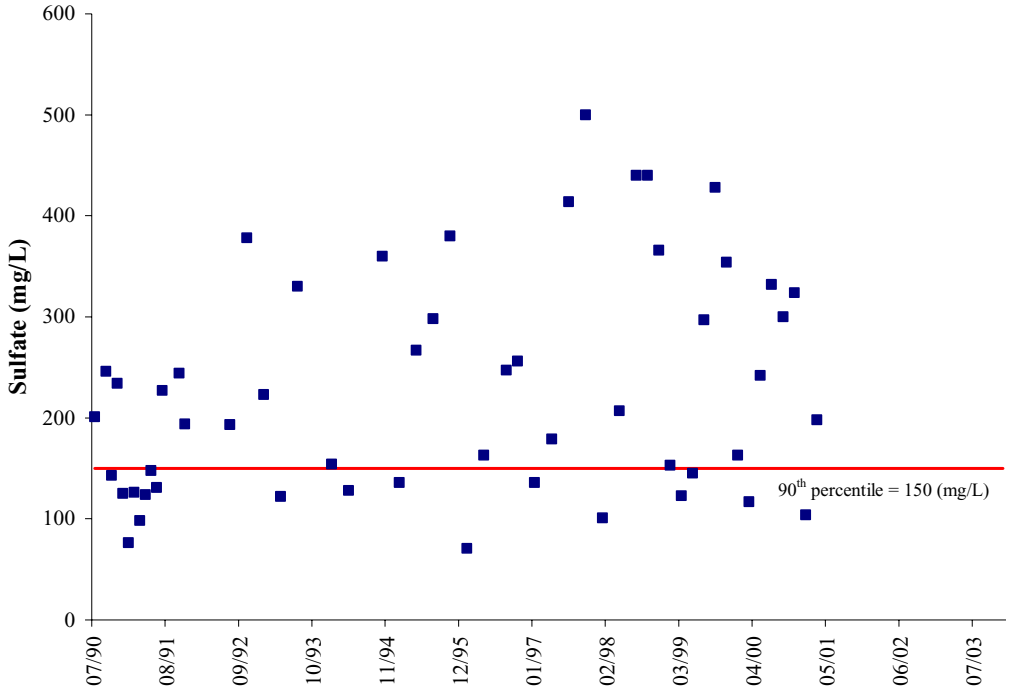

Figure 7.19 SO_4 concentrations at VADEQ station 6BSRA001.11.

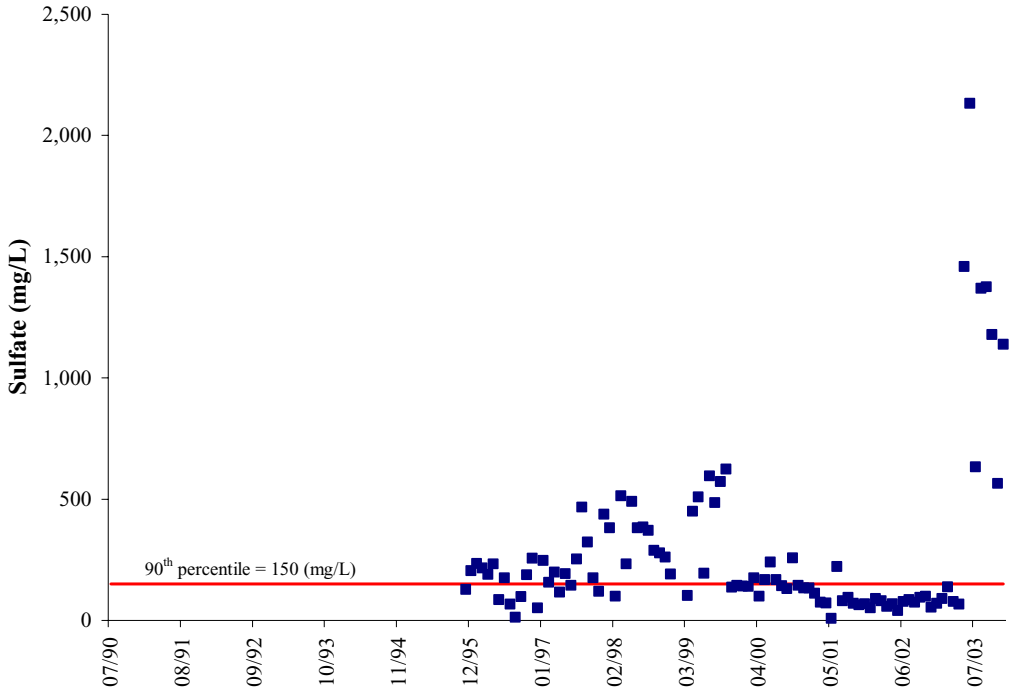

Figure 7.20 SO_4 concentrations at DMME MPID 1020127.

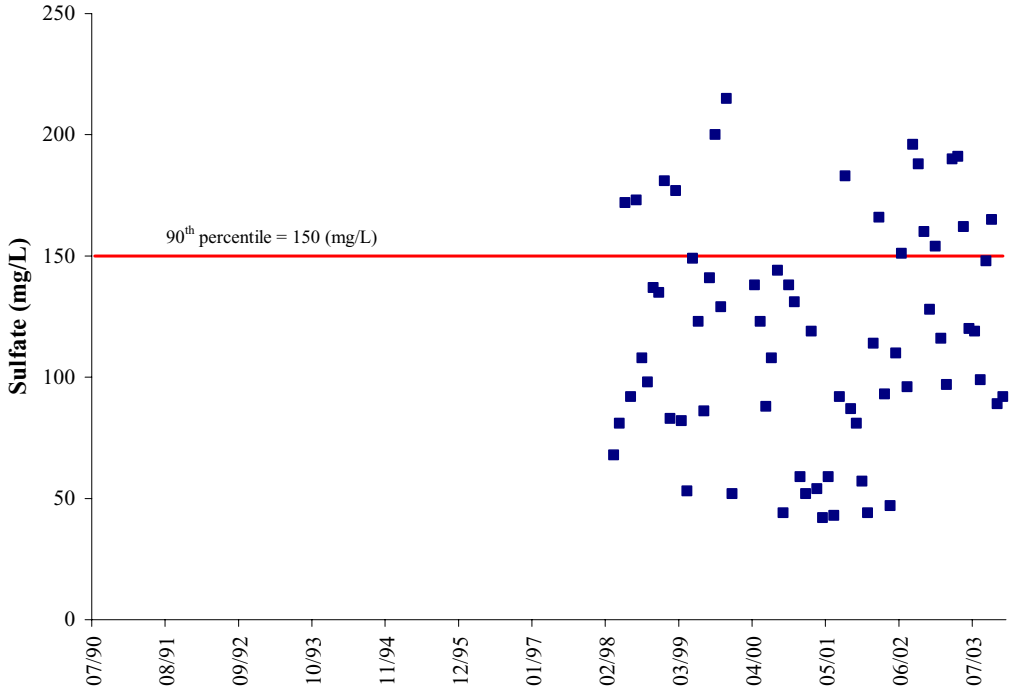

Figure 7.21 SO_4 concentrations at DMME MPID 0002877.

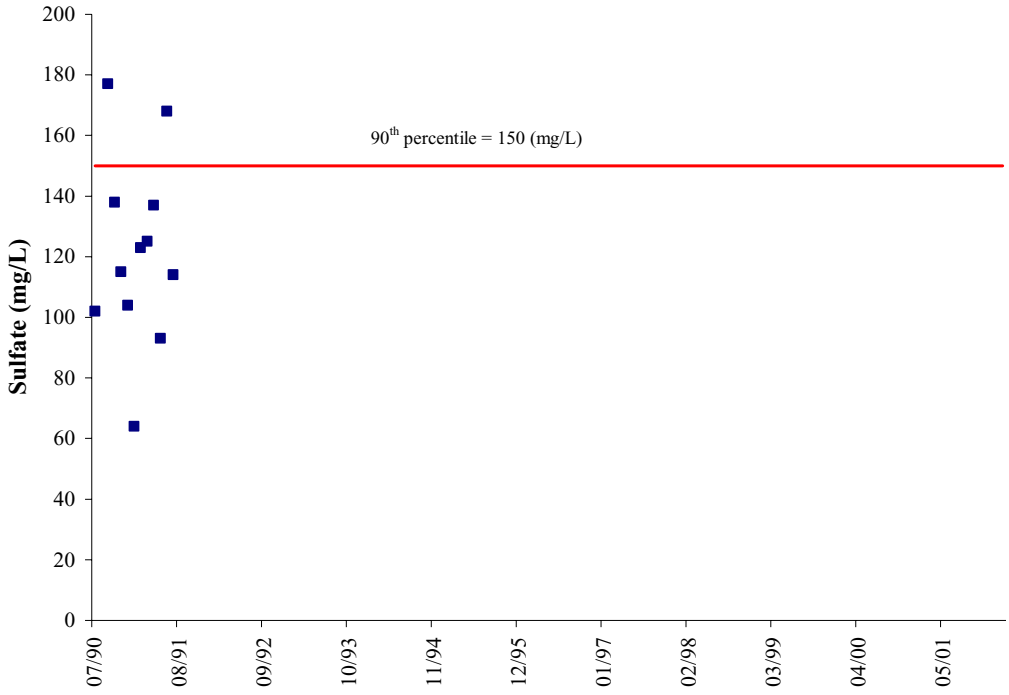

Figure 7.22 SO_4 concentrations at DMME MPID 1020209.

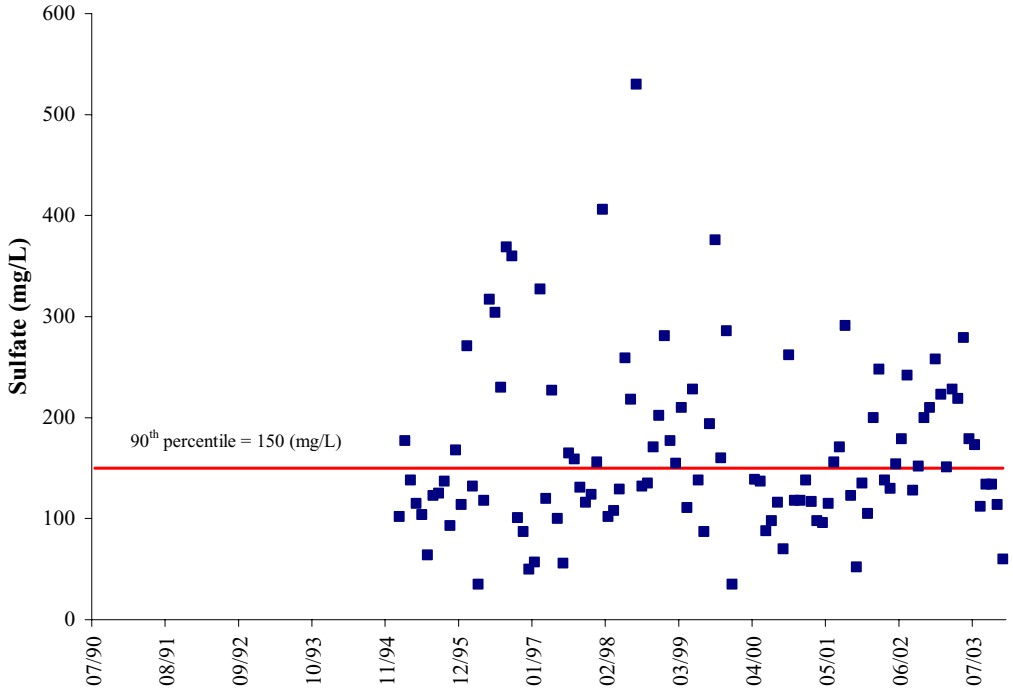

Figure 7.23 SO_4 concentrations at DMME MPID 1020237.

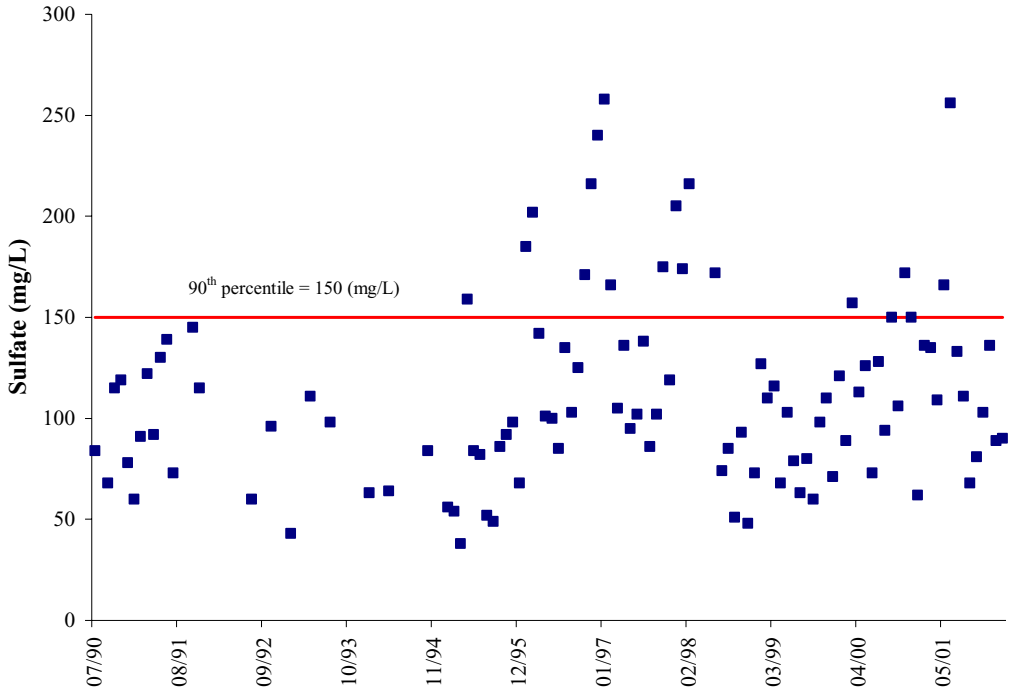

Figure 7.24 SO_4 concentrations at DMME MPID 1020226.

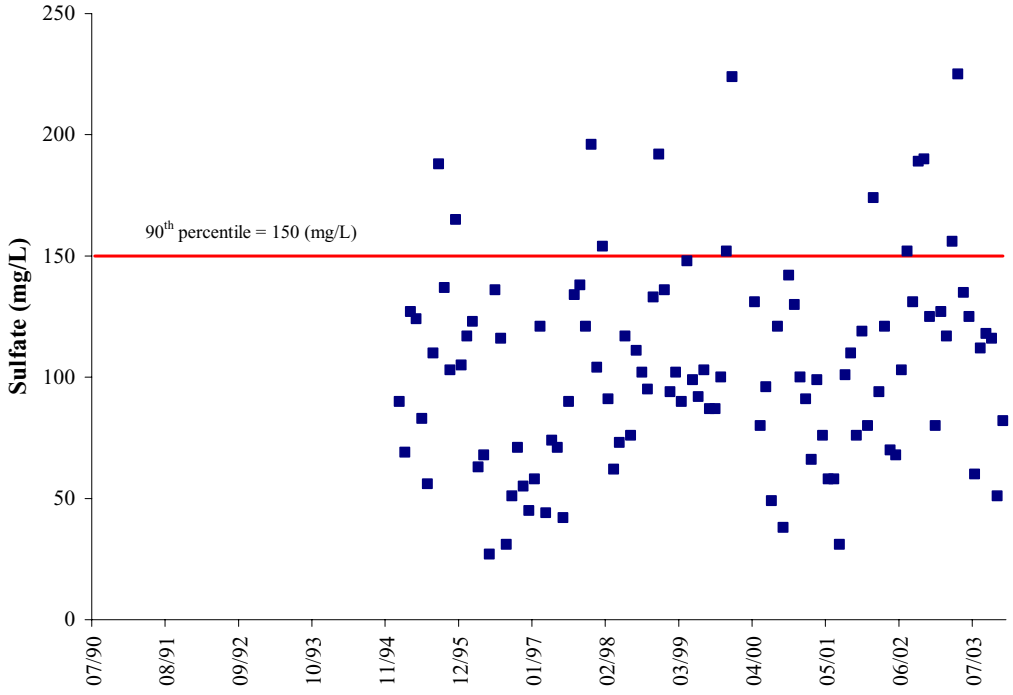

Figure 7.25 SO_4 concentrations at DMME MPID 1020225.

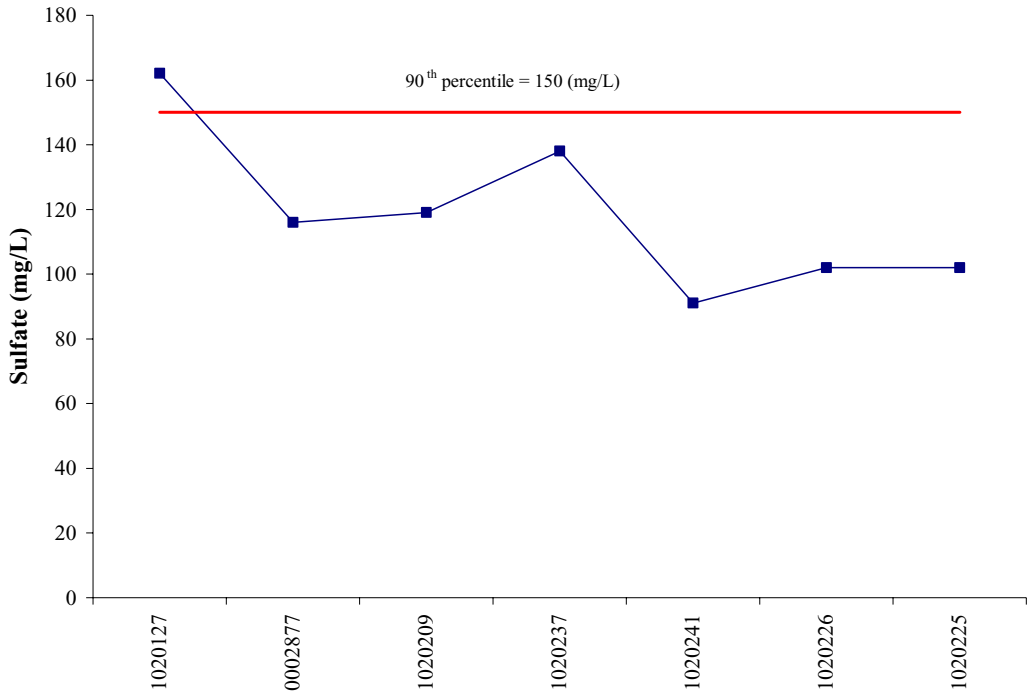

Figure 7.26 Median SO_4 concentrations at DMME MPIDs on Straight Creek.

7.3.3 PH

The maximum and minimum pH values were within the state standard range (6.0≤ pH ≤9.0) at all of the VADEQ stations with one exception at station 6BSRA004.16. The exception was a value of 9.28 (std units) measured in March of 2004. Median pH values were within the state standards range at four VADEQ stations (Figure 7.27). Maximum and minimum pH values were within the state standard range at the seven DMME MPIDs on Straight Creek. Median values are shown in Figure 7.28. In addition, all seven pH measurements collected by ECI on Straight Creek were within the state water quality standards range.

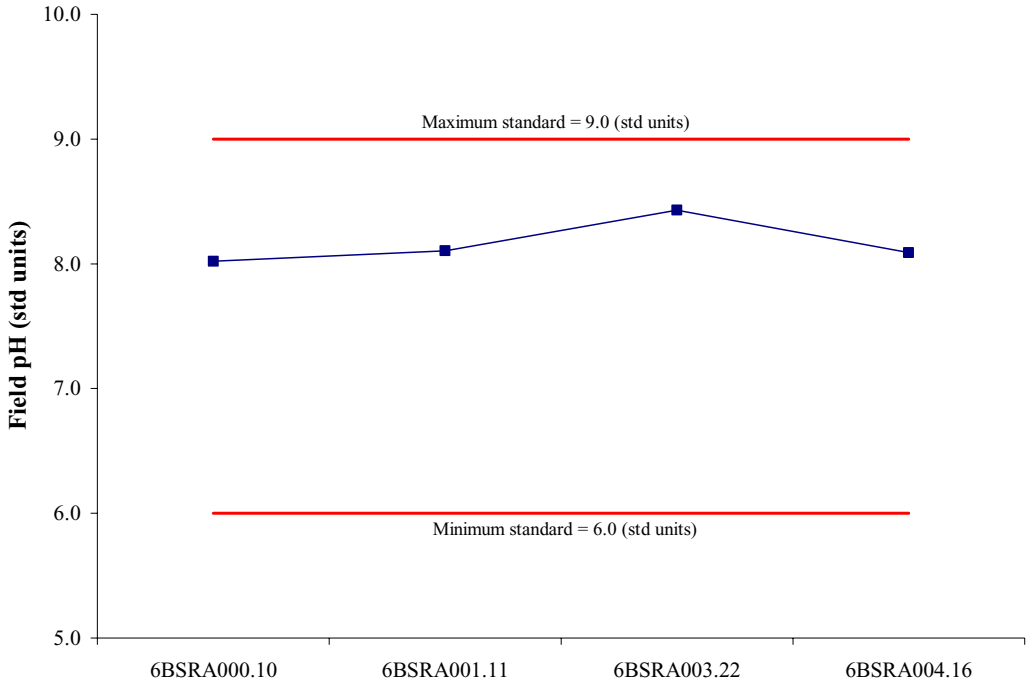

Figure 7.27 Median field pH values at VADEQ stations on Straight Creek.

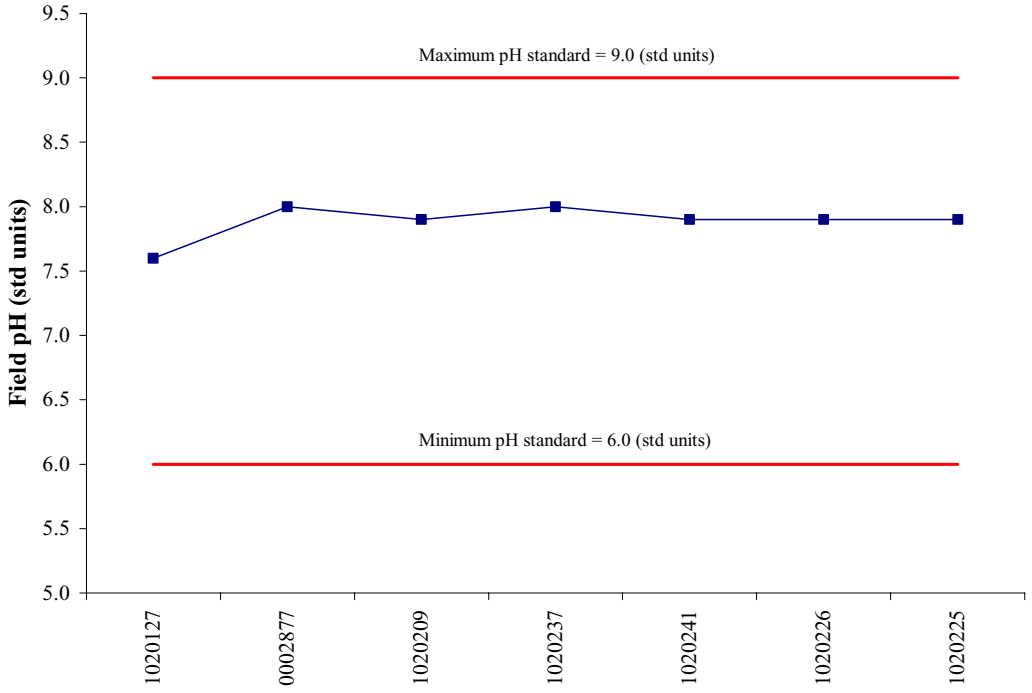

Figure 7.28 Median field pH values at DMME MPIDs on Straight Creek.

Alkalinity concentrations were excessive at three DMME MPIDs based on a 90th percentile value of 200 mg/L calculated from the McClure River (6AMCR000.20) data (Table 7.9 and Figures 7.29 through 7.31). Median alkalinity concentrations at the DMME MPIDs were below the 90th percentile value of 200 mg/L (Figure 7.32). Alkalinity concentrations did not exceed the 90th percentile value at VADEQ station 6BSRA001.11 (Figure 7.33). However, ECI measured an alkalinity concentration of 1,144 mg/L at site SB, which is downstream of the confluence with Fawn Branch (river mile 2.40). Alkalinity is measured in terms of $CaCO_3$ and it is used as a measure of the buffering capacity of a stream. Too little, as well as too much can be harmful to aquatic life; however, there are no water quality standards or screening values for alkalinity. Excessive alkalinity concentrations can contribute to high conductivity and total dissolved solids values, which will be discussed in more detail later in the analysis. Based on the fact that alkalinity concentrations are excessive and there was a pH maximum water quality exceedance, pH is considered a possible stressor.

Table 7.9 DMME MPIDs with excessive alkalinity concentrations.

MPID	River Mile	% Exceedances	Range (mg/L)
0002877	4.87	12	16 – 385
1020209	5.32	17	79 – 333
1020237	5.37	21	14 – 674

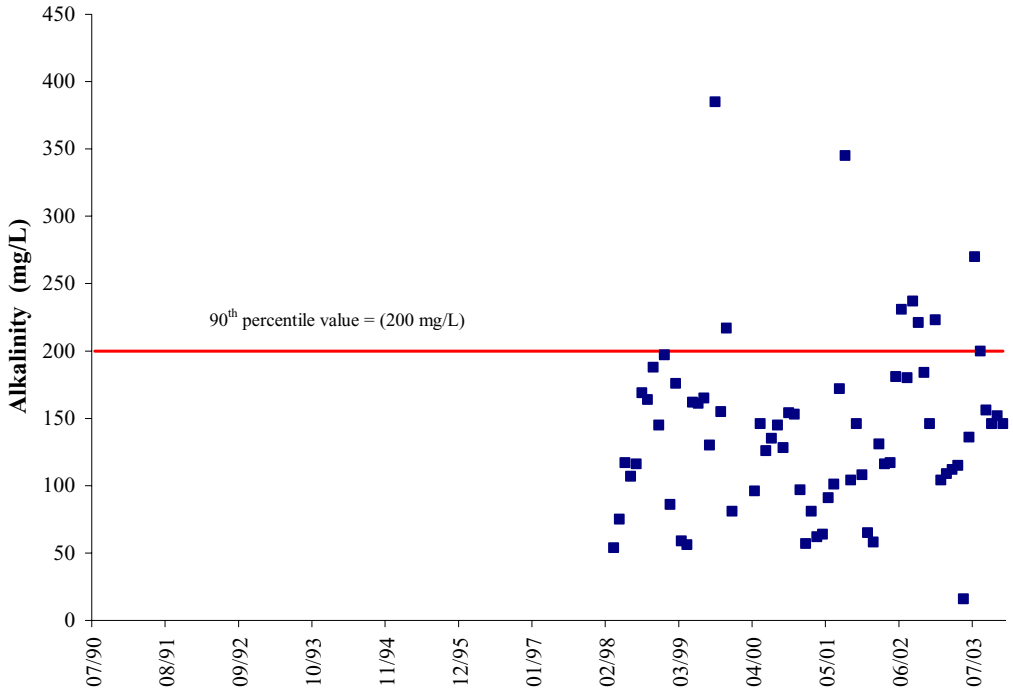

Figure 7.29 Alkalinity concentrations at DMME MPID 0002877.

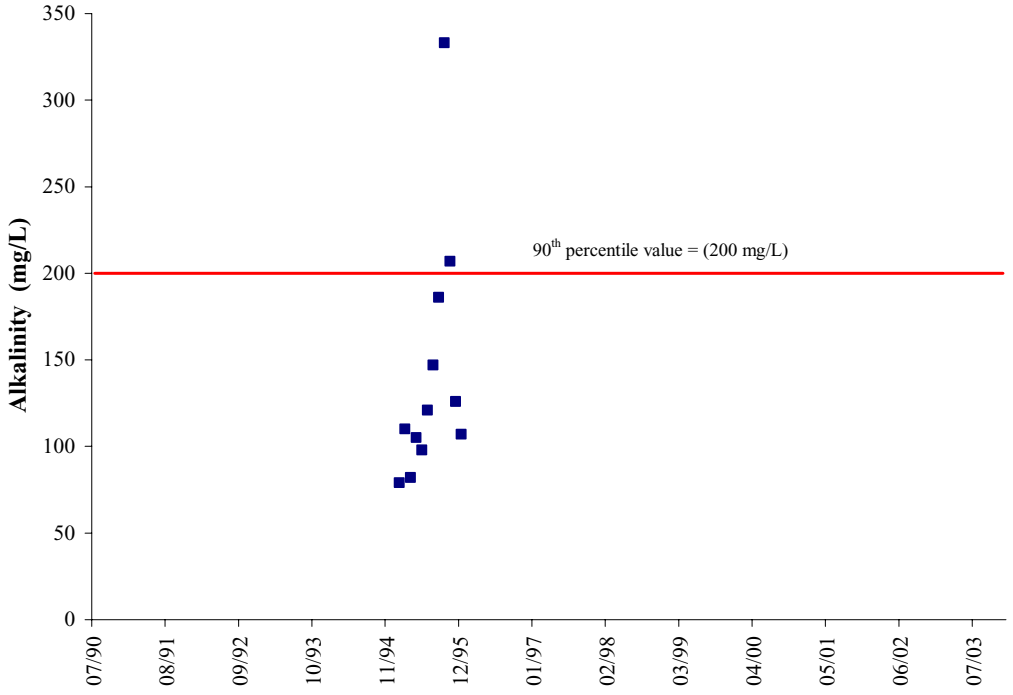

Figure 7.30 Alkalinity concentrations at DMME MPID 1020209.

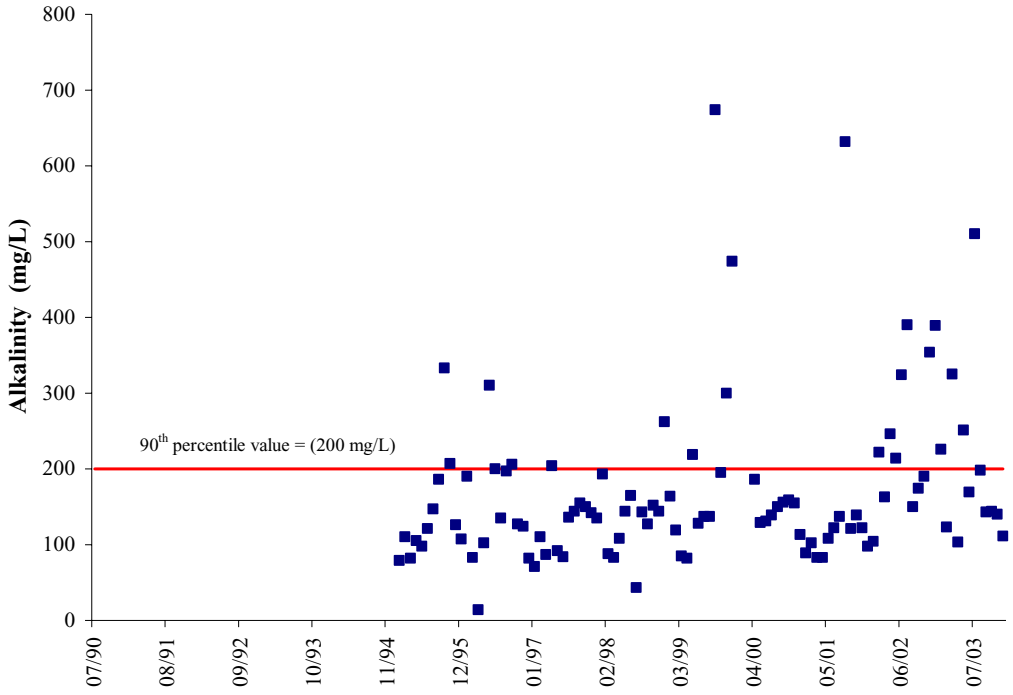

Figure 7.31 Alkalinity concentrations at DMME MPID 1020237.

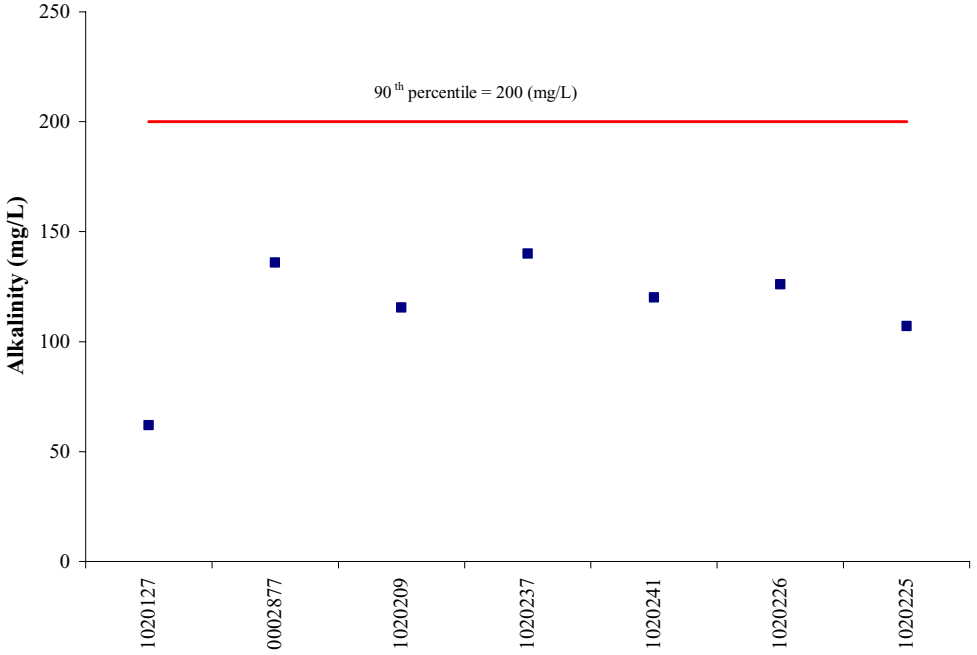

Figure 7.32 Median alkalinity concentrations at DMME MPIDs on Straight Creek.

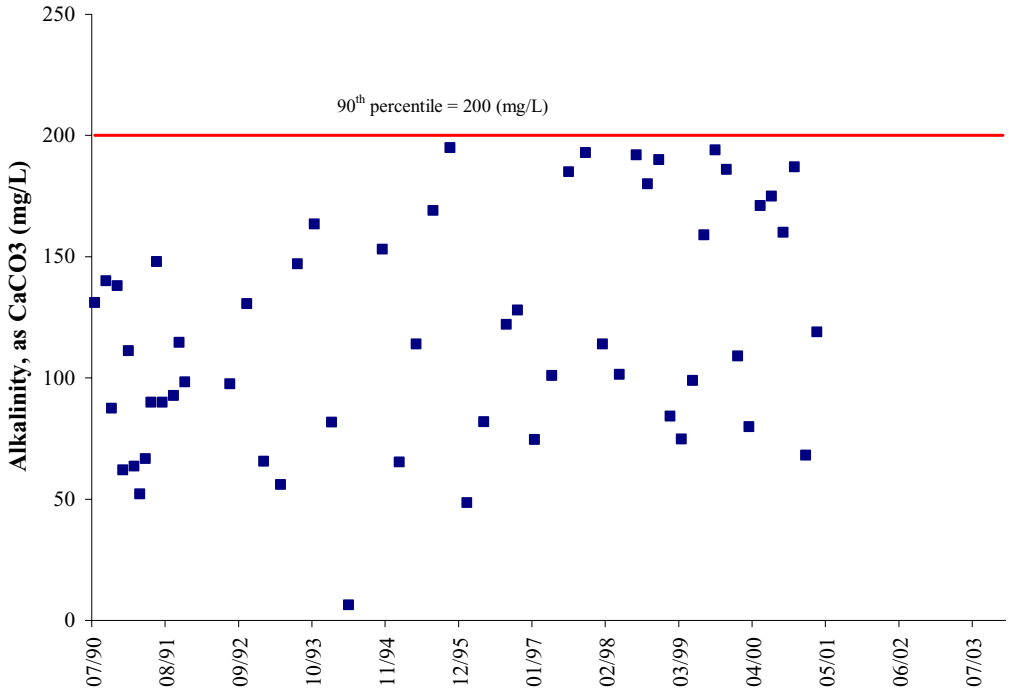

Figure 7.33 Alkalinity concentrations at VADEQ station 6BSRA001.11.

7.3.4 Nickel

Four out of ten sediment samples values were above the PEC value of 48.6 mg/kg for nickel (Ni) at VADEQ station 6BSRA001.11 (Figure 7.34). The maximum value reported was 64.5 mg/kg and the median was 43 mg/kg. In the absence of sediment toxicity data confirming whether nickel is bioavailable or not, it is considered a possible stressor.

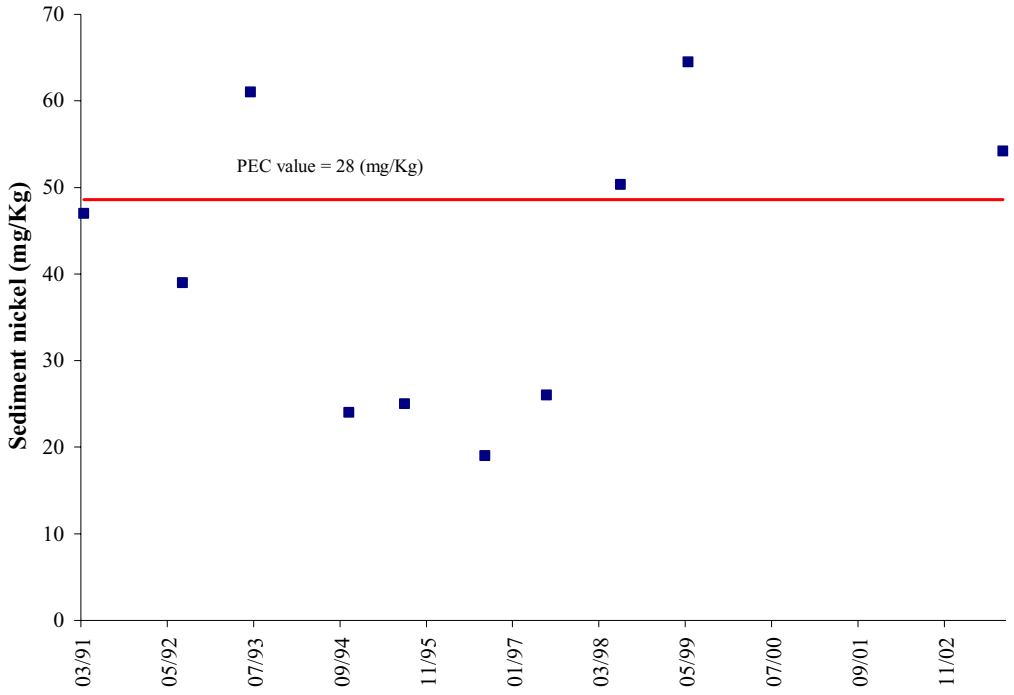

Figure 7.34 Ni sediment values at VADEQ station 6BSRA001.11.

7.3.5 Organic matter

Several different parameters were used to determine if organic matter in the stream was impacting the benthic macroinvertebrate community. Biochemical oxygen demand (BOD_5) provides an indication of how much dissolved organic matter is present. Total organic carbon (TOC), chemical oxygen demand (COD), and volatile suspended solids (VSS) provide an indication of particulate organic matter in a stream, and volatile solids (VS) measure how much dissolved organic matter is present. There is no water quality standard or screening value for BOD_5, therefore a 90th percentile value of 2.0 mg/L was calculated from the McClure River data (6AMCR000.20). This value was not exceeded in more than 10% of the concentrations at VADEQ station 6BSRA001.11.

COD concentrations are considered excessive because 24% of the concentrations at VADEQ station 6BSRA001.11 exceeded the 90th percentile value of 12.5 mg/L (Figure 7.35). TOC concentrations, on the other hand, were very low. VS concentrations are

excessive, with 13% surpassing the 90th percentile value of 68 mg/L (Figure 7.36). VSS are excessive with 41% exceeding the 90th percentile value of 3.4 mg/L (Figure 7.37).

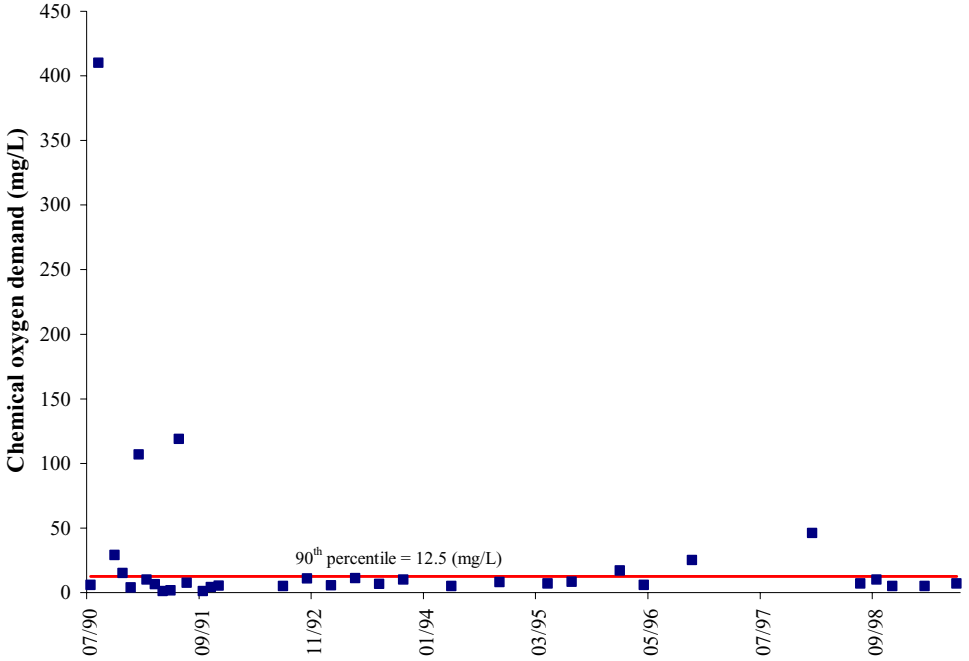

Figure 7.35 COD concentrations at VADEQ station 6BSRA001.11.

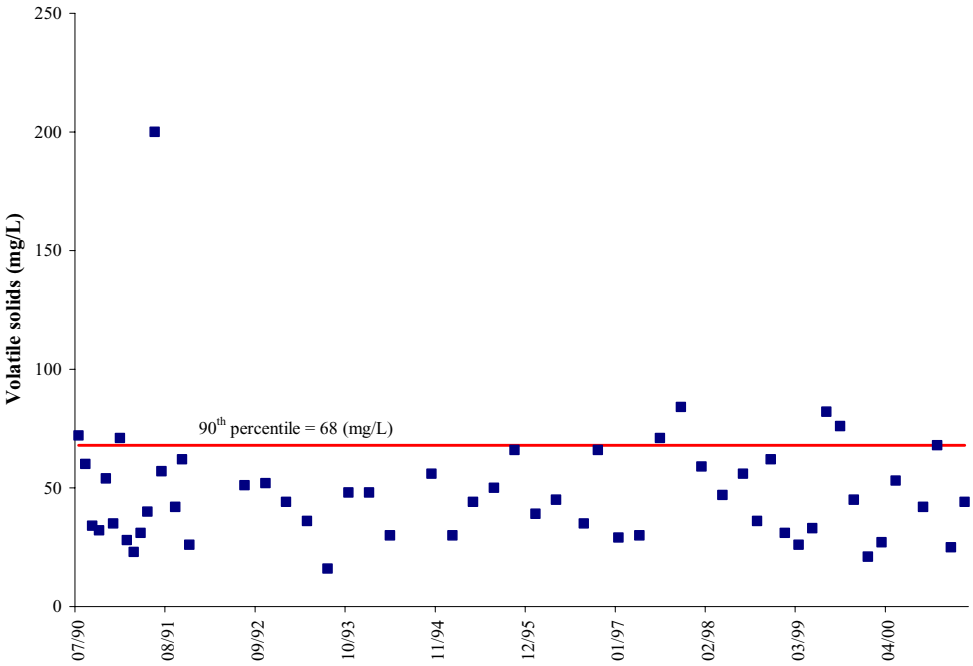

Figure 7.36 VS concentrations at VADEQ station 6BSRA001.11.

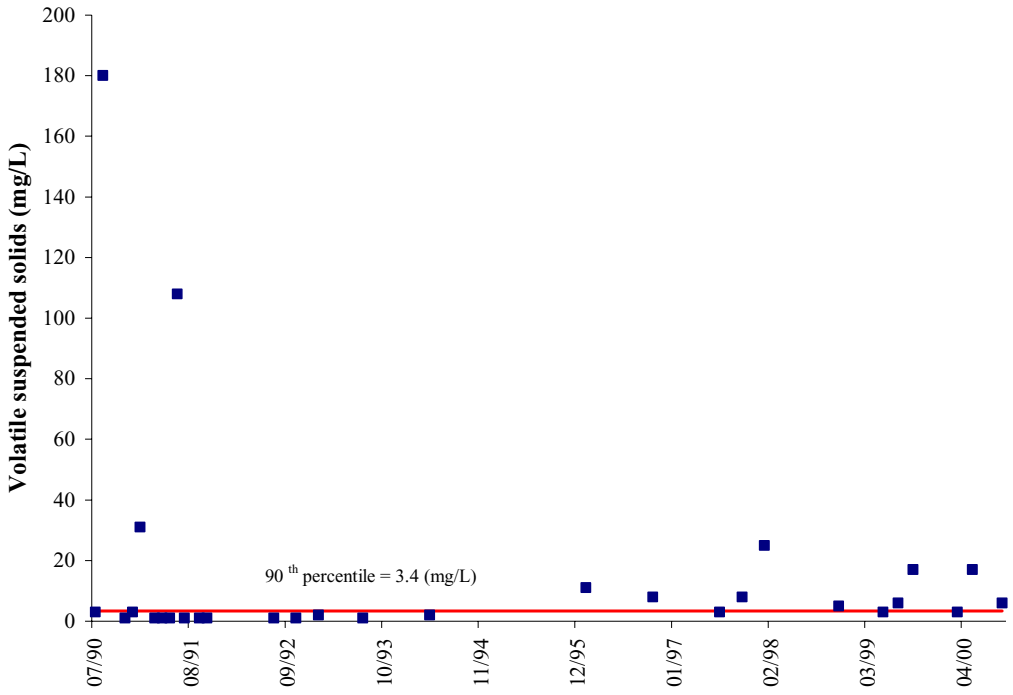

Figure 7.37 VSS concentrations at VADEQ station 6BSRA001.11.

The benthic metrics also indicate that organic matter is a potential problem in Straight Creek; the benthic metric MFBI can be an indicator of excessive organic solids. The average MFBI score was greater in Straight Creek relative to the reference stations. MFBI scores range from 0 to 10 and increasing values have been correlated with increasing organic matter. MFBI values alone do not definitively indicate that a benthic population is influenced by organic enrichment. This index provides an indication of the relative pollution tolerance of organisms in the sample. Other stressors can play a role in increasing MFBI values. The average MFBI score for the six benthic surveys at 6BSRA000.40 was 5.74. The reference stations had an average MFBI score of 3.81. The assemblage for benthic station 6BSRA000.40 from the VADEQ Ecological Data Application System (EDAS) database was examined, and hydropsychidae (netspinning caddisflies) were found to be the dominant family (38%). Hydropsychidae represented 10% of the total assemblages at the reference stations. According to Voshell (2002), "If common netspinners account for the majority of the community that is a reliable indicator of organic or nutrient pollution." However, the EPA noted, in a preliminary review of

this chapter, that hydropsychidae can thrive in watersheds with mining operations without excessive organic matter levels. Many species of hydropsychidae are tolerant to both metals and high conductivity (Pond, 2005). The dominance of hydropsychidae is reasonable in this watershed. In addition, organic matter increases the productivity of a stream, which normally increases the abundance of benthic macroinvertebrates. Recent benthic monitoring in Straight Creek shows abundance numbers that average less 300 organisms per two square meter sample. Typically in organic enriched streams abundance numbers are expected to be near 1,000 organisms or more. It is anticipated that there will be significant reductions in the primary sources of organic matter via implementation of the fecal bacteria TMDL also being developed for Straight Creek. Therefore, organic matter is considered a possible stressor.

7.4 Probable Stressors

Table 7.10 Probable Stressors in Straight Creek.

Parameter	Location in Document
Conductivity/Total dissolved solids	Section 7.4.1
Sediment	Section 7.4.2

7.4.1 Conductivity/Total dissolved solids

High conductivity values have been linked to poor benthic health (Merricks, 2003) and elevated conductivity is common with land disturbance and mine drainages. In the development of both the Virginia and West Virginia Stream Condition Index, the reference streams used had conductivity levels that did not exceed 500 µmhos/cm. In the absence of a water quality standard or screening value, a 90th percentile value of 800 µmhos/cm was calculated from the McClure River (6AMCR000.20). Conductivity values at the VADEQ stations 6BSRA001.11 and 6BSRA003.22 exceeded the 90th percentile value in 39% and 89% of the samples, respectively (Table 7.11 and Figures 7.38 and 7.39). Median conductivity values exceeded the 90th percentile value of 800 µmhos/cm at VADEQ station 6BSRA003.22 (Figure 7.40). In data provided by DMME, the 90th percentile value was exceeded in 10% of the samples at two DMME MPIDs (Table 7.11 and Figures 7.41 and 7.42). Median conductivity values for all seven DMME MPIDs are shown in Figure 7.43.

The state of Mississippi has a water quality conductivity standard of 1,000 µmhos/cm (MDEQ, 2004). The VADEQ stations and DMME MPIDs had a total of 57 conductivity measurements that exceeded 1,000 µmhos/cm. The conductivity measurements exceeded 1,000 µmhos/cm in 24%, 89%, 20% and 14% of the samples taken at 6BSRA001.11, 6BSRA003.22, MPID 1020127, and 1020237, respectively.

Table 7.11 VADEQ stations and DMME MPIDs with excessive conductivity values.

MPID or VADEQ Station	River Mile	% Exceedances	Range (µmhos/cm)
6BSRA001.11	1.11	39.4	40.1 – 2,114
6BSRA003.22	3.22	88.9	581.5 – 2,251
1020127	3.26	25.0	130 – 5,800
1020237	5.37	39.4	270 – 2,620

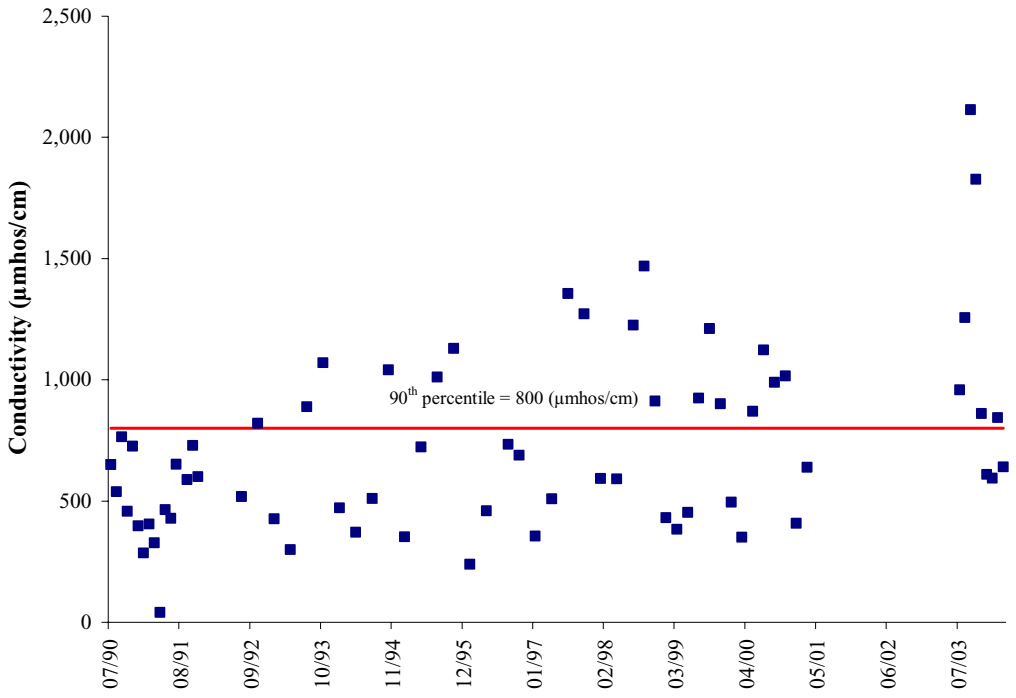

Figure 7.38 Conductivity measurements at VADEQ station 6BSRA001.11.

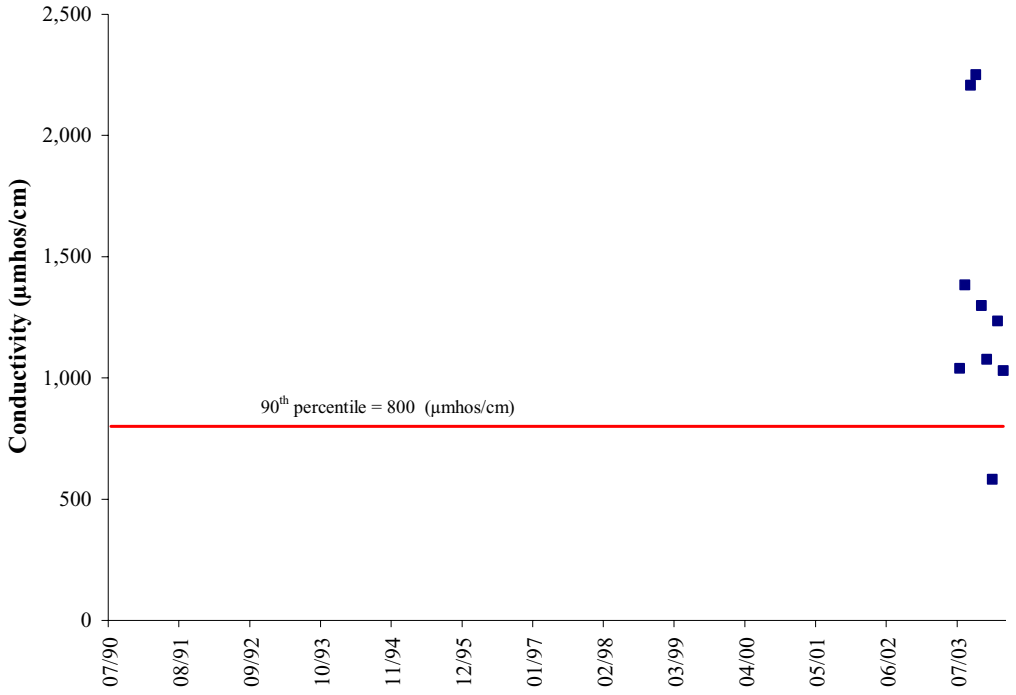

Figure 7.39 Conductivity measurements at VADEQ station 6BSRA003.22.

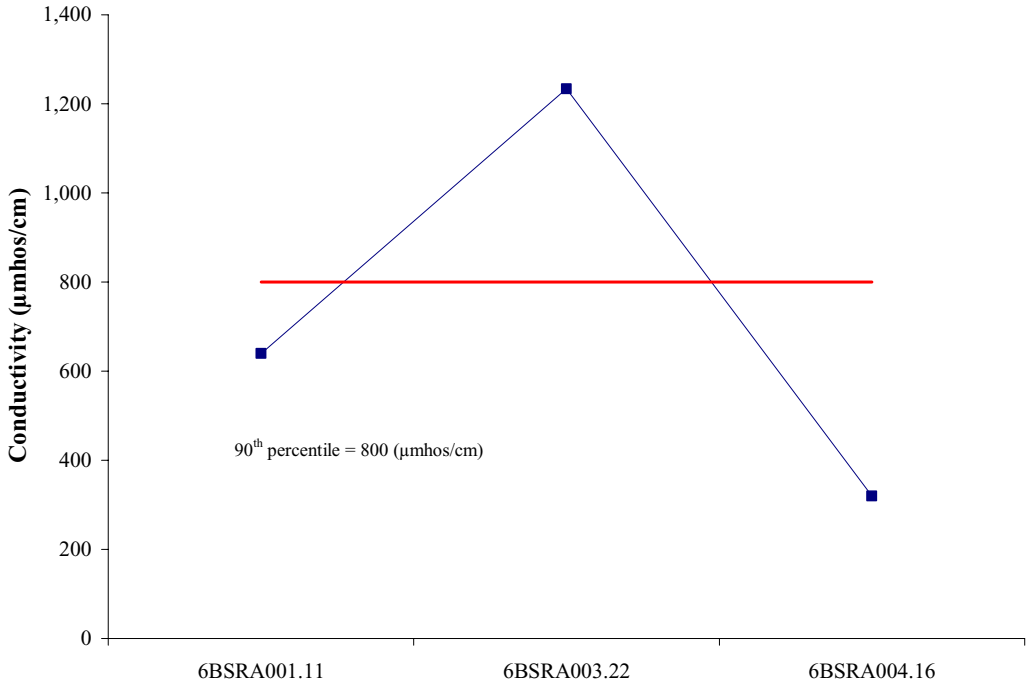

Figure 7.40 Median conductivity values at VADEQ stations on Straight Creek.

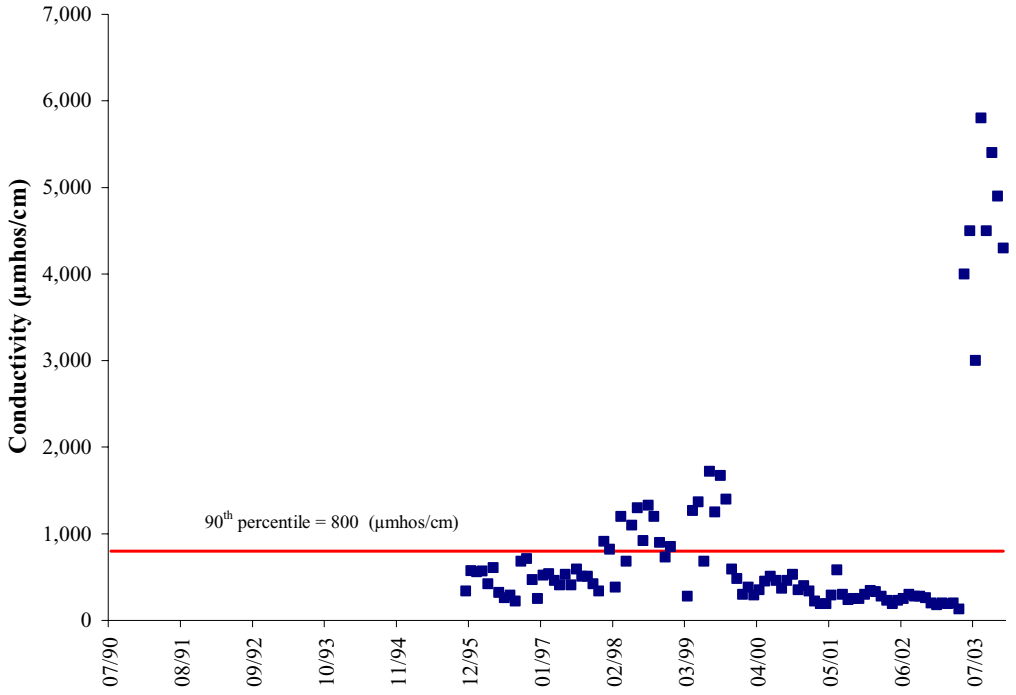

Figure 7.41 Conductivity measurements at DMME MPID 1020127.

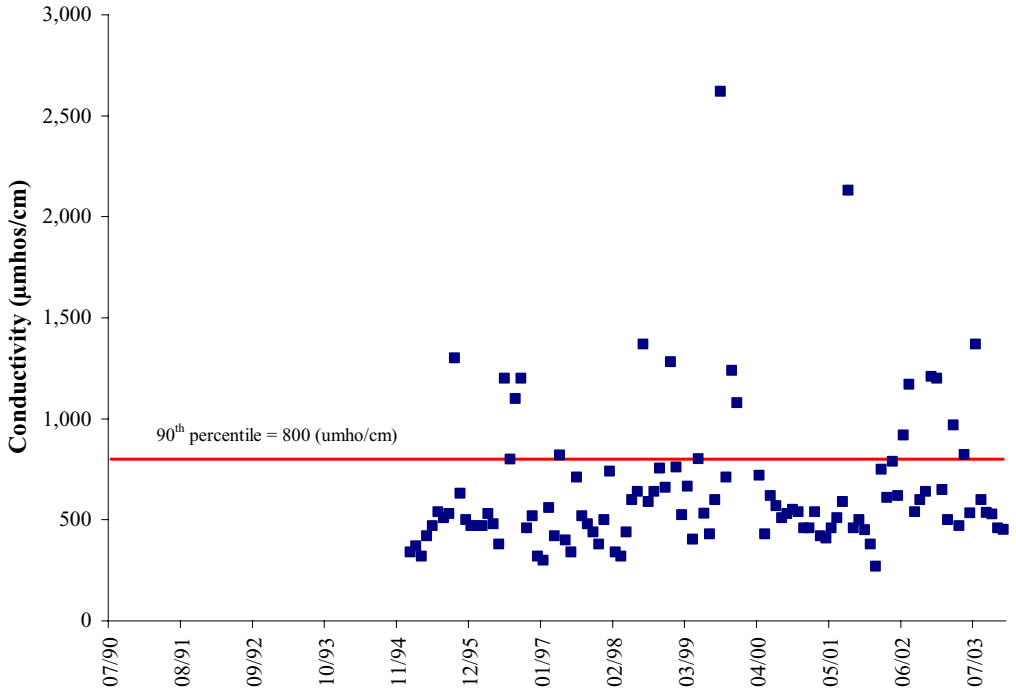

Figure 7.42 Conductivity measurements at DMME MPID 1020237.

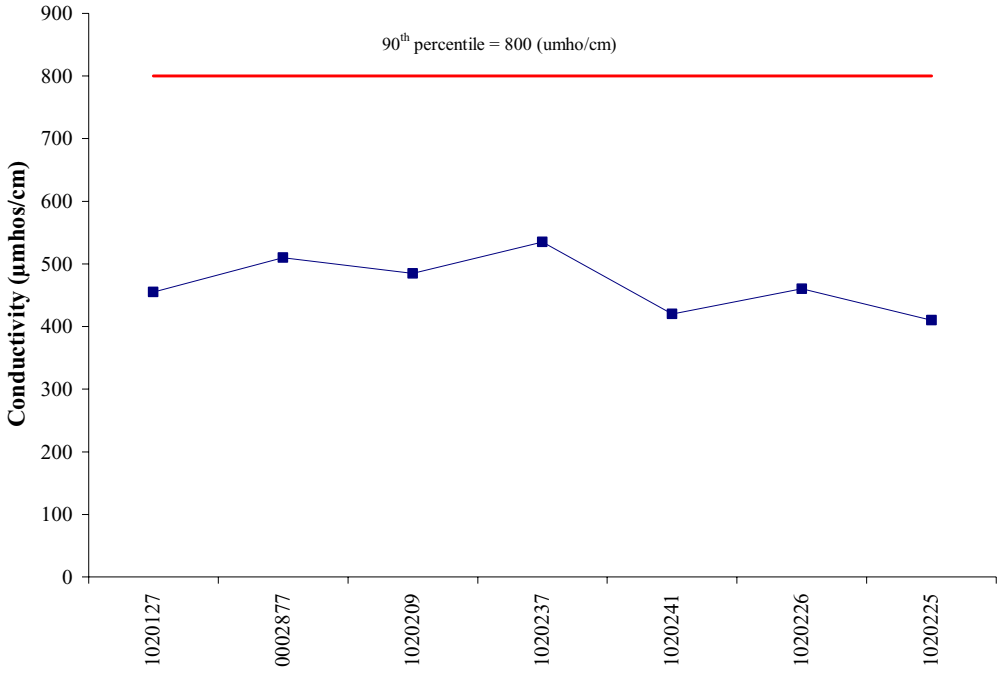

Figure 7.43 Median conductivity measurements at DMME MPIDs on Straight Creek.

Conductivity is a measure of the electrical potential in the water based on the ionic charges of the dissolved compounds that are present. TDS is a measure of the actual concentration of the dissolved ions, dissolved metals, minerals, and organic matter in water. Dissolved ions can include sulfate, calcium carbonate, chloride, etc. Therefore, even though they are two different measurements, there is a direct correlation between conductivity and TDS.

A TDS 90th percentile value of 525 mg/L was calculated from the McClure River (6AMCR000.20) data. TDS concentrations were excessive at VADEQ stations 6BSRA001.11 and 6BSRA003.22 (Table 7.12 and Figures 7.44 and 7.45) and at DMME MPIDs 1020127 and 1020237 (Table 7.12 and Figures 7.46 and 7.47). Median TDS values exceeded the 90th percentile value of 525 mg/L at VADEQ station 6BSRA003.22 (Figure 7.48). Median values for all of the DMME MPIDs are shown in Figure 7.49. TDS toxicity depends on the relative contribution of the various ions it includes. Therefore, toxicity cannot only vary between different watersheds but within the same watershed.

Ohio and Illinois have aquatic life TDS water quality standards set at 1,500 mg/L (OEPA, 2005; IPCB, 2005). The VADEQ stations and DMME MPIDs had a total of 14 TDS concentrations that exceeded 1,500 mg/L. The TDS concentrations at MPID 1020127 (river mile 3.26) exceeded 1,500 mg/L 11 times; eight of these were between May and December 2003. In addition, New Jersey and Kentucky all have aquatic life water quality standards addressing TDS (NJ Dept. of Environmental Protection, 2005; Kentucky Administrative Regulations Title 401, 2005). The fact that five states consider high TDS and conductivity a problem and have implemented state standards, shows there is concern over the affect these constituents have on aquatic life.

Table 7.12 VADEQ stations and DMME MPIDs with excessive TDS values.

MPID or VADEQ Station	River Mile	% Exceedances	Range (mg/L)
6BSRA001.11	1.11	40.0	179 - 1,320
6BSRA003.22	3.22	77.8	450 - 1,560
1020127	3.26	29.2	30 - 5,122
1020237	5.37	26.7	35 – 1,596

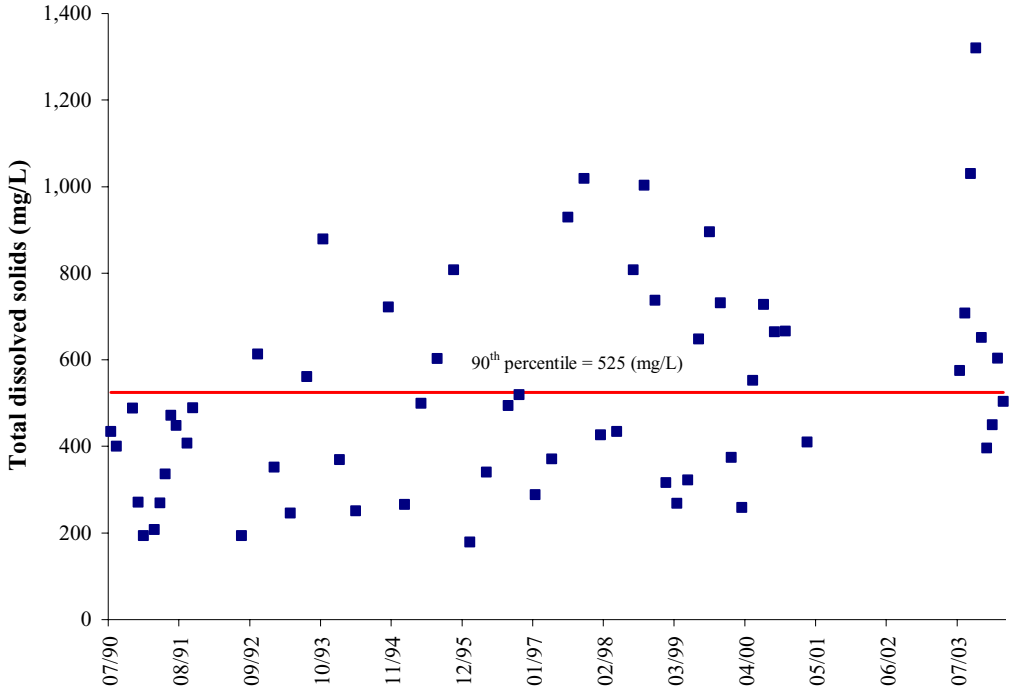

Figure 7.44 TDS concentrations at VADEQ station 6BSRA001.11.

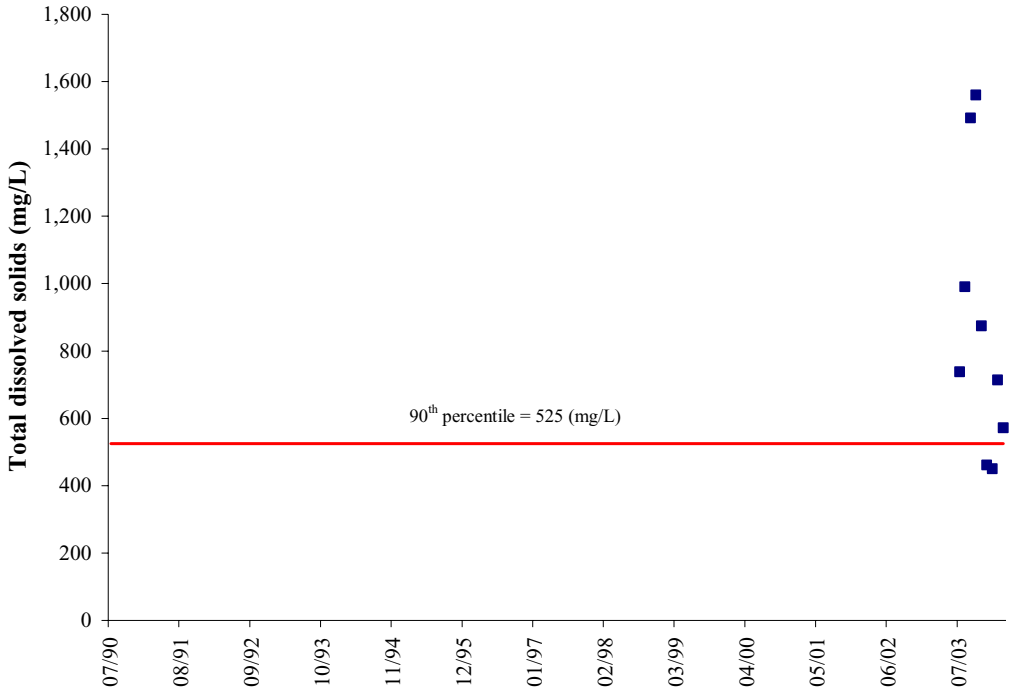

Figure 7.45 TDS concentrations at VADEQ station 6BSRA003.22.

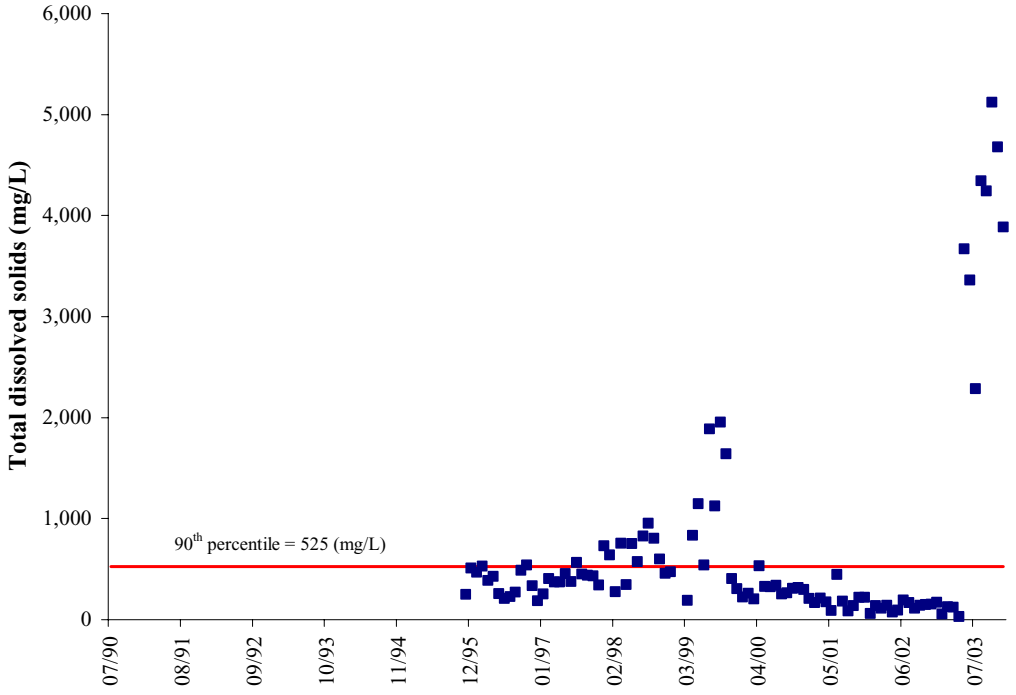

Figure 7.46 TDS concentrations at DMME MPID 1020127.

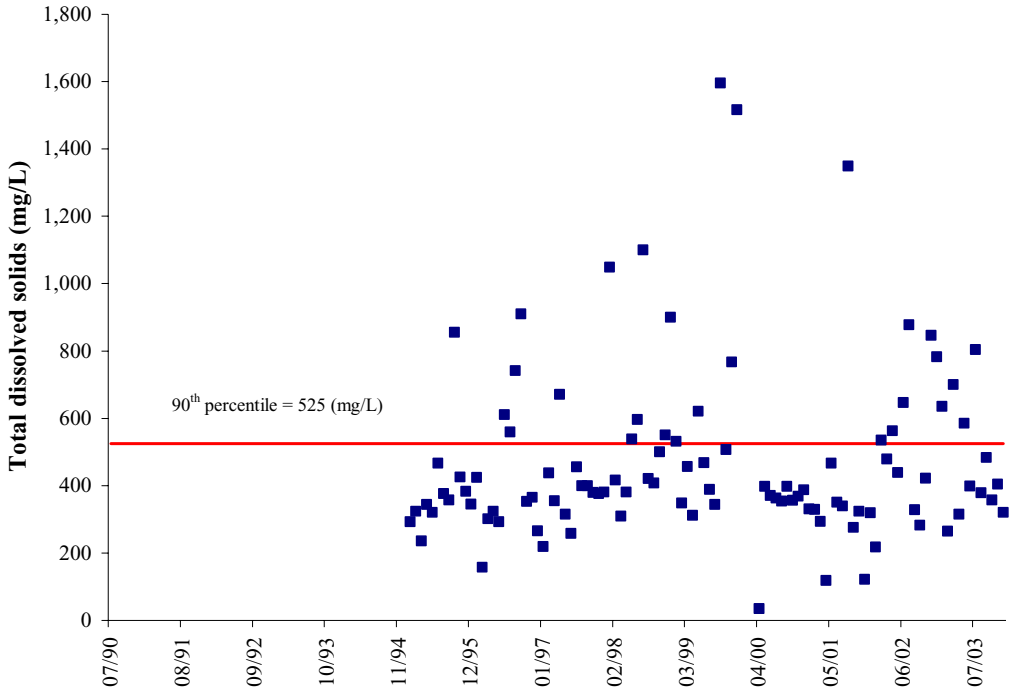

Figure 7.47 TDS concentrations at DMME MPID 1020237.

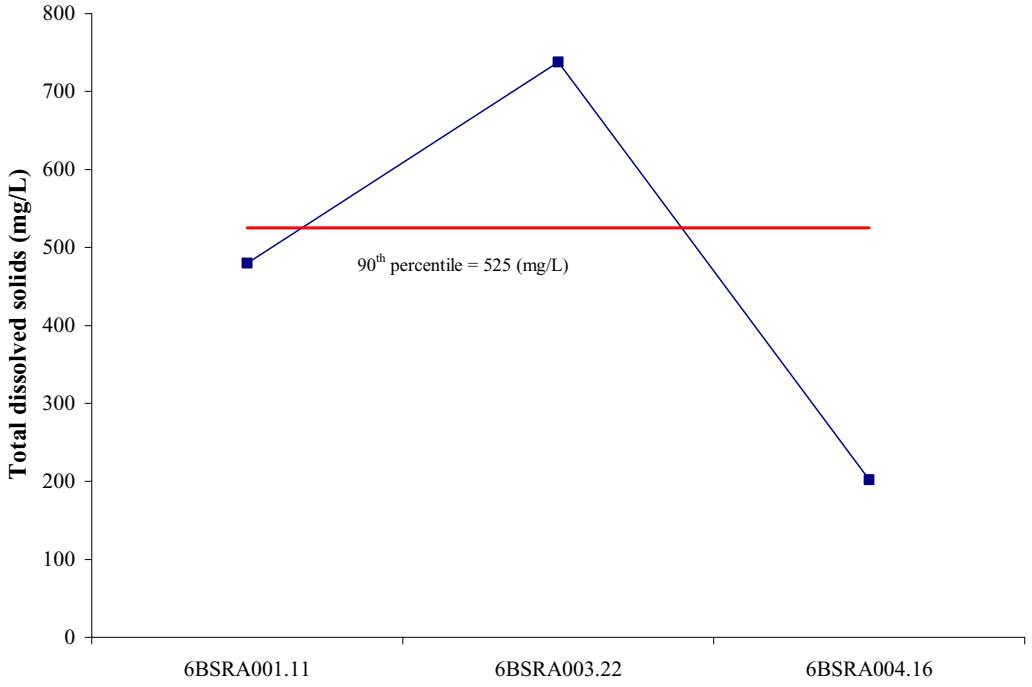

Figure 7.48 Median TDS concentrations at VADEQ stations on Straight Creek.

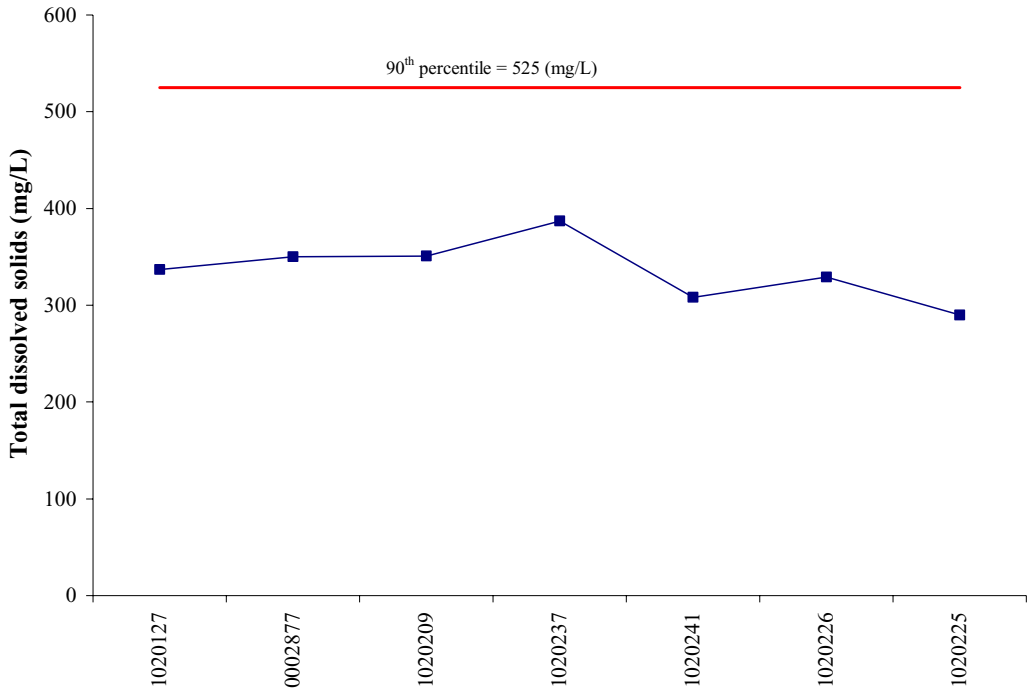

Figure 7.49 Median TDS concentrations at DMME MPIDs on Straight Creek.

TDS concentrations can be harmful to aquatic organisms without causing death. Aquatic organisms balance water and internal ions through a number of different mechanisms. Therefore high concentrations and significant changes in TDS over long periods of time can place a lot of stress on the organisms. The resulting chronic stress affects processes such as growth and reproduction. Sudden large spikes in TDS concentration can be fatal. In general, if TDS concentrations in freshwater effluents (discharges from industrial or municipal wastewater treatment facilities) is above 1,340 mg/L, the concentration of dissolved ions can be high enough to stress aquatic organisms (Society of Environmental Toxicology and Chemistry, 2004). A similar research paper noted that conductivity can be used as a screening tool for TDS toxicity in freshwater effluents. In general, if the conductivity of a freshwater effluent exceeds 2,000 µmhos/cm then the concentration of dissolved ions can be high enough to cause stress to aquatic organism (Goodfellow et al., 2000). Conductivity values exceeded 2,000 µmhos/cm at both VADMME and VADEQ monitoring stations on Straight Creek.

A study of TDS toxicity in a coal mining watershed in southeastern Ohio found the lowest observed effect concentration (LOEC) on the test organism *Isonychia bicolor* (a species of Mayfly) was 1,066 mg/L (Kennedy, 2002). The author carefully noted that this concentration was specific to the watershed studied, but noted that similar studies with the same test organism and TDS with varying ionic compositions were toxic between 1,018 and 1,783 mg/L (Kennedy, 2002). Kennedy referenced a study that suggested aquatic organisms should be able to tolerate TDS concentrations up to 1,000 mg/L; however, the test organism used was *Chironomous tentans*, which is considerably more pollution tolerant than *Isonychia bicolor* (Kennedy, 2002).. Research also indicates that the likely mechanism(s) of TDS benthic macroinvertebrate mortality is from gill and internal tissue dehydration, salt accumulation and compromised osmoregulatory function. In fact, the rate of change in TDS concentrations may be more toxic to benthic macroinvertebrates than the TDS alone (Kennedy, 2002).

A recent report on the effects of surface mining on headwater stream biotic integrity in Eastern Kentucky noted that one of the most significant stressors in these watersheds was elevated TDS (Pond, 2004). Elevated TDS concentrations impact pollution sensitive mayflies the most. Figure 7.50 from this report shows that "drastic reductions in mayflies occurred at sites with conductivities generally above 500 µmhos/cm" (approximately 375 mg/L TDS) (Pond, 2004).

Pond speculated that the increased salinity may irritate the gill structures on mayflies and inhibit the absorption of oxygen but research has not confirmed this. He also noted that mayfly sensitivity to increases in dissolved ions varies by genus. For example, the genera *Baetis, Isonychia* and *Caenis* commonly inhabit streams with elevated conductivity (Pond, 2004). The benthic monitoring results from VADEQ and ECI sampling showed that mayflies made up only 15% and 16% of the total benthic assemblage, respectively. A typical reference station in this part of the state can be expected to have at least nearly 50% mayflies out of the total assemblage. These surveys only produced family level data but it is significant that in the VADEQ and ECI data the families Baetidae, Isonychiidae and Caenidae comprised 83 and 87% of the total mayflies, respectively.

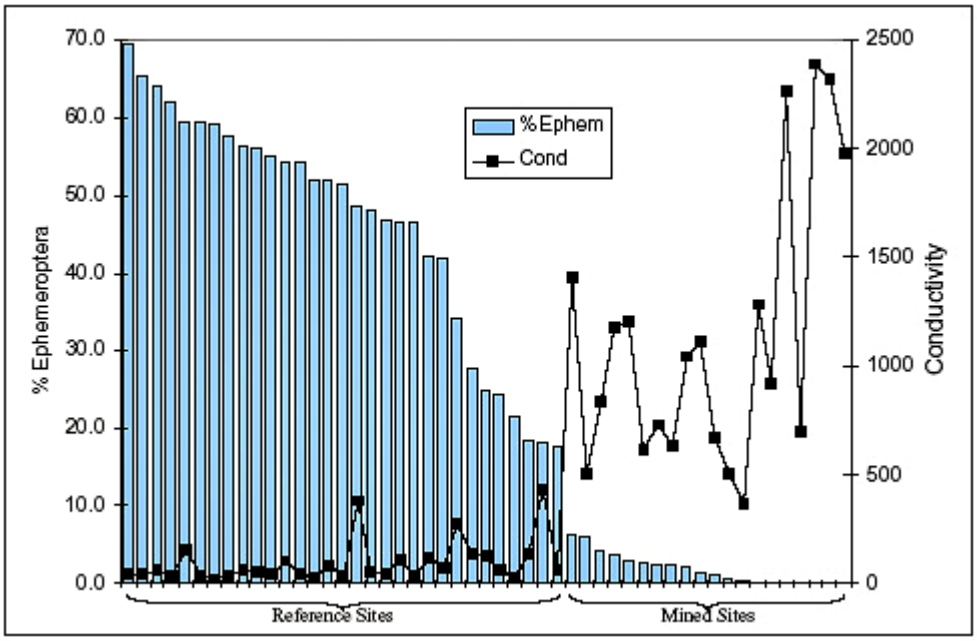

Figure 7.50 The relationship between %Ephemeroptera and conductivity from reference and mined sites (Pond, 2004).

It is clear from the data available that conductivity and TDS values are too high and there have been very large fluctuations over the sampling period. There seems to be little doubt that the extremely high TDS concentrations often present in Straight Creek are responsible for depressing the sensitive benthic community. Therefore, conductivity and TDS are considered probable stressors. Modeling and subsequent allocations will focus on TDS.

7.4.2 Sediment

The median habitat scores were marginal for metrics that indicate sediment problems. Embeddedness scores were low in a majority of the benthic monitoring done prior to 2002 and sediment deposition scores were marginal at various monitoring stations on Straight Creek throughout the sampling period. Marginal sediment deposition scores indicate large-scale movements of sediment in the stream. Bank stability, bank vegetation and riparian vegetation scored in the marginal category at various VADEQ monitoring stations on Straight Creek throughout the sampling period. Marginal scores for these habitat metrics are indicative of potential erosion during high flows and the subsequent deposition of more sediment. Total suspended solids (TSS) concentrations

exceeded the 90th percentile of 25 mg/L at six of the seven DMME MPIDs (Table 7.13 and Figures 7.51 - 7.55). Median TSS concentrations for the DMME MPID sites are shown in Figure 7.56. TSS concentrations also exceeded the 90th percentile in 23% of samples collected from the VADEQ station 6BSRA001.11 (Figure 7.57).

Table 7.13 VADEQ stations and DMME MPIDs with excessive TSS values.

MPID or VADEQ Station	River Mile	% Exceedances	Range (mg/L)
6BSRA001.11	1.11	23	0.8 - 1,460
1020127	3.26	12	2 – 112
1020209	5.32	33	4 – 43
1020237	5.37	13	2 – 930
1020241	5.57	28	4 - 1,610
1020226	5.64	17	2 - 1,610
1020225	6.06	19	2 – 590

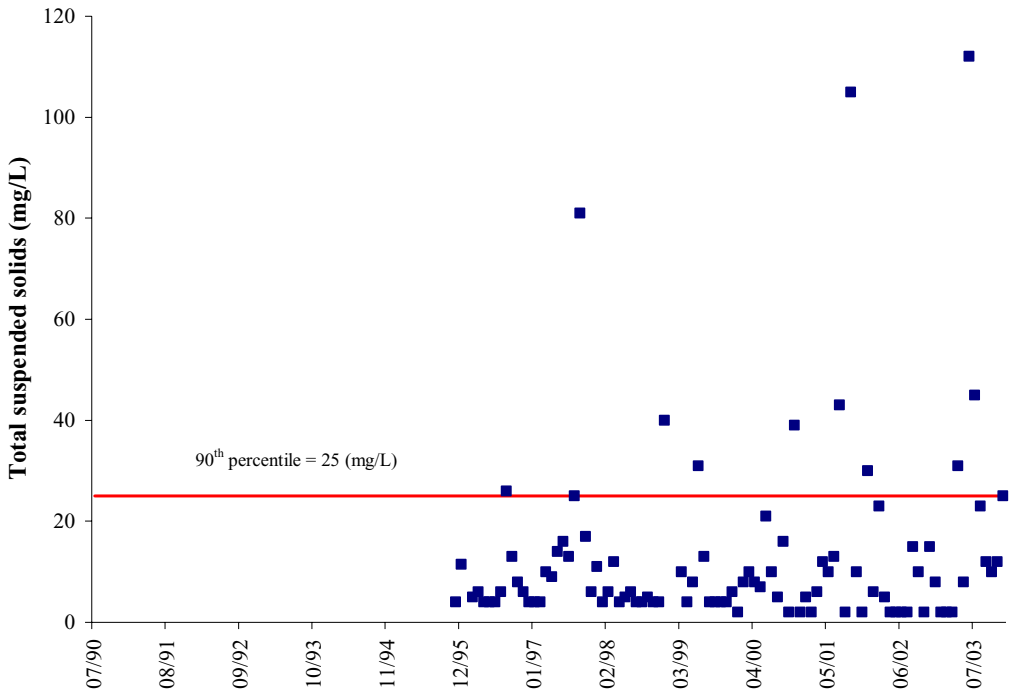

Figure 7.51 TSS concentrations at DMME MPID 1020127.

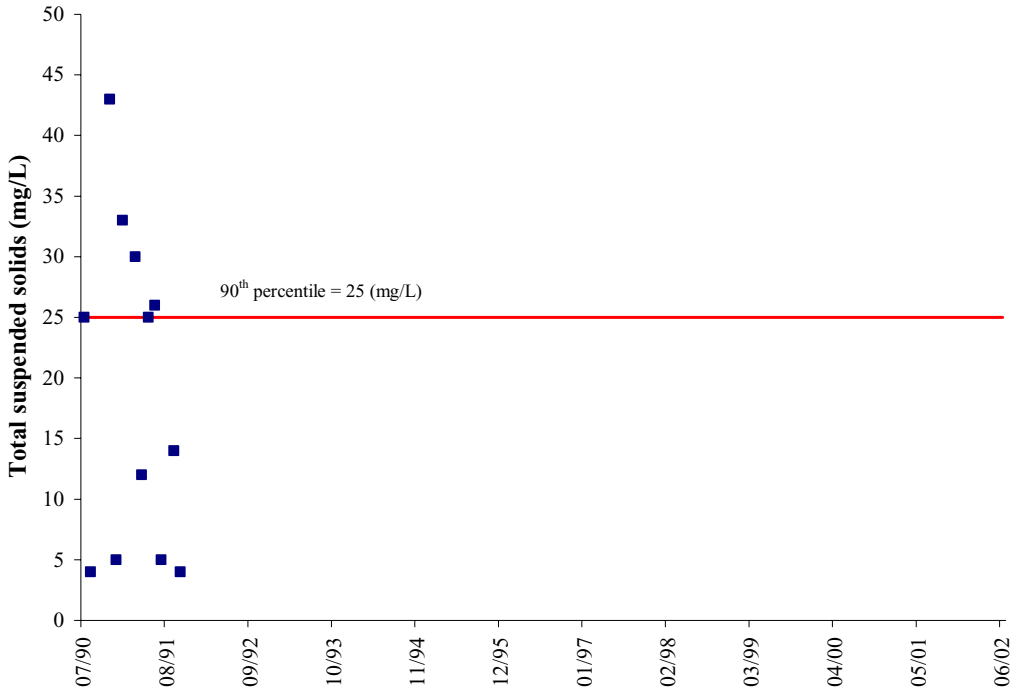

Figure 7.52 TSS concentrations at DMME MPID 1020209.

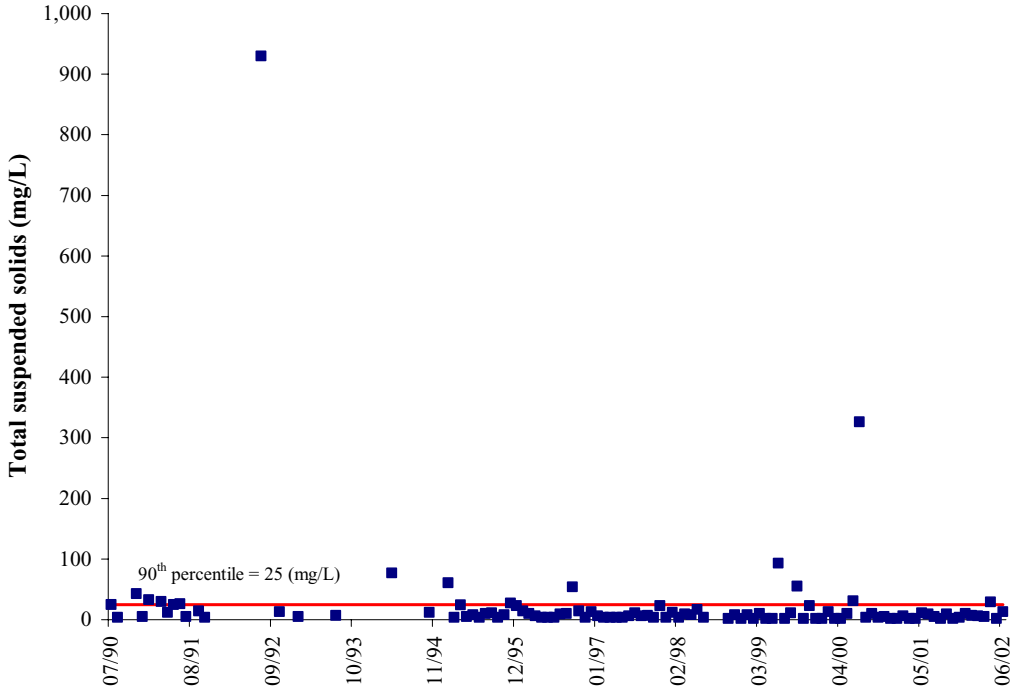

Figure 7.53 TSS concentrations at DMME MPID 1020237.

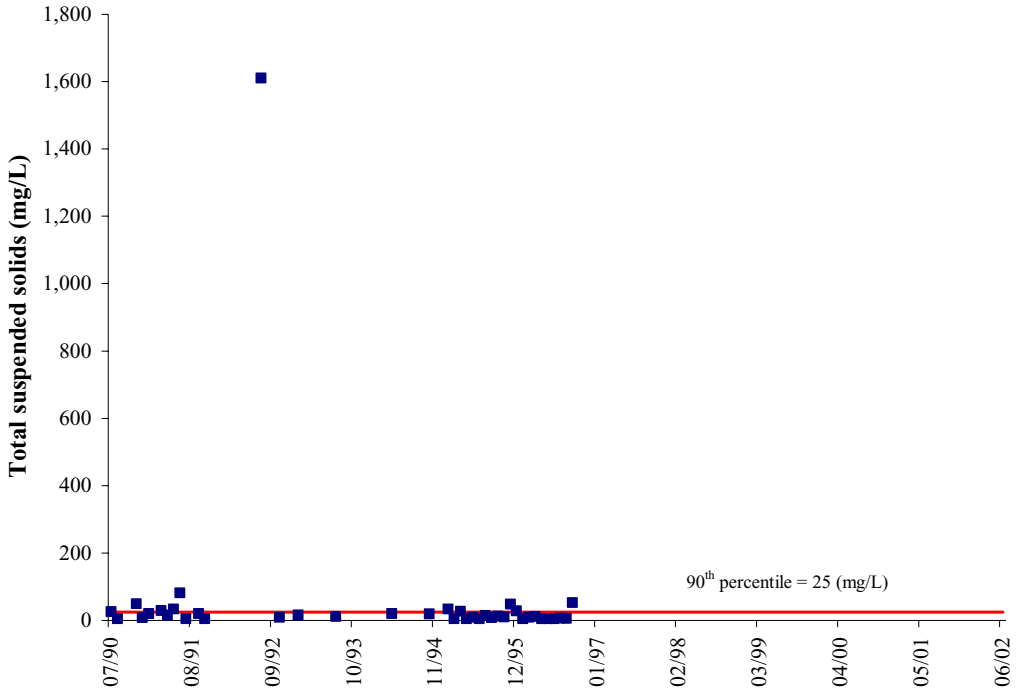

Figure 7.54 TSS concentrations at DMME MPID 1020241.

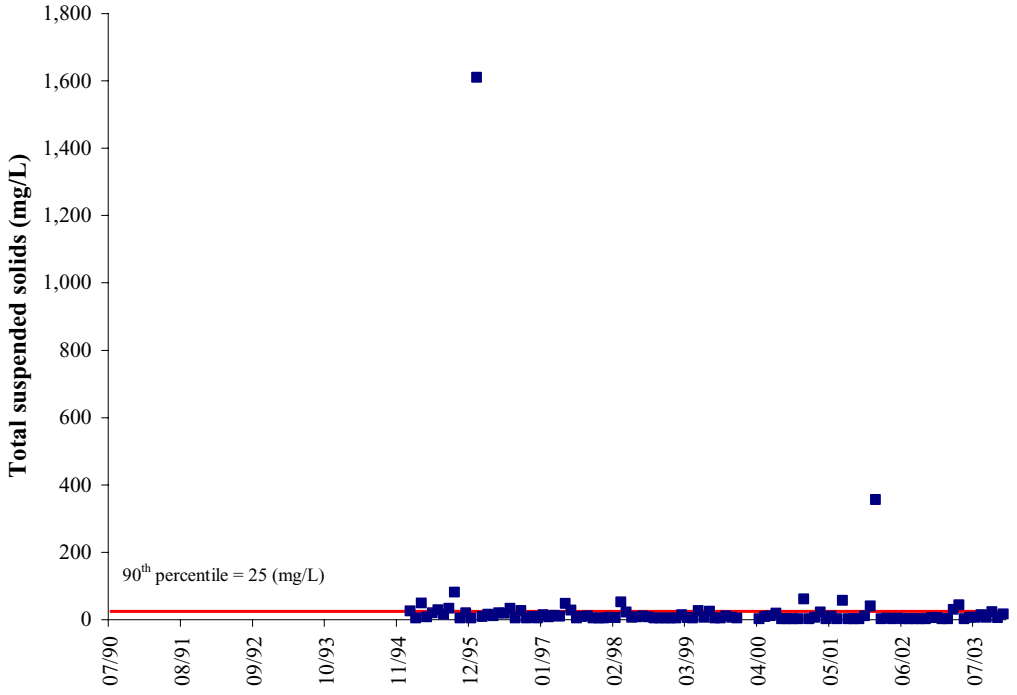

Figure 7.55 TSS concentrations at DMME MPID 1020226.

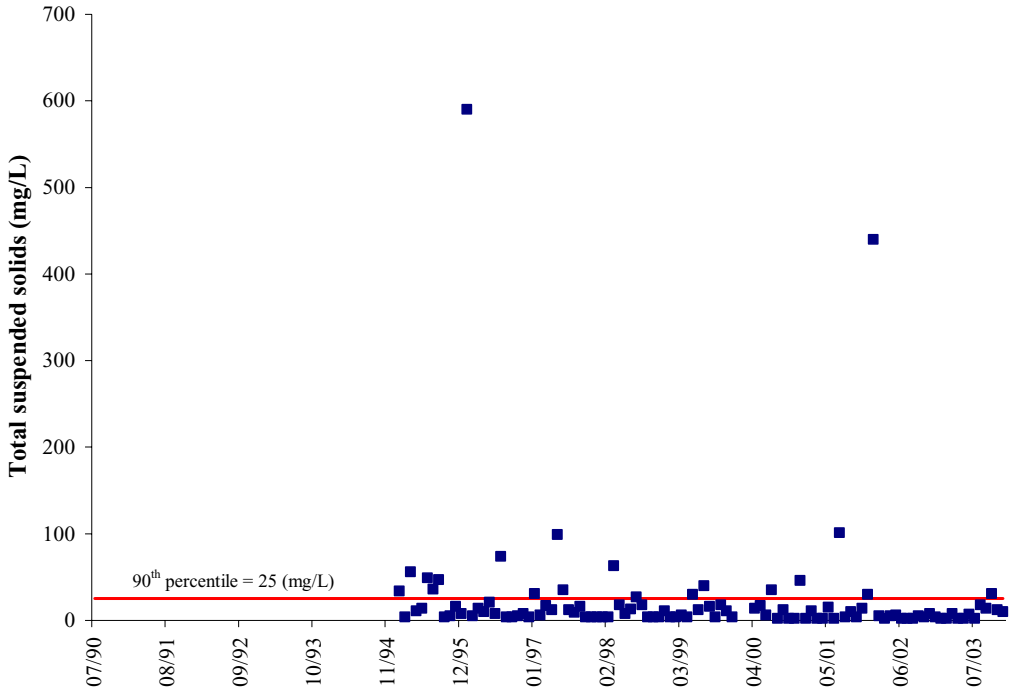

Figure 7.56 TSS concentrations at DMME MPID 1020225.

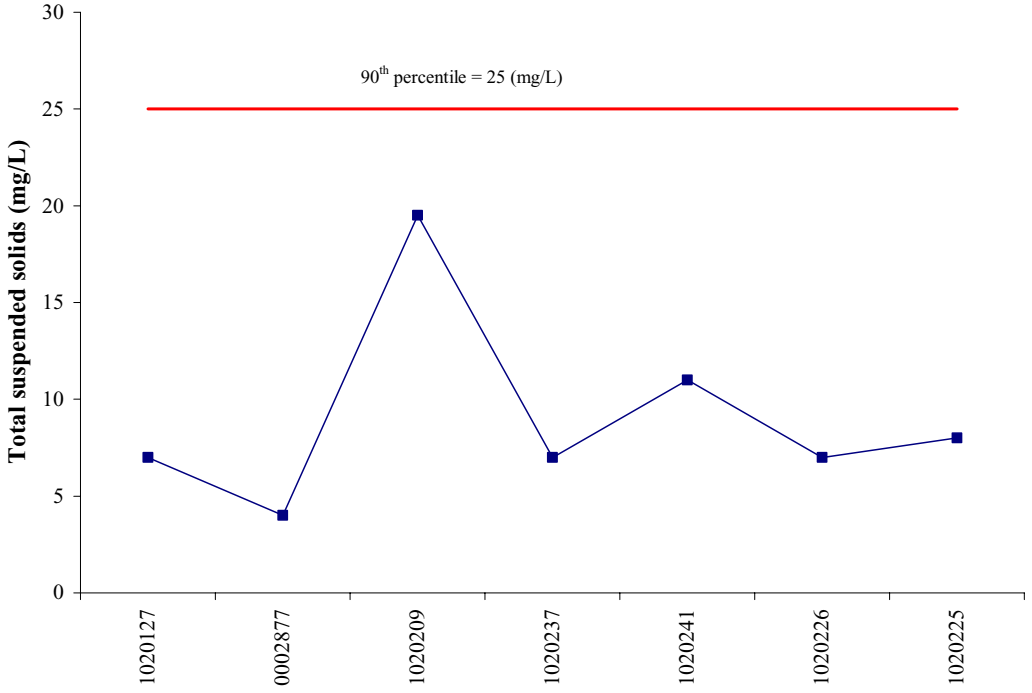

Figure 7.57 Median TSS concentrations at DMME MPIDs on Straight Creek.

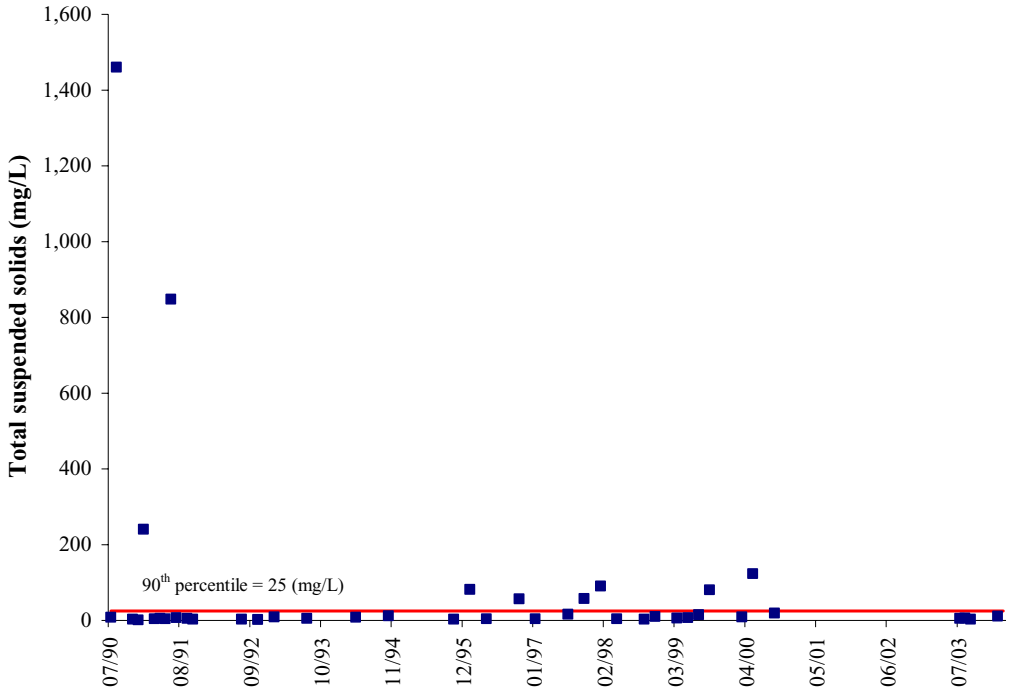

Figure 7.58 TSS concentrations at VADEQ station 6BSRA001.11.

Turbidity was sampled at the VADEQ stations and there were excessive values at station 6BSRA001.11 (Figure 7.59). Median turbidity values for the VADEQ stations are shown in Figure 7.60.

TSS concentrations at both the VADEQ station and the DMME MPIDs clearly show a pattern of periodic excess concentrations. Habitat scores from the seven VADEQ benthic surveys at station 6BSRA000.40 between 1991 and 1999 demonstrate that sediment is a problem in Straight Creek. Based on the high TSS concentrations and turbidity values, and consistently low habitat scores sediment is a probable stressor.

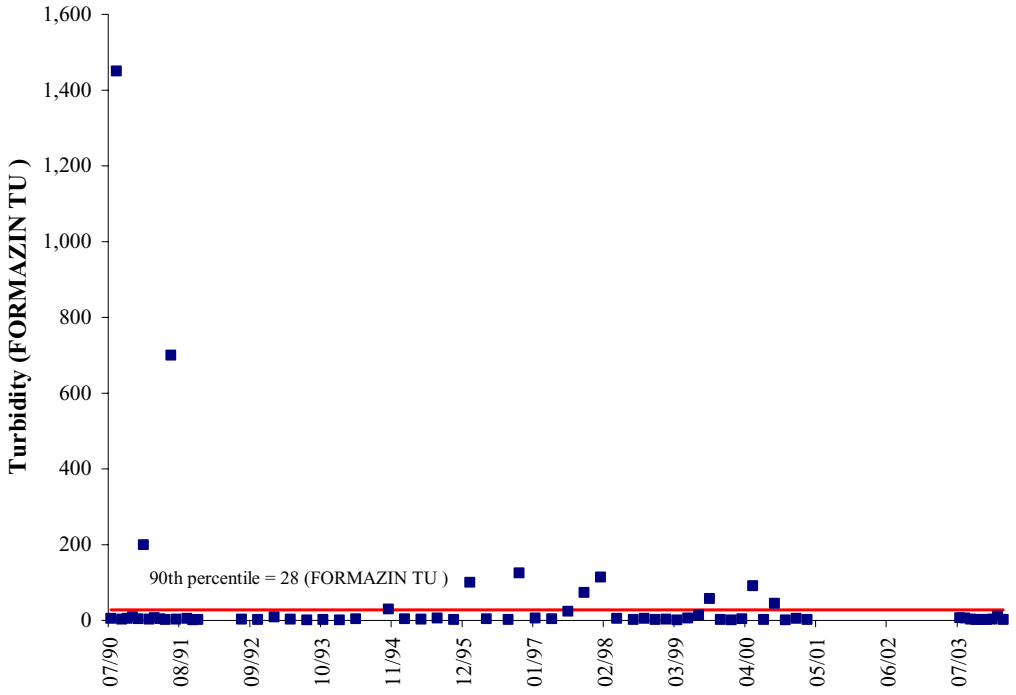

Figure 7.59 Turbidity values at VADEQ station 6BSRA001.11.

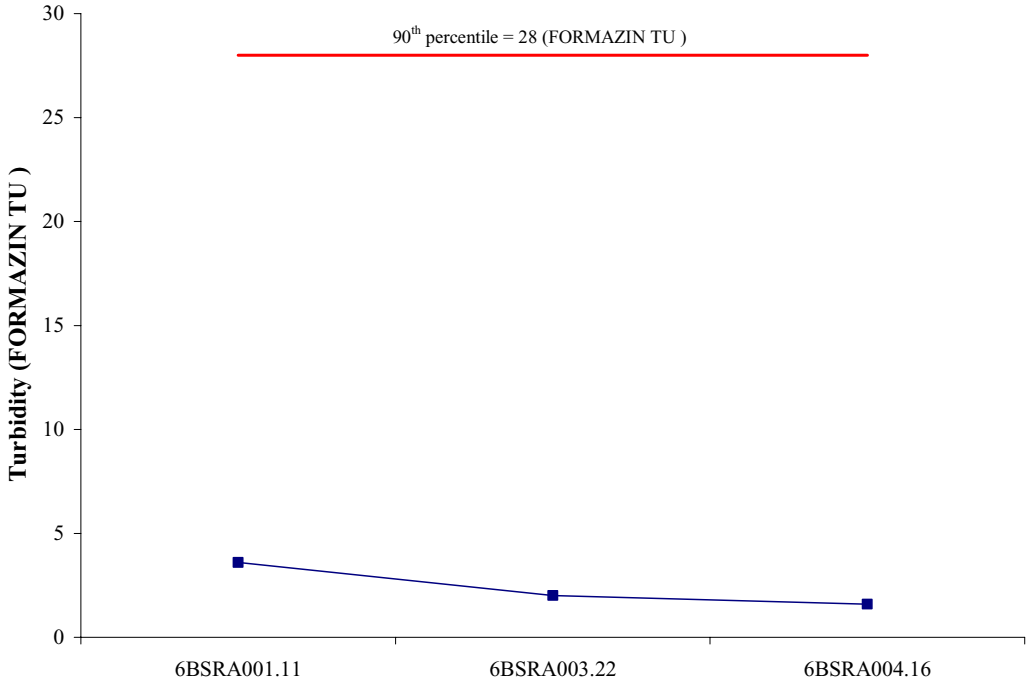

Figure 7.60 Median turbidity values at VADEQ stations on Straight Creek.

Coal mining is a major land use in the Straight Creek watershed and a recent study by the United States Geological Survey (USGS, 20011) noted that this activity results in the moving of significant amounts of earth and rock that alters the chemistry and geomorphology of the watershed. As water percolates through this unconsolidated material TDS, conductivity, and sulfate values will likely increase. The fracturing of rock also increases the transport and deposition of fine-grained material into the stream, reducing the quality and quantity of available habitat for benthic macroinvertebrates (USGS, 2001). The data in this chapter indicate that sediment and TDS are the stressors most responsible for the benthic impairment in Straight Creek. A preliminary draft of this chapter was sent to the EPA for review and comment. The review was done at the EPA Region 3 office in Wheeling, West Virginia and they noted that the selection of the most probably stressors in particular TDS was definitely correct (Pond, 2005). The EPA further noted that addressing a pollutant like TDS was, "definitely going in the right direction to improve aquatic life in this watershed." It is acknowledged that there have been four significant pollution events in the past nine years. Some were related to current mining operations and some to historic mining activities (see Chapter 6). These incidents may have played a role in the depression of the benthic community in Straight Creek.

MapTech received additional data from Biological Monitoring, Inc. (BMI) on January 10, 2005. The data consisted of benthic monitoring performed by BMI at six locations on Straight Creek (10/97 – 9/1998) and additional chemical data (10/1996 – 12/1998) collected by Lone Mountain Processing, Inc. (LMPI). The benthic data was assessed using the West Virginia Stream Condition Index (WVASCI). All six biological monitoring sites showed consistent impairment based on the WVASCI. The chemical monitoring data was very similar to the data supplied by DMME that was discussed in Chapter 6. The analysis of this data did not alter the decision that sediment and TDS are the probable stressors in Straight Creek.

8. REFERENCE WATERSHED SELECTION

A reference watershed approach was used to estimate the necessary load reductions that are needed to restore a healthy aquatic community and allow the streams in the Powell River watershed to achieve their designated uses. This approach is based on selecting a non-impaired watershed that has similar land use, soils, stream characteristics (*e.g.*, stream order, corridor, slope), area (not to exceed double or be less than half that of the impaired watershed), and is in the same ecoregion as the impaired watershed.

The modeling process uses load rates or pollutant concentrations in the non-impaired watershed as a target for load reductions in the impaired watershed. The impaired watershed is modeled to determine the current load rates and establish what reductions are necessary to meet the load rates of the non-impaired watershed.

Eight potential reference watersheds were selected from the Central Appalachians and the Valley and Ridge ecoregions for analyses that would lead to the selection of a reference watershed for Straight Creek (Figure 8.1). These watersheds include Dismal Creek in Buchanan County, Indian Creek and Middle Creek in Tazewell County, the McClure River and Fryingpan Creek in Dickenson County, the South Fork Powell River in Wise County, Stoney Creek in Scott County, and Martin Creek in Lee County. The potential reference watersheds were ranked based on quantitative and qualitative comparisons of watershed attributes (*e.g.*, land use, soils, slope, stream order, watershed size). Based on these comparisons and after conferring with state and regional VADEQ personnel, Middle Creek watershed, Tazewell County was selected as the reference watershed for the streams in the Powell River watershed.

Middle Creek watershed is a good choice as the reference watershed, as information that is needed to select numeric endpoints is readily available from water quality monitoring performed by DMME. The Middle Creek watershed has a history of mining activity and has recovered from a benthic impairment. Computer simulation models have been developed to simulate flow, TDS concentrations, and sediment loads in Middle Creek. In addition, the necessary reductions in loadings to the impaired streams can be shown as achievable targets, as exemplified by the improvement in water quality of Middle Creek.

Figure 8.2 shows the location of Straight Creek and Middle Creek within the ecoregion. Figure 8.3 compares the land use distributions between the watersheds. Figure 8.4 shows the soils in the watersheds. Table 8.1 compares soil characteristics between the watersheds.

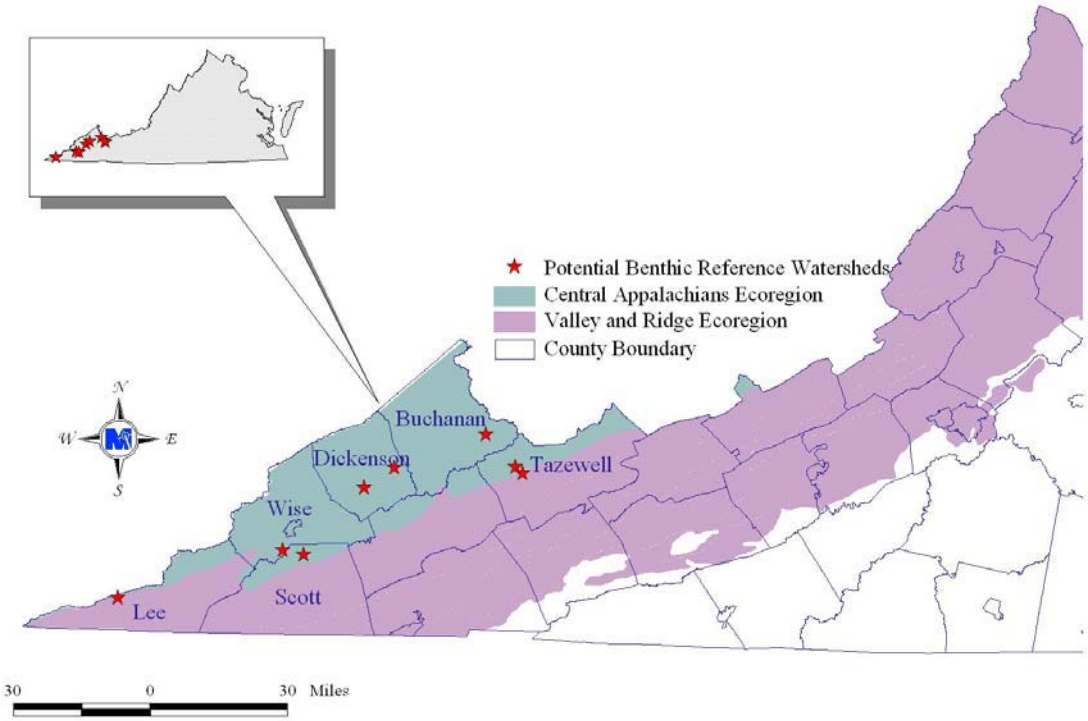

Figure 8.1 Location of potential reference watersheds.

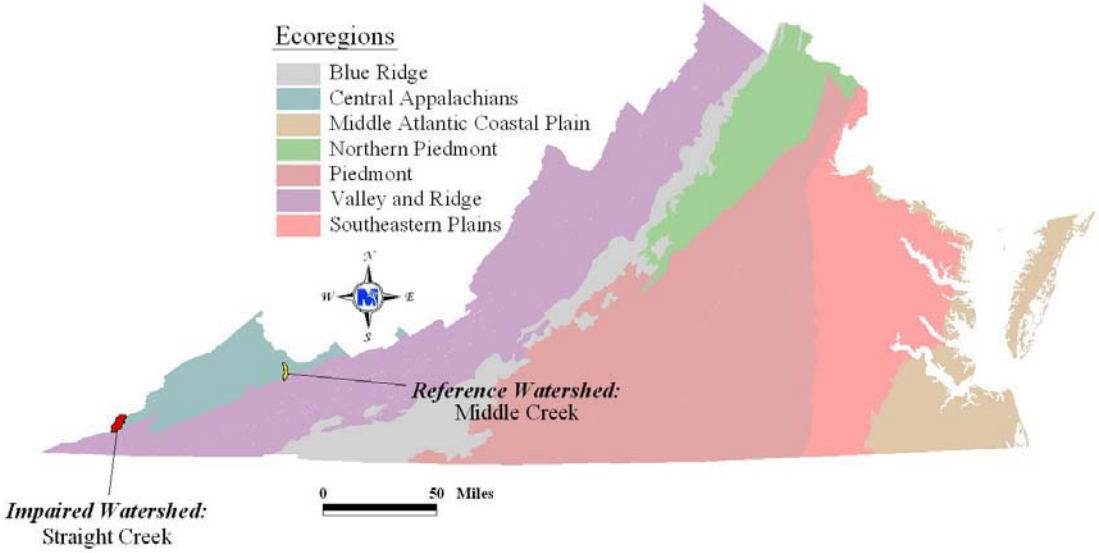

Figure 8.2 Location of impaired and reference watershed within ecoregion.

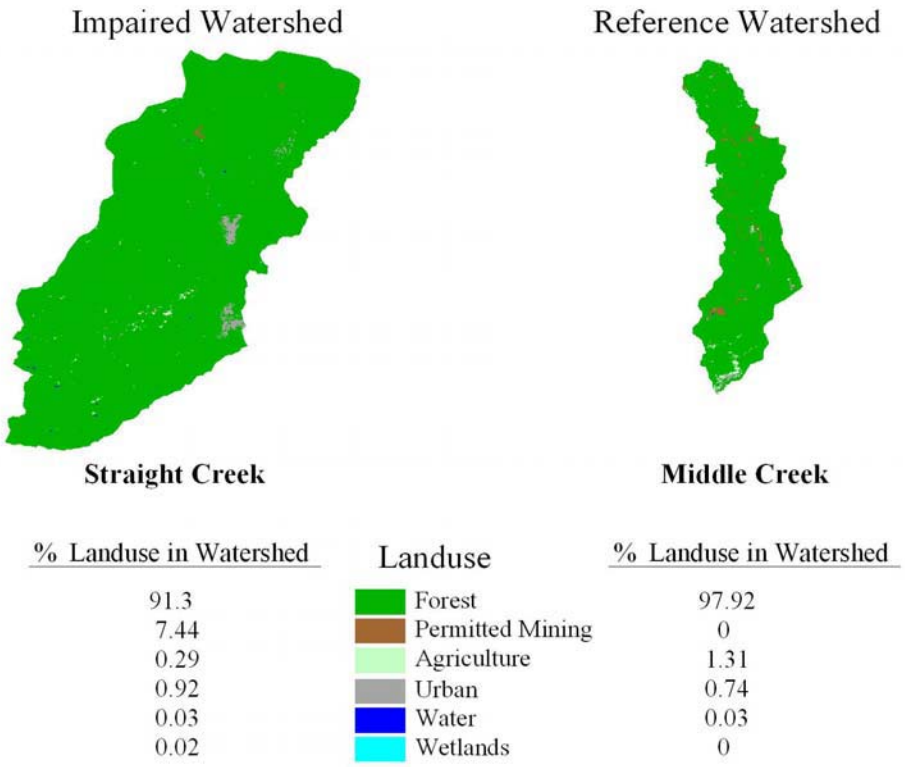

Figure 8.3 Straight Creek and Middle Creek land use comparisons.

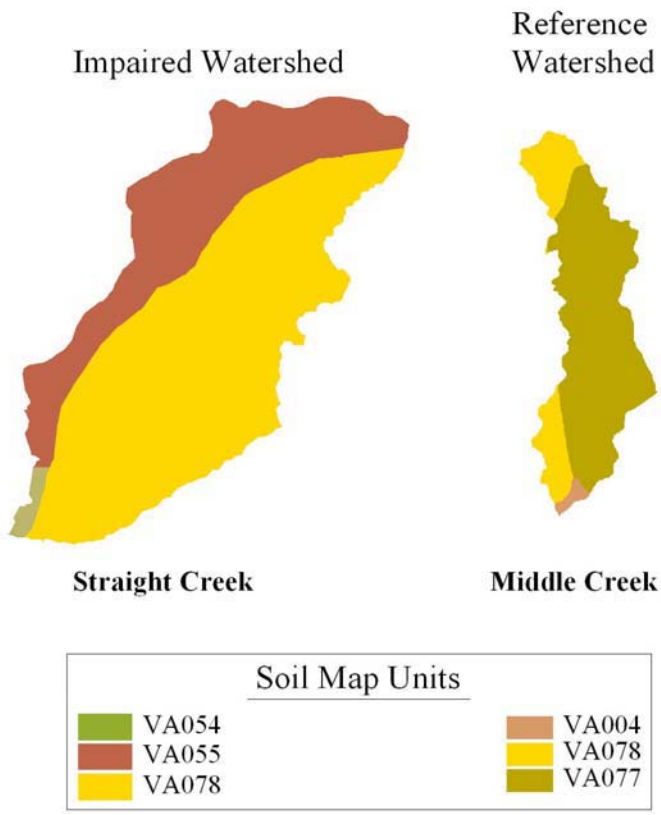

Figure 8.4 Straight Creek and Middle Creek soil comparisons.

Table 8.1 Straight Creek and Middle Creek soil characteristics.

Soil Characteristic	Straight Creek	Middle Creek
Hydrologic Group	B	B
Slope (degrees) (area weighted values)	20.58	20.89
Erodibility Factor (K) (area weighted values)	0.203	0.270
Soil Moisture Capacity (in) (area weighted values)	0.233-1.243	0.216-1.047

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9. MODELING PROCEDURE: LINKING THE SOURCES TO THE ENDPOINT

Establishing the relationship between in-stream water quality and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired water quality endpoint. In the development of a TMDL for the Straight Creek watershed, the relationship was defined through computer modeling based on data collected throughout the watershed. Monitored water quality data were then used to verify that the relationships developed through modeling were accurate. In this section, the selection of modeling tools, parameter development, calibration, and model application for TDS and sediment are discussed.

As described in Chapter 8 of this document, Middle Creek in Tazewell County, VA was selected as the reference watershed. Using a reference watershed with a history of coal mining and benthic impairment ensures that the TDS and sediment TMDLs developed for Straight Creek are achievable scenarios. The maximum recorded TDS concentration since the delisting of Middle Creek (334 mg/L) and the average annual sediment load from the Middle Creek watershed were used to define the benthic TMDL loads for the Straight Creek watersheds.

9.1 Modeling Framework Selection

9.1.1 HSPF - TDS

The USGS Hydrologic Simulation Program - Fortran (HSPF) water quality model was selected as the modeling framework to simulate existing conditions and to perform the TDS TMDL allocations. The HSPF model is a continuous simulation model that can account for NPS pollutants in runoff, as well as pollutants entering the flow channel from point sources. In establishing the existing and allocation conditions, seasonal variations in hydrology, climatic conditions, and watershed activities were explicitly accounted for in the model. The use of HSPF allowed consideration of seasonal aspects of precipitation patterns within the watershed. The mining land uses within a subwatershed that discharged surface runoff were collectively modeled as a separate RCHRES, with appropriate characteristics to model the detention time associated with the structures. It

was assumed that all runoff from active mining was controlled by one of these structures (Section 4.2.1). The HSPF hydrology model is explained in Chapter 4.

9.1.2 GWLF - Sediment

A reference watershed approach was used in this study to develop benthic TMDLs for sediment for the Straight Creek watershed. As noted in Chapter 7 sediment was identified as a probable stressor for Straight Creek. A watershed model was used to simulate sediment loads from potential sources in Straight Creek, and the Middle Creek reference watershed. The model used in this study was the Visual *Basic*™ version of the Generalized Watershed Loading Functions (GWLF) model with modifications for use with ArcView (Evans et al., 2001). The model also included modifications made by Yagow et al., 2002 and BSE, 2003. Numeric endpoints were based on unit-area loading rates calculated for the reference watershed. The TMDLs were then developed for the impaired watershed based on these endpoints and the results from load allocation scenarios.

The GWLF model was developed at Cornell University (Haith and Shoemaker, 1987; Haith, et al., 1992) for use in ungaged watersheds. It was chosen for this study as the model framework for simulating sediment. GWLF is a continuous simulation, spatially lumped model that operates on a daily time step for water balance calculations and monthly calculations for sediment and nutrients from daily water balance. In addition to runoff and sediment, the model simulates dissolved and attached nitrogen and phosphorus loads delivered to streams from watersheds with both point and nonpoint sources of pollution. The model considers flow input from both surface and groundwater. Land use classes are used as the basic unit for representing variable source areas. The calculation of nutrient loads from septic systems, stream-bank erosion from livestock access, and the inclusion of sediment and nutrient loads from point sources are also supported. Runoff is simulated based on the Soil Conservation Service's Curve Number method (SCS, 1986). Erosion is calculated from a modification of the Universal Soil Loss Equation (USLE) (Schwab et al., 1981; Wischmeier and Smith, 1978). Sediment estimates use a delivery ratio based on a function of watershed area and erosion estimates from the modified USLE. The sediment transported depends on the transport capacity of runoff.

For execution, GWLF uses three input files for weather, transport, and nutrient loads. The weather file contains daily temperature and precipitation for the period of record. Data are based on a water year typically starting in April and ending in March. The transport file contains input data related to hydrology and sediment transport. The nutrient file contains primarily nutrient values for the various land uses, point sources, and septic system types, but does include urban sediment buildup rates.

9.2 Model Setup

9.2.1 HSPF – TDS

No deep mine discharges were present in the Straight Creek and North Fork Powell River watersheds during the hydrology calibration period. TDS loads were incorporated into the HSPF models calibrated for hydrology for Straight Creek. TDS was modeled as a conservative constituent. The pathways for delivery to the stream are transport with surface runoff, interflow, and groundwater. Sensitivity analyses were performed on the TDS model to ascertain how the model responds to changes in each parameter.

9.2.2 GWLF - Sediment

Watershed data needed to run GWLF used in this study were generated using GIS spatial coverage, local weather data, streamflow data, literature values, and other data. Watershed boundaries for the impaired stream segment and the selected reference watershed were delineated from USGS 7.5 minute digital topographic maps using GIS techniques. The reference watershed outlet for Middle Creek was located at biological monitoring station 6BMID000.20 just upstream of the confluence with the Clinch River. For TMDL development, the total area for the Middle Creek reference watershed was equated with the area of Straight Creek watershed. To accomplish this, the area of land use categories in reference watershed Middle Creek, was proportionately increased based on the percentage land use distribution. As a result, the watershed area for Middle Creek was increased to be equal to the watershed areas for the Straight Creek watershed. After adjustment, the distribution of land use remained the same as pre-adjustment values.

The GWLF was developed to simulate runoff, sediment and nutrients in ungaged watersheds based on landscape conditions such as land use/landcover, topography, and

soils. In essence, the model uses a form of the hydrologic units (HU) concept to estimate runoff and sediment from different pervious areas (HUs) in the watershed (Li, 1975; England, 1970). In the GWLF model, the nonpoint source load calculation for sediment is affected by land use activity (*e.g.,* farming practices), topographic parameters, soil characteristics, soil cover conditions, stream channel conditions, livestock access, and weather. The model uses land use categories as the mechanism for defining homogeneity of source areas. This is a variation of the HU concept, where homogeneity in hydrologic response or nonpoint source pollutant response would typically involve the identification of soil land use topographic conditions that would be expected to give a homogeneous response to a given rainfall input. A number of parameters are included in the model to index the affect of varying soil-topographic conditions by land use entities. A description of model parameters is given in Section 9.2.2.1 followed by a description of how parameters and other data were calculated and/or assembled.

9.2.2.1 Description of GWLF Model Input Parameters

The following description of GWLF model input parameters was taken from a TMDL Draft report prepared by BSE, 2003.

Hydrologic Parameters

Watershed Related Parameter Descriptions

- *Unsaturated Soil Moisture Capacity (SMC): 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): 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.*
- *Seepage Coefficient (/day): The seepage coefficient represents the amount of flow lost to deep seepage.*

Running the model for a 3-month period prior to the chosen period during which loads were calculated, initialized the following parameters.

- *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 files.*

Month Related Parameter Descriptions

- *Month: Months were ordered, starting with April and ending with March – in keeping with the design of the GWLF model and its assumption that stored sediment is flushed from the system at the end of each Apr-Mar cycle. Model output was modified in order to summarize loads on a calendar year basis.*

- *ET CV: Composite evap-transpiration 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 a regional coefficient used in Richard's equation for calculating daily erosivity. Each region is assigned separate coefficients for the months October-March, and for April-September.*

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 the inverse function of watershed size (Evans et al., 2001).*

Land use-Related Parameter Descriptions

- *USLE K-factor (erodibility): 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.*

- *USLE C-factor: The vegetative cover factor for each land use was evaluated following GWLF manual guidance and Wischmeier and Smith (1978).*

- *Daily sediment build-up 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, 2002)

- *% 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 watershed area in acres.*

- *Stream length: Calculated as the total stream length of natural stream channel, in meters. Excludes the non-erosive hardened and piped sections of the stream.*

- *Stream length with livestock access: calculated as the total stream length in the watershed where livestock have unrestricted access to streams, resulting in streambank trampling, in meters.*

9.3 Source Representation

9.3.1 Total Dissolved Solids (TDS)

Nonpoint sources were modeled as having four potential delivery pathways, delivery with surface runoff, delivery through interflow, delivery through groundwater, and delivery through point sources. Pollutants associated with interflow and/or groundwater were modeled by assigning a constant concentration for each in a particular PERLND. Much of the data used to develop the model inputs for modeling water quality is time-dependent (*e.g.,* existence of control structures). Depending on the timeframe of the simulation being run, the model was varied appropriately. Data representing the water quality calibration periods were used to develop the model used in this study.

9.3.1.1 TDS Point Sources

There were no deep mine discharges in the Straight Creek watershed during the water quality calibration time period. TDS loading from uncontrolled discharges (straight pipes) was applied directly to the stream in the model. The TDS concentration from human waste from uncontrolled discharges was estimated as 500 mg/L (Metcalf and Eddy, 1991).

9.3.1.2 TDS Nonpoint Sources

Nonpoint source contributions from the fourteen land use categories (Table 4.1) were assumed to be delivered to the stream flow system in surface runoff, interflow and groundwater. The HSPF model was used to link pollutants from nonpoint sources with downstream water quality. Runoff from surface mine areas is collected in ponds. These ponds are considered permitted discharges since the mining industry and DMME are required to monitor the outflow. As discussed in Chapter 4, a runoff event is necessary to transport TDS from the land to the pond water. The mining ponds were assumed not to reduce the TDS load from the collected water and all TDS in runoff from mining land uses was routed to the stream via the ponds.

9.3.1.3 Road Salt Applications

Annual road salt application rates for Lee (Straight Creek) County were provided by the Virginia Department of Transportation (VDOT). The road salt applications were deposited on paved roads in the watershed on days with recorded snowfall. The daily rate was calculated using a ratio of snowfall on a given day to the total snowfall during the modeling time period. This was done to simulate the practice of applying less salt for light snowfall and more salt during heavy snow events. These daily salt applications were used to estimate TDS in surface runoff from paved roads during the winter months. The road salt applications were modeled using an external time series depositing on the paved road PERLNDs in the watershed.

9.3.2 Sediment

Three source areas identified as the primary contributors to sediment loading in the Straight Creek watershed include surface runoff, point sources, and streambank erosion.

The sediment process is continual but is often accelerated by human activity. An objective of the TMDL process is to minimize this acceleration. This section describes predominant sediment source areas, model parameters, and input data needed to simulate sediment loads.

9.3.2.1 Surface Runoff - Sediment

During runoff events (natural rainfall or irrigation), sediment is transported to streams from pervious land areas (*e.g.,* agricultural fields, lawns, forest.). Rainfall energy, soil cover, soil characteristics, topography, and land management affect the magnitude of sediment loading. Agricultural management activities such as overgrazing (particularly on steep slopes), high tillage operations, livestock concentrations (*e.g.,* along stream edge, uncontrolled access to streams), forest harvesting, land disturbance due to mining and construction (roads, buildings, etc.) all tend to accelerate erosion at varying degrees. During dry periods, sediment from air or traffic builds up on impervious areas and is transported to streams during runoff events. The magnitude of sediment loading from this source is affected by various factors (*e.g.,* the deposition from wind erosion and vehicular traffic).

The mining ponds were assumed to reduce the TSS load from the collected water, therefore, the effluent from all mining land was assumed to deliver only the permitted 70 mg/L TSS to the stream for all storm events.

9.3.2.2 Channel and Streambank Erosion

An increase in impervious land without appropriate stormwater control increases runoff volume and peaks, which leads to greater channel erosion potential. It has been well documented that livestock with access to streams can significantly alter physical dimensions of streams through trampling and shearing (Armour et al., 1991; Clary and Webster, 1989; Kaufman and Kruger, 1984). Increasing the bank full width decreases stream depth, increases sediment, and adversely affects aquatic habitat (USDI, 1998).

9.3.2.3 TSS Point Sources

Fine sediments are included in TSS loads that are permitted for various facilities with wastewater and industrial stormwater VPDES permits within the Straight Creek watershed. In the Straight Creek watershed, there is one permitted construction stormwater discharge. There were no MS4 permits located in the Straight Creek watershed. Sediment loads from permitted wastewater and industrial stormwater dischargers are included in the WLA component of the TMDL, in compliance with 40 CFRξ130.2(h). The TSS loading from uncontrolled discharges (straight pipes) was accounted for in the GWLF model results. A TSS concentration from human waste was estimated as 320 mg/L (Lloyd, 2004).

9.4 Selection of Representative Modeling Period

Selection of the modeling period was based on three factors; availability of data (discharge and water quality), the degree of land-disturbing activity, and the need to represent critical hydrological conditions. Calibration is the process of comparing modeled data to observed data and making appropriate adjustments to model parameters to minimize the error between observed and simulated events. Using observed data that is reported at a shorter time-step improves this process and subsequently the performance of a time-dependent model.

Water quality data were collected from Straight Creek on a monthly basis. Water quality (TDS) data were available in the period from 7/11/1990 through 3/4/2004 at various locations throughout the watershed (Table 9.1).

As described in Chapter 4, the primary limiting factor in determining a modeling period was selection of a timeframe with relatively stable land use and manmade hydraulics. Since there was a limited amount of data for the impairment during the identified period of relative stability, it was determined that the modeling effort would be more successful if all of these data were used for calibration, rather than dividing the dataset into smaller datasets for calibration and validation.

Table 9.1 Summary of modeling time periods for Straight Creek.

Impairment	Hydrology Calibration - HSPF	TDS Calibration - HSPF	Hydrology Calibration - GWLF
Straight Creek	10/1/1991 to 3/31/1995	10/1/1992 to 9/30/1996	10/1/1991 to 3/31/1995

9.5 Sensitivity Analysis

9.5.1 Sensitivity Analysis - HSPF

Sensitivity analyses were conducted to assess the sensitivity of the model to changes in water quality parameters as well as to assess the impact of unknown variability in source allocation (*e.g.,* seasonal and spatial variability of TDS loading).

For the water quality sensitivity analyses, an initial base run was performed during the calibration time period. Descriptions of the three parameters adjusted for the water quality sensitivity analyses with base values for the model runs given are presented in Table 9.2.

Table 9.2 Base parameter values used to determine water quality model response for Straight Creek.

Parameter	Description	Units	Base Value
IOQC	TDS in interflow	mg/ft^3	20,000.00
AOQC	TDS in groundwater flow	mg/ft^3	20,000.00
WSQOP	wash-off rate for TDS on land surface	in/hr	1.64

The three parameters were increased and decreased by amounts that were consistent with the range of values for the parameter. The model's responses to these changes are shown in Table 9.3.

Table 9.3 Percent change in average monthly TDS (mg/L) for Straight Creek.

Model Parameter	Parameter Change (%)	Percent Change in Average Monthly TDS mg/L for 1992-1996					
		Jan	Feb	Mar	Apr	May	Jun
IOQC	-50	-25.82	-26.81	-27.43	-25.34	-25.59	-20.12
IOQC	-10	-5.16	-5.36	-5.49	-5.07	-5.12	-4.02
IOQC	10	5.16	5.36	5.49	5.07	5.12	4.02
IOQC	50	25.82	26.81	27.43	25.34	25.59	20.12
AOQC	-50	-21.87	-21.05	-20.35	-22.50	-22.28	-26.22
AOQC	-10	-4.37	-4.21	-4.07	-4.50	-4.46	-5.24
AOQC	10	4.37	4.21	4.07	4.50	4.46	5.24
AOQC	50	21.87	21.05	20.35	22.50	22.28	26.22
WSQOP	-50	-0.01	0.00	0.10	-0.03	0.00	0.00
WSQOP	-10	0.00	0.00	0.02	-0.01	0.00	0.00
WSQOP	10	0.00	0.00	-0.01	0.01	0.00	0.00
WSQOP	50	0.00	0.01	-0.06	0.06	0.01	0.00

Table 9.3 Percent change in average monthly TDS (mg/L) for Straight Creek (continued).

Model Parameter	Parameter Change (%)	Percent Change in Average Monthly TDS mg/L for 1992-1996					
		Jul	Aug	Sept	Oct	Nov	Dec
IOQC	-50	-16.03	-16.43	-15.57	-15.71	-18.85	-21.49
IOQC	-10	-3.21	-3.29	-3.11	-3.14	-3.77	-4.30
IOQC	10	3.21	3.29	3.11	3.14	3.77	4.30
IOQC	50	16.03	16.43	15.57	15.71	18.85	21.49
AOQC	-50	-29.31	-29.33	-29.55	-31.25	-28.69	-26.06
AOQC	-10	-5.86	-5.87	-5.91	-6.25	-5.74	-5.21
AOQC	10	5.86	5.87	5.91	6.25	5.74	5.21
AOQC	50	29.31	29.33	29.55	31.25	28.69	26.06
WSQOP	-50	0.17	0.08	0.08	0.01	-0.05	0.05
WSQOP	-10	0.03	0.02	0.01	0.00	-0.01	0.01
WSQOP	10	-0.02	-0.02	-0.01	0.00	0.01	-0.01
WSQOP	50	-0.10	-0.09	-0.05	-0.02	0.04	-0.02

9.5.2 Sensitivity Analysis - GWLF

Sensitivity analyses were conducted to assess the sensitivity of the model to changes in hydrologic and water quality parameters as well as to assess the impact of unknown variability in source allocation (*e.g.*, seasonal and spatial variability of land disturbance, runoff curve number, etc.). Sensitivity analyses were run on the runoff curve number (CN) and the combined erosion factor (KLSCP), which combines the effects of soil erodibility, land slope, land cover, and management practices (Table 9.5). For a given simulation, the model parameters in Table 9.5 were set at the base value except for the parameter being evaluated. The parameters were adjusted to -10%, and 10% of the base value. Results are listed in Table 9.6. The results show that the parameters are directly correlated with runoff and sediment load. The relationships show fairly linear responses, with outputs being slightly more sensitive to changes in CN than KLSCP. The results tend to reiterate the need to carefully evaluate conditions in the watershed and follow a systematic protocol in establishing values for model parameters.

Table 9.4 Base watershed parameter values used to determine hydrologic and sediment response for Straight Creek.

Land use	Straight Creek	
	CN	**KLSCP**
Abandoned Mine Lands	76.86	0.52
Commercial Impervious	98.00	-
Commercial Pervious	93.76	0.012
Cropland	70.63	2.62
Forest	61.44	0.013
Forest Disturbed	70.74	1.03
Pasture/Hay	70.84	0.067
Permitted Mining:		
Reclaimed Mine Area[1]	71.29	0.18
Active Mine Area	85.72	4.42
Residential Impervious	98.00	-
Residential Pervious	70.09	0.016
Water	100	-

[1]values from Barfield et al., 1983.

Table 9.5 Sensitivity of GWLF model response to changes in selected parameters for Straight Creek.

Model Parameter	Parameter Change (%)	Change in Runoff (%)	Change in Sediment Load (%)
CN	10	9.76	19.57
CN	-10	-5.78	-9.10
KLSCP	10	0.00	10.01
KLSCP	-10	0.00	-9.99

9.6 Model Calibration of HSPF - TDS

Calibration is performed in order to ensure that the model accurately represents the water quality processes in the watershed. Hydrology calibration for Straight Creek was discussed in Chapter 4. Through calibration, water quality parameters were adjusted within appropriate ranges until the model performance was deemed acceptable.

Water quality calibration is complicated by a number of factors, some of which are described here. First, water quality concentrations are highly dependent on flow conditions. Any variability associated with the modeling of stream flow compounds the variability in modeling water quality parameters such as TDS concentration. Additionally, the limited amount of measured data for use in calibration impedes the calibration process.

The water quality (TDS) calibration of Straight Creek used TDS data from 10/1/1992 through 9/30/1996. Three parameters were utilized for model adjustment: concentration in interflow (IOQC), concentration in groundwater (AOQC), and rate of surface runoff of concentration from land surfaces (WSQOP). Changes in the IOQC and WSQOP parameters change TDS levels during runoff events, while changes in AOQC effect base flow TDS concentrations All of these parameters were initially set at acceptable levels for the watershed conditions and adjusted within reasonable limits until an acceptable match between measured and modeled TDS concentrations was established (Table 9.6). Careful visual inspection of graphical comparisons between continuous simulation results and limited observed points was the primary tool used to guide the calibration process. Results of the calibration are presented in Figures 9.1 through 9.3.

Table 9.6 Model parameters utilized for water quality calibration of Straight Creek.

Parameter	Units	Initial Parameter Estimate	Calibrated Parameter Value
WSQOP	in/hr	1.64	1.64
IOQC	mg/ft^3	20,000	5,250 – 475,000
AOQC	mg/ft^3	20,000	5,750 – 800,000

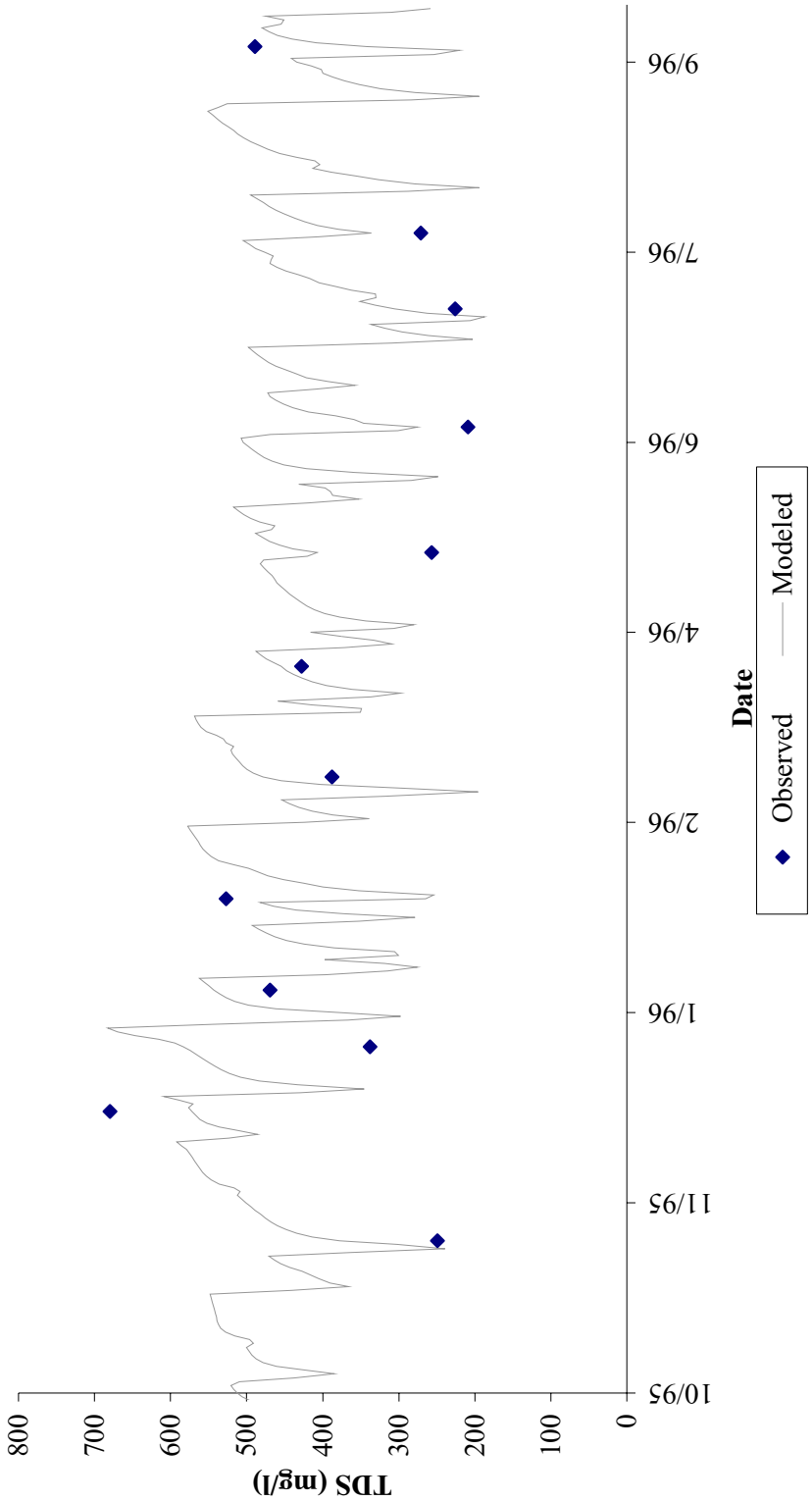

Figure 9.1 **Mean daily modeled TDS concentrations compared to instantaneous observed TDS concentrations for subwatershed 6 in the Straight Creek impairment, during the calibration period.**

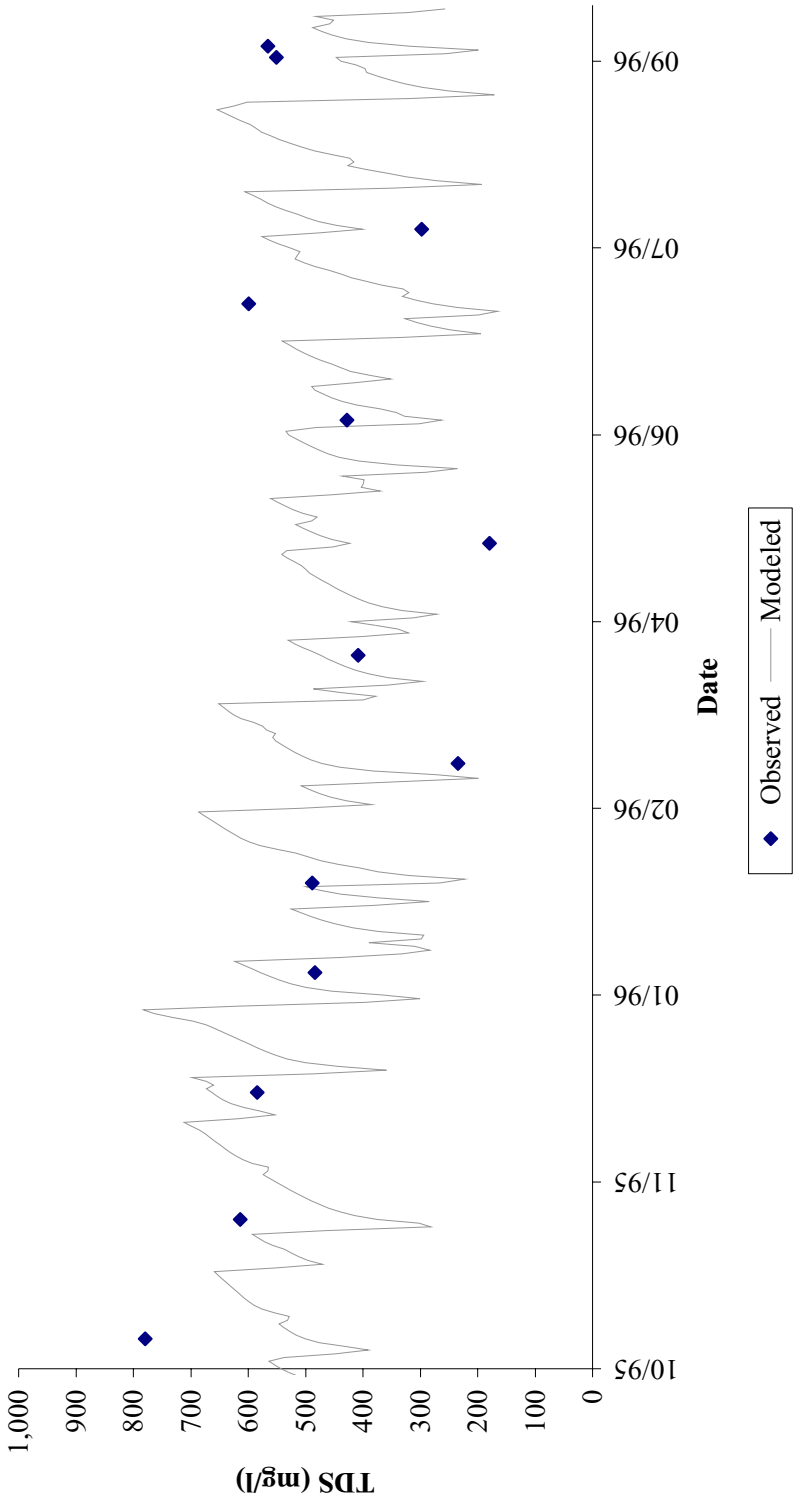

Figure 9.2 Mean daily modeled TDS concentrations compared to instantaneous observed TDS concentrations for subwatershed 7 in the Straight Creek impairment, during the calibration period.

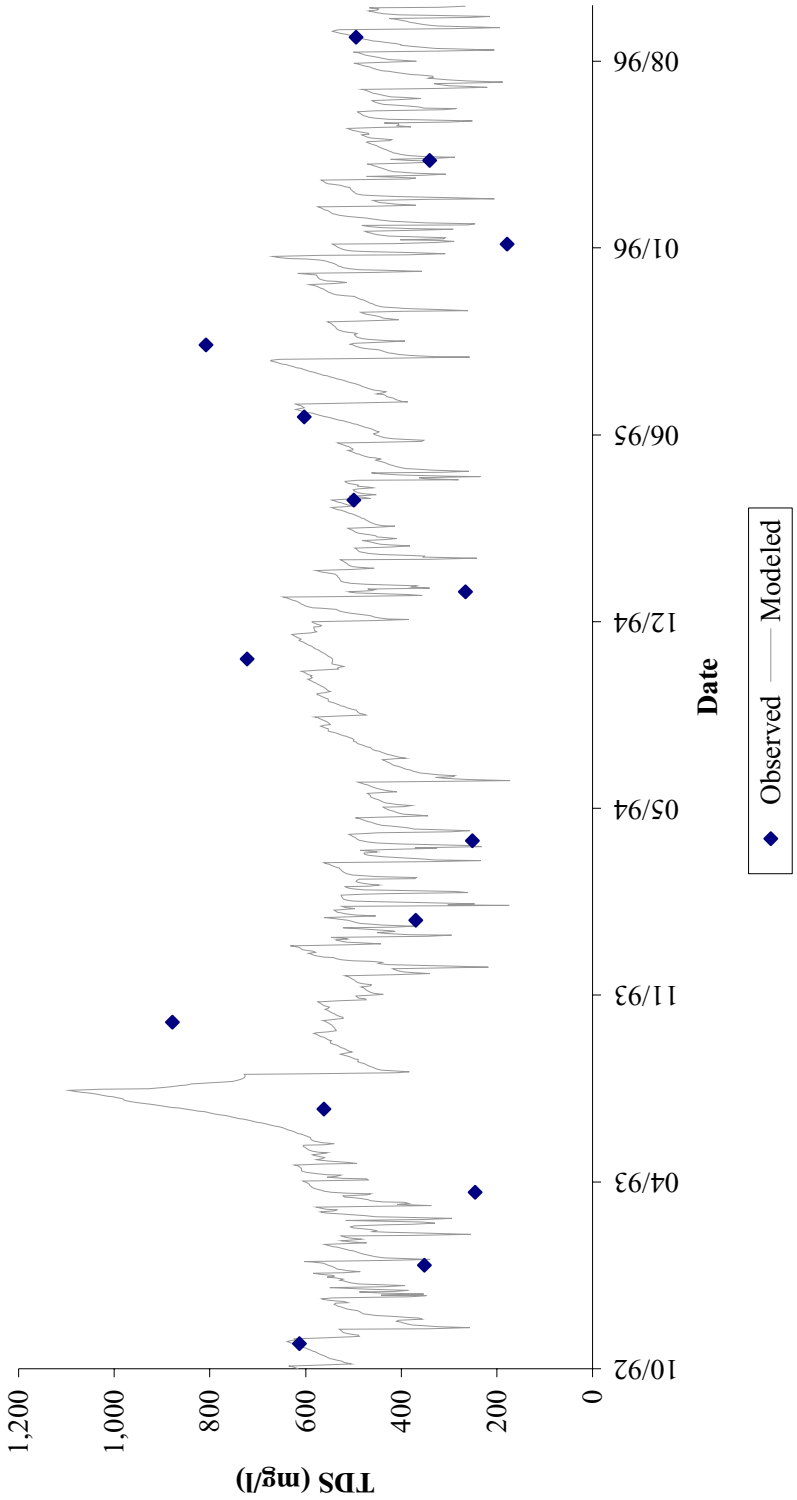

Figure 9.3 Mean daily modeled TDS concentrations compared to instantaneous observed TDS concentrations for subwatershed 8 in the Straight Creek impairment, during the calibration period.

9.7 Model Calibration of GWLF - Hydrology and Sediment

Although the GWLF model was originally developed for use in ungaged watersheds, calibration was performed to ensure that hydrology was being simulated accurately. This process was preferred in order to minimize errors in sediment simulations due to potential gross errors in hydrology. The model's parameters were assigned based on available soils, land use, and topographic data. Parameters that were adjusted during calibration included the recession constant, the evapotranspiration cover coefficients, the unsaturated soil moisture storage, and the seepage coefficient.

9.7.1 Middle Creek

The final hydrologic calibration results for Middle Creek are displayed in Figures 9.4 and 9.5 for the calibration period with statistics showing the accuracy of fit given in the Table 9.8. The reference watershed, Middle Creek, did not have an observed streamflow station located within the watershed boundary. Precipitation and temperature data were obtained from NCDC station 447174 in Richlands, VA. The model for Middle Creek was calibrated using the mean monthly flow simulated from the HSPF model for the period 10/1/1995 through 9/30/1999.

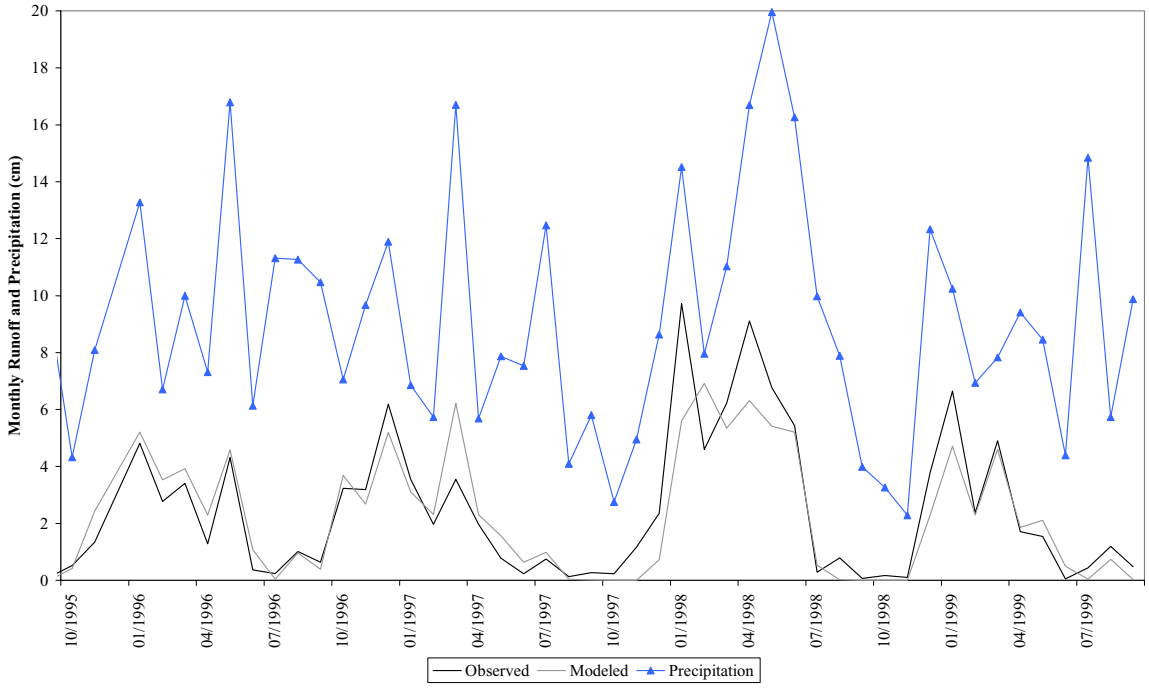

Figure 9.4 Comparison of monthly GWLF simulated (Modeled) and HSPF simulated (Observed) for the Middle Creek watershed.

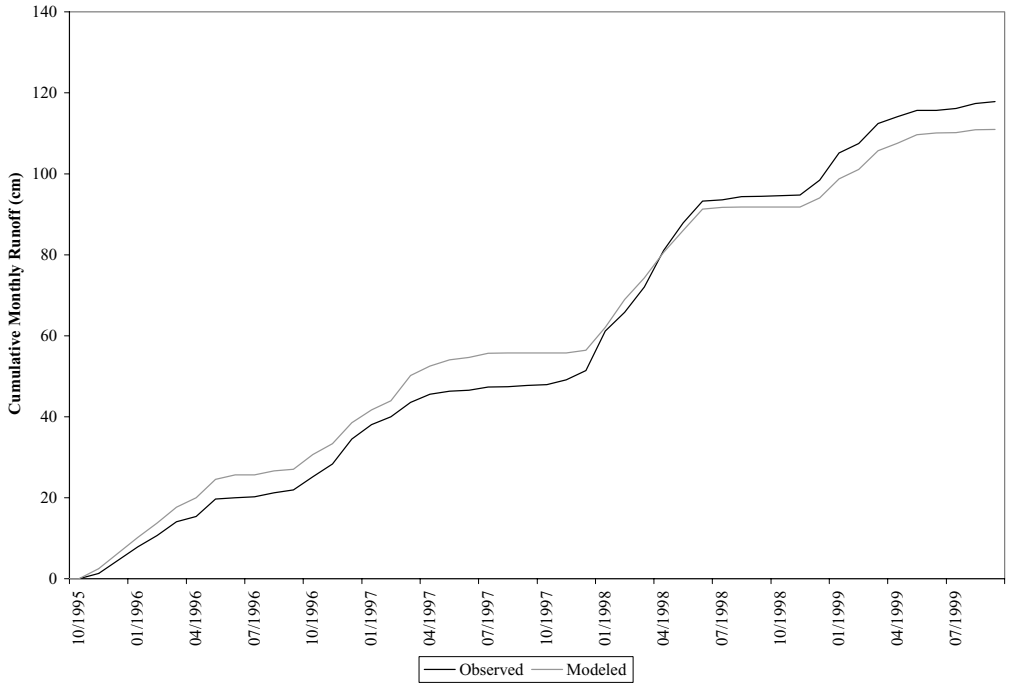

Figure 9.5 Comparison of cumulative monthly GWLF simulated (Modeled) and HSPF simulated (Observed) for the Middle Creek watershed.

9.7.2 Straight Creek

The model for Straight Creek was calibrated using simulated flow from the calibrated hydrology HSPF model for the period October 1, 1991 through March 31, 1995. Precipitation and temperature data were obtained from NCDC station 446626 with some adjustments from IFLOWs stations close to Straight Creek watershed. The final calibration results for Straight Creek are given in the Figures 9.6 and 9.7 with accuracy of fit statistics given in Table 9.7.

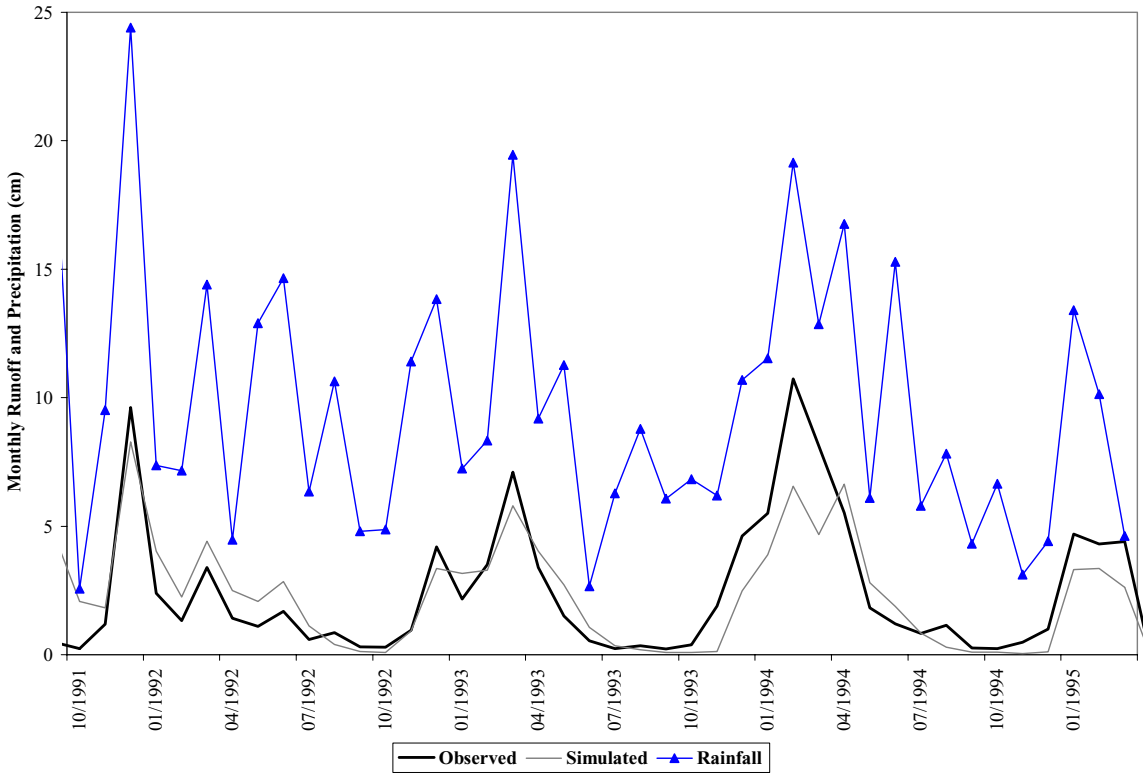

Figure 9.6 Comparison of monthly GWLF simulated (Modeled) and HSPF simulated (Observed) for the Straight Creek watershed.

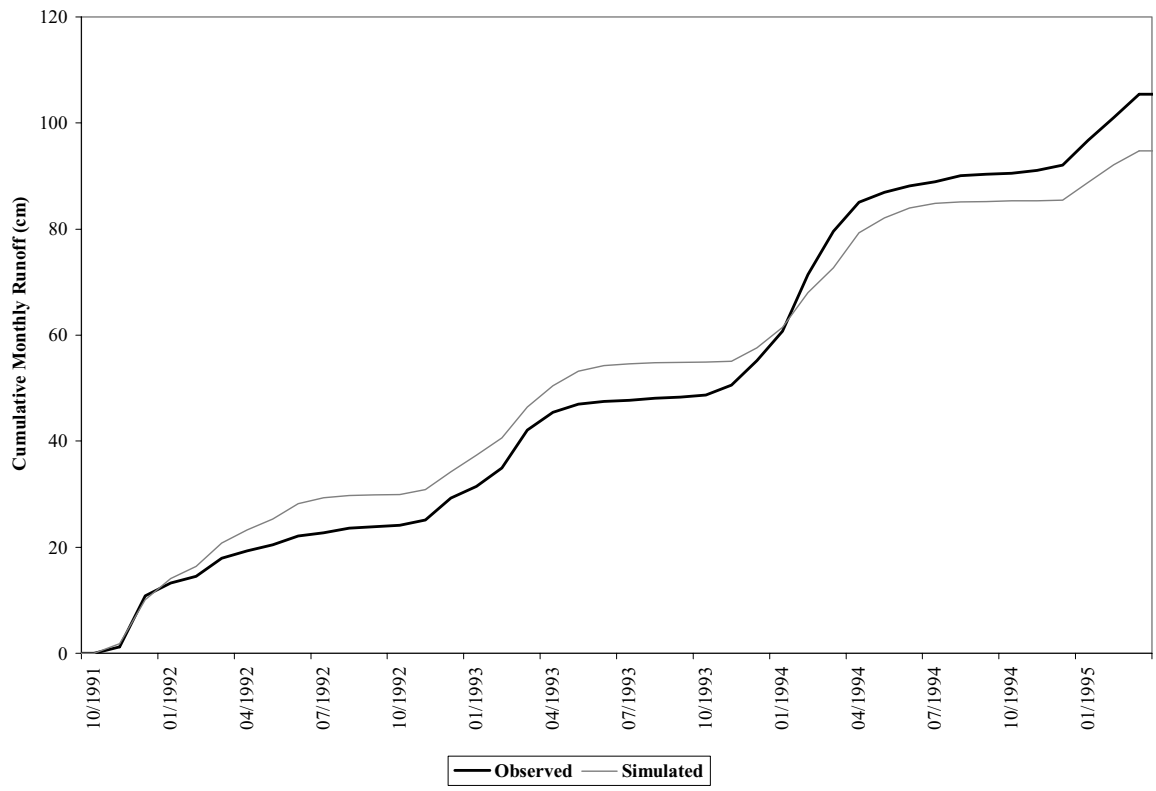

Figure 9.7 Comparison of cumulative monthly GWLF simulated (Modeled) and HSPF simulated (Observed) for the Straight Creek watershed.

9.7.3 GWLF Hydrology Calibration Statistics

Model calibrations were considered good to excellent for total runoff volume (Table 9.7). Monthly fluctuations were variable but were still reasonably good considering the general simplicity of GWLF. Results were also consistent with other applications of GWLF in Virginia (*e.g.,* Tetra Tech, 2001 and BSE, 2003).

Table 9.7 GWLF flow calibration statistics for Straight Creek and Middle Creek.

Watersheds	Simulation Period	R^2 Correlation value	Total Volume Error (Sim-Obs)
Straight Creek	10/1/1991 – 3/31/1995	0.880	-0101
Middle Creek	10/1/1995 – 9/30/1999	0.893	-0.058

9.8 Existing Conditions - GWLF

A listing of parameters from the GWLF transport input files that were finalized during hydrologic calibration for conditions existing at the time of impairment are given in Tables 9.8 through 9.10. Watershed parameters for Straight Creek, and reference watershed Middle Creek are given in Table 9.8. Monthly evaporation cover coefficients are listed in Table 9.9.

Table 9.8 GWLF watershed parameters for existing conditions in the impaired and reference watersheds.

GWLF Watershed Parameter	Units	Straight Creek	Middle Creek
Recession Coefficient	Day^{-1}	0.15	0.052
Seepage Coefficient	Day^{-1}	0.0291	0.062
Sediment Delivery Ratio	---	0.13	0.13
Unsaturated Water Capacity	(cm)	9.94	7.440
Erosivity Coefficient (Apr-Sep)	---	0.25	0.25
Erosivity Coefficient (Oct-Mar)	---	0.06	0.06
% Developed land	(%)	0.138	0.225
Livestock density	(AU/ac)	0.0001	0.0000
Area-weighted soil erodibility (K)	---	0.198	0.270
Area weighted runoff curve number	---	66.50	68.90
Total Stream Length	(m)	101,354	15,840
Mean channel depth	(m)	5.14	0.9

Table 9.9 Straight Creek and reference watershed Middle Creek GWLF monthly evaporation cover coefficients for existing conditions.

Watershed	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Straight Creek	0.32	0.79	0.89	0.897	0.897	0.89	0.79	0.42	0.42	0.42	0.32	0.32
Middle Creek	0.68	0.70	0.82	0.88	0.88	0.71	0.70	0.66	0.65	0.65	0.65	0.66

Table 9.10 lists the area-weighted USLE erosion parameter and runoff curve number by land use erosion source areas for Straight Creek and the reference watershed Middle Creek. The loads from permitted mine lands were modeled by multiplying the runoff volume by the maximum permitted TSS concentration.

Table 9.10 GWLF land use parameters for existing conditions in the impaired and reference watersheds.

Land use	Straight Creek		Middle Creek	
	CN	KLSCP	CN	KLSCP
Abandoned Mine Lands	76.86	0.52		
Commercial Impervious	98.00	-	98.00	-
Commercial Pervious	93.76	0.012	93.67	0.026
Cropland	70.63	2.62	80.80	3.19
Forest	61.44	0.013	65.05	0.014
Forest Disturbed	70.74	1.03	73.37	1.10
Pasture/Hay	70.84	0.067	70.63	0.036
Permitted Mining:				
Reclaimed Mine Area[1]	71.29	0.18		
Active Mine Area	85.72	4.42		
Reclaimed Mine Area-not permitted[1]			65.38	0.39
Residential Impervious	98.00	-	98.00	-
Residential Pervious	70.09	0.016	70.30	0.012
Water	100	-	100	-

[1]values from Barfield et al., 1983.

The area adjustments for the reference watershed compared to Straight Creek are listed in Table 9.11.

Table 9.11 Land use areas for the impaired, reference, and area-adjusted reference watersheds.

Sediment Source	Straight Creek (ha)	Reference Watershed Middle Creek (ha)	Reference Watershed Middle Creek Area-Adjusted (ha)
Abandoned Mine Lands	805.7	0.00	0.00
Commercial Impervious	5.88	6.50	16.05
Commercial Pervious	1.04	1.10	2.83
Cropland	4.23	13.40	33.04
Forest	5,838	2,623	6,487
Forest Disturbed	29.92	81.10	200.6
Pasture/Hay	17.82	23.70	58.52
Permitted Mining:			
Reclaimed Mine Area	304.2	0.00	
Active Mine Area	6.98	0.00	
Reclaimed Mine Area-not permitted	0.00	98.70	244.2
Residential Impervious	6.98	1.60	4.08
Residential Pervious	51.15	12.10	29.90
Water	79.38	29.80	73.71

[1] 1ha = 2.47 ac

The sediment loads existing at the time of impairment were modeled for Straight Creek and the reference watershed Middle Creek. The existing condition for the Straight Creek watershed is the combined sediment load, which compares to the target TMDL load under existing conditions for the area-adjusted reference watershed Middle Creek (Table 9.12). The target sediment TMDL load for Straight Creek is the average annual load in metric tons per year (Mg/yr) from the area-adjusted Middle Creek watershed under existing conditions minus the Margin of Safety (MOS) (Table 9.12).

Table 9.12 Existing sediment loads for the impaired and area-adjusted reference watersheds.

Sediment Source	Straight Creek		Reference Watershed Middle Creek Area-Adjusted	
	(Mg/yr)	(Mg/ha/yr)	(Mg/yr)	(Mg/ha/yr)
Abandoned Mine Lands	15,014	18.63	0.00	0.00
Commercial Impervious	1.33	0.23	3.51	0.22
Commercial Pervious	0.61	0.59	2.22	0.79
Cropland	375.2	88.60	2,245	67.95
Forest	2,207	0.38	669.1	0.10
Forest Disturbed	1,040	34.78	3,495	17.42
Pasture/Hay	40.59	2.28	25.53	0.44
Reclaimed Mine Area-not permitted	0.00	0.00	951.3	3.90
Residential Impervious	1.58	0.23	0.89	0.22
Residential Pervious	28.25	0.55	3.98	0.13
NPS loads	**18,709**	**146.3**	**7,396**	**91.17**
Permitted Mining:				
Reclaimed mine area	0.39	0.13	0.00	0.00
Active mine area	49.72		0.00	0.00
VAR102252	0.02	0.02		
Straight Pipes	30.55		0.00	0.00
PS loads	**80.68**	**0.15**	**0.00**	**0.00**
Channel Erosion	2.24		1.24	
Watershed Total Loads	**18,792**	**146.4**	**7,398**	**91.2**

10. ALLOCATION

Total Maximum Daily Loads consist of waste load allocations (WLAs, permitted point sources) and load allocations (LAs, nonpoint/non-permitted sources), including natural background levels. Additionally, the TMDL must include a margin of safety (MOS) that either implicitly or explicitly accounts for uncertainties in the process. The definition is typically denoted by the expression:

$$TMDL = WLAs + LAs + MOS$$

The TMDL becomes the amount of a pollutant that can be assimilated by the receiving water body and still achieve water quality standards. For TDS, the TMDL is expressed in terms of loads (kg/yr). For sediment, the TMDL is expressed in terms of annual load in metric tons per year (Mg/yr).

This section describes the development of TMDLs for TDS and sediment for Straight Creek using a reference watershed approach. The Straight Creek model was run for existing conditions over the period of 10/01/1992 to 9/30/1996 to model TDS and from April 1991 to March 1995 to model sediment losses.

The maximum TDS concentration of 334 mg/L measured in Middle Creek was used as the TMDL endpoint. The average annual sediment load from the Middle Creek reference watershed was used to define the TMDL loads for the Straight Creek watershed.

10.1 Incorporation of a Margin of Safety

In order to account for uncertainty in modeled output, an MOS was incorporated into the TMDL development process. Individual errors in model inputs, such as data used for developing model parameters or data used for calibration, may affect the load allocations in a positive or a negative way. For example, the typical method of assessing water quality through monitoring involves the collection and analysis of grab samples. The results of water quality analyses on grab samples collected from the stream may or may not reflect the “average” condition in the stream at the time of sampling. Calibration to observed data derived from grab samples introduces modeling uncertainty.

An MOS can be incorporated implicitly in the model through the use of conservative estimates of model parameters, or explicitly as an additional load reduction requirement.

10.2 TDS TMDL

10.2.1 Scenario Development

The allocation scenario was modeled using HSPF. Existing conditions were adjusted until the TMDL endpoint was attained. The TMDL developed for Straight Creek was based on the maximum TDS concentration (334 mg/L) sampled in Middle Creek since biological monitoring indicated that it is not impaired. An implicit MOS was used in the development of this TMDL. By adopting an implicit MOS in estimating the loads in the watershed, it is ensured that the recommended reductions will in fact succeed in meeting the water quality standard.

Pollutant concentrations were modeled over the entire duration of a representative modeling period, and pollutant loads were adjusted until the endpoint was met. The development of the allocation scenario was an iterative process that required numerous runs with each followed by an assessment of source reduction against the water quality target.

10.2.1.1 Wasteload Allocations

In the Straight Creek watershed there are currently no NPDES permitted point sources from deep mining operations.

The NPDES permits associated with surface mining in these watersheds were modeled as NPS loads since a runoff event is required to deliver pollutants to the stream from these sources. These sources are considered to be transient as they are temporary best management practices (*e.g.*, ponds) installed to control NPS pollution (mainly sediment) resulting from active surface mining operations. Upon completion of current mining operations, these ponds will likely be removed and additional ponds installed as new operations begin. As such, the wasteload allocation developed for Straight Creek includes a “transient” load, which represents the acceptable load from these sources.

10.2.1.2 Load Allocations

Load allocations to nonpoint sources are divided into land-based loadings from land uses and directly applied loads in the stream (*e.g.,* uncontrolled residential discharges). The TDS loads from straight pipes were modeled as a direct source, but they are not permitted so these loads are included in the LA. Source reductions include those that are affected by both high and low flow conditions. In-stream TDS concentrations are highest during low flow conditions, but TDS concentrations spike during extreme rainfall events (high flow due to runoff).

In the first allocation scenario, uncontrolled residential discharges (*i.e.*, straight pipes) were reduced 100%, but this scenario failed to reduce TDS to the target concentration. Additional scenarios were made by reducing the TDS load in surface runoff (WSQOP), interflow (IOQC), groundwater (AOQC), and direct permitted point sources until the modeled TDS concentration for the modeling period was less than or equal to the target TDS concentration.

10.2.2 TDS TMDL

Table 10.1 shows the final TMDL load for the impairment. Based on the need to meet the endpoint during low stream flow conditions, direct discharges to Straight Creek need to be at or below this endpoint (334 mg/L). The permitted discharges are listed under the lumped load for WLA allocation, which include all surface mine ponds. These permit numbers are the current permits in the watersheds (Table 10.1).

Table 10.1 Average annual TDS loads (kg/yr) modeled after TMDL allocation in the Straight Creek impairment.

Allocation	Description	TDS (kg/year)
Waste Load Allocation[1]		**1.80E+5**
Permit Number	MPID	
Transient Loads[2]		
1100486	*1080828, 1080829, 1080830, 1080832*	
1101320	*1070143, 1070144, 1070145, 1070146, 1070147*	
1201075	*1084495*	
1201079	*1084516*	
1200819	*1084208*	
1200863	*0002021, 0002022, 1070102*	
1201075	*1084494, 1084496*	
1201076	*1084498*	
1201078	*1084498*	
1201079	*1084513, 1084514, 1084515, 1084517*	
1201121	*1070008, 1070009*	
1201286	*1070105, 1070106*	
1201287	*1070109, 1070110, 1070113*	
	0001380, 1070188, 1070189, 1070190, 1070191, 1070192, 1070193, 1070194, 1070195, 1070196, 1070197, 1070198, 1070199, 1070203, 1070204,	
1201390	*1070205, 1070207, 1070208*	
1201395	*1070234, 1070235, 1070239*	
1201676	*0003097, 0003098*	
1201810	*0004836, 0004837*	
1300627	*1085114, 1085116*	
1300959	*1085330, 1085331*	
	1070254, 1070255, 1070256, 1070257, 1070258,	
1301411	*1070259, 1070260, 1070261*	
	0000059, 0001008, 0001630, 1070262, 1085587, 1085588, 1085590, 1085591, 1085593, 1085594, 1085595, 1085596, 1085597, 1085598, 1085602,	
1400357	*1085603*	
1501391	*1070215, 1070216, 1070217*	
	Proposed Permit #1 Spring, 2005	
	Proposed Permit #2 Spring, 2005	
Load Allocation		**8.52E+6**
TMDL		**8.70E+6**

[1] TDS from WLA is presented as a combined load from all permitted sources.
[2] The waste load from runoff-controlling BMPs (*i.e.,* ponds) that are likely to be removed upon completion of current mining operations.

Table 10.2 indicates the land-based and direct load reductions resulting from the final allocation. The land-based load includes TDS from surface mine ponds and in runoff from all land uses. The direct load includes TDS from deep mine discharges and straight pipes.

Table 10.2 Land-based and direct nonpoint source load reductions in the Straight Creek impairment for final allocation.

Source	Total Annual Loading for Existing Run (kg/yr)	Total Annual Loading for Allocation Run (kg/yr)	Percent Reduction
Land Based	1.68E+7	8.70E+6	48
Direct[1]	1.87E+4	0.00E+0	100

[1] The only direct discharges to Straight Creek are straight pipes during the allocation time period.

Figure 10.1 shows the existing and allocated conditions at the outlet of Straight Creek.

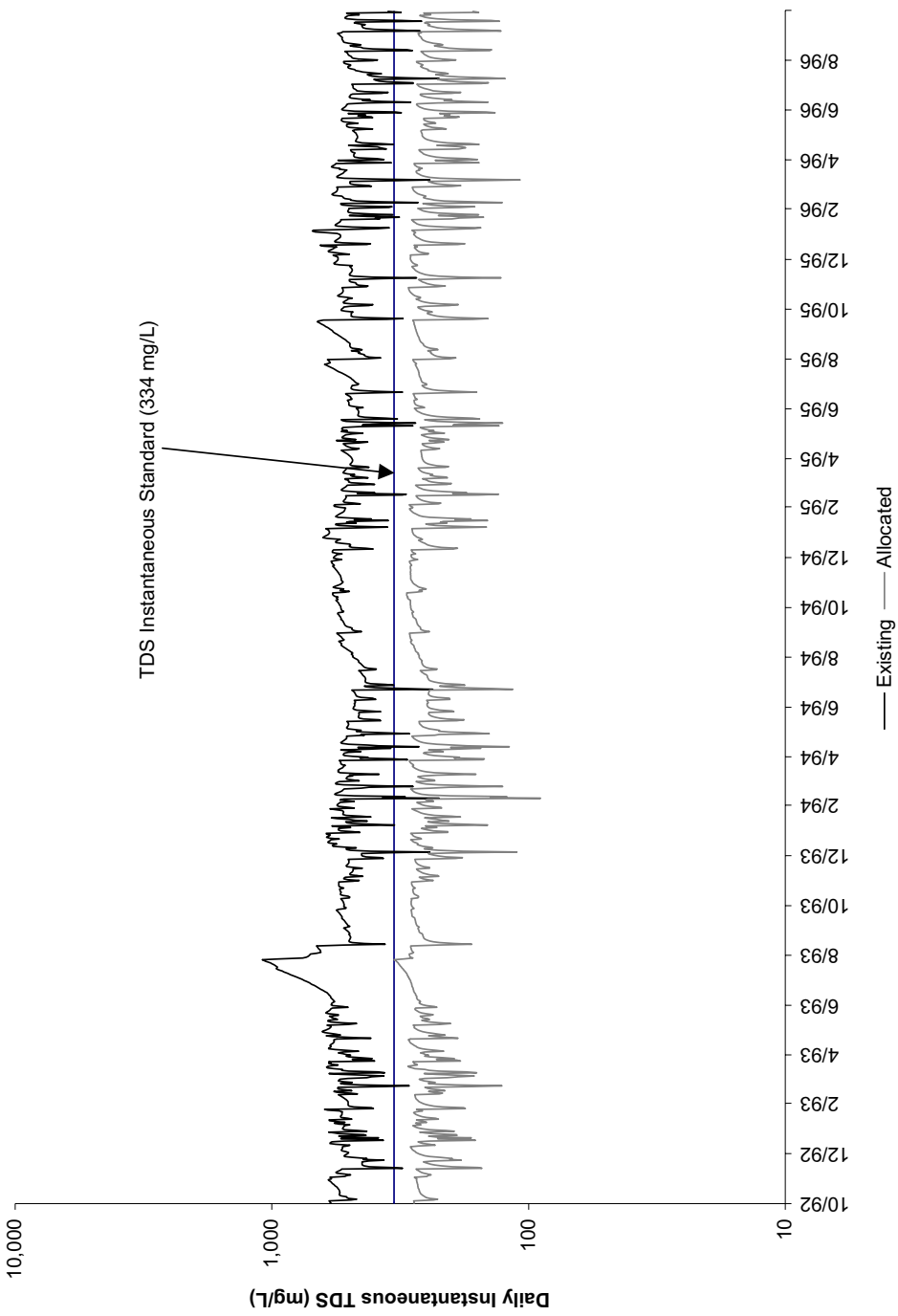

Figure 10.1 TDS concentrations for the Straight Creek impairment under existing and allocated conditions at the outlet.

10.3 Sediment TMDL

Allowable sediment loads for Straight Creek were developed with the Middle Creek watershed as the reference watershed. The area of the Middle Creek watershed was increased by the ratio of the impaired watershed area to the reference watershed area. Land use areas for the Middle Creek watershed were increased while maintaining the original land use distribution.

To aid in the development of TMDL allocation scenarios, nonpoint source areas were grouped into agriculture, forest, urban, and current and previously mined land, categories. Sub-categories for agriculture, urban, and forest were also included to provide better definition of allocation within the broader groupings (Table 10.3).

Table 10.3 Comparison of categorized sediment loads for the impaired and reference watersheds.

Sediment Source	Straight Creek (Mg/yr)	Reference Watershed Middle Creek Area-Adjusted (Mg/yr)
Agriculture		
Cropland	375.2	2,245
Pasture/Hay	40.59	25.53
Forest		
Forest	2,207	669.1
Forest Disturbed	1,040	3,495
Urban		
Commercial Impervious	1.33	3.51
Commercial Pervious	0.61	2.22
Residential Impervious	1.58	0.89
Residential Pervious	28.25	3.98
Current and Previously Mined Land		
Abandoned Mine Lands	15,014	0
Reclaimed Mine Area-not permitted	0	951.3
Permitted Mining:		
Reclaimed Mine Area	0.39	0
Active Mine Area	49.72	0

The target TMDL load for Straight Creek is the average annual load from the area-adjusted Middle Creek watershed under existing conditions (Table 10.4). The sediment

TMDL for Straight Creek includes three components – WLA, LA, and a MOS. The WLA was calculated as the sum of all permitted point source discharges. The MOS was explicitly set to 10% to account for uncertainty in developing TMDLs. The LA was calculated as the target TMDL load minus the WLA load minus the MOS.

Table 10.4 TMDL Targets for the impaired watershed.

Impairment	WLA (Mg/yr)	LA (Mg/yr)	MOS	TMDL (Mg/yr)
Straight Creek	50.1	6,607.8	739.8	7,397.7

Review of the Lee County Comprehensive Plan (Lee County Planning Commission, 2003) indicated that land use is not expected to change significantly over the next 25 years. The Straight Creek watershed is highly rural and it is assumed that residential and commercial growth in the watershed will not have an impact on future sediment loads. However, increased mining operations could have an impact if sediment control ponds exceed the permitted 70mg/L.

The reductions required to meet the TMDLs were based on the conditions existing at the time of impairment (Table 10.5). The final overall sediment load reduction required for Straight Creek is 64.58%.

Table 10.5 Required reductions from the impaired watershed.

Load Summary	Straight Creek (Mg/yr)	Reductions Required (Mg/yr)	(% of existing load)
Sediment Loads	18,792	12,136	64.58
Straight Final TMDL Load	6,656		
Target Modeling Load	6,658		

The sediment allocation scenario for Straight Creek is presented in Table 10.6 broken down into nonpoint sources and point sources. The scenario requires sediment reductions of 65% from disturbed forest, 79% from AML, as well as 100% reduction from straight pipes (uncontrolled residential discharges).

Table 10.6 Final TMDL allocation scenario for the impaired watershed.

Sediment Source	Straight Existing Loads (Mg/yr)	Reduction (%)	Straight Allocated Loads (Mg/yr)
Abandoned Mine Lands	15,014	79.0	3153
Commercial Impervious	1.33	0	1.33
Commercial Pervious	0.61	0	0.61
Cropland	2,207	0	2207
Forest	1,040	0	1040
Forest Disturbed	375.2	65.0	131
Pasture/Hay	40.59	0	40.59
Residential Impervious	1.58	0	1.58
Residential Pervious	28.25	0	28.25
NPS loads	**18,709**	**64.70**	**6,604**
Permitted Mining:			
Reclaimed mine area	0.39	0	0.39
Active mine area	49.72	0	49.72
VAR102252	0.02	0	0.02
Straight Pipes	30.55	100	0.00
PS loads	**80.68**	**37.86**	**50.14**
Channel Erosion	2.24	0	2.24
Watershed Total Loads	**18,792**	**64.58**	**6,656**

PART IV: IMPLEMENTATION AND PUBLIC PARTICIPATION

11. 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 bacteria and benthic impairments in the Straight Creek Watershed. The second step is to develop a TMDL Implementation Plan (IP). The final step is to implement the TMDL IP, and to monitor stream water quality to determine if water quality standards are being attained.

Once a TMDL has been approved by the EPA and the State Water Control Board (SWCB), measures must be taken to reduce pollution 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 IP. The process for developing an implementation plan has been described in the *Guidance Manual for Total Maximum Daily Load Implementation Plans,* published in July 2003 and available upon request from the VADEQ and VADCR TMDL project staff or at http://www.deq.state.va.us/tmdl/implans/ipguide.pdf. With successful completion of implementation plans, Virginia will be well on the way to 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.

VADCR and VADEQ 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. Since this TMDL consists of NPS load allocations originating from mining activities, DMME will share responsibilities with VADCR during implementation.

11.1 Staged Implementation

Implementation of BMPs in the watershed 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. For example, in agricultural areas, the most promising management practice to control bacteria and minimize streambank erosion is livestock exclusion from streams. This has been shown to be very effective in lowering bacteria concentrations in streams, both by reducing the cattle deposits themselves and by providing additional riparian buffers. Reduced trampling and soil shear on streambanks by livestock hooves has been shown to reduce bank erosion.

Additionally, in both urban and rural areas, reducing the human bacteria loading from uncontrolled discharges (straight pipes) and failing septic systems should be a primary implementation focus because of its health implications. This component could be implemented through education on proper sewage disposal systems, septic tank pump-outs as well as a septic system repair/replacement program and the use of alternative waste treatment systems.

In urban areas, reducing the human bacteria loading from leaking sewer lines could be accomplished through a sanitary sewer inspection and management program. Other BMPs that might be appropriate for controlling urban wash-off from parking lots and roads and that could be readily implemented may include more restrictive ordinances to reduce fecal loads from pets, improved garbage collection and control, and improved street cleaning.

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. While specific goals for BMP implementation will be established as part of the implementation plan development, the following Stage I scenarios are targeted at controllable, anthropogenic bacteria sources.

11.1.1 Staged Implementation – Bacteria

The goal of the Stage I scenarios is to reduce the bacteria loadings from controllable sources, excluding wildlife. The Stage I scenarios were generated with the same model setup as was used for the TMDL allocation scenarios.

The Stage I water quality goal was to reduce the number of violations of the instantaneous standard in Straight Creek to approximately 10%. Table 11.1 contains sets of reductions in land-based and direct loads that are projected to achieve this goal, along with a projected percent of violation occurrence. The Stage I allocation for Straight Creek requires a 100% reduction in loads from uncontrolled residential discharges (straight pipes), and no reductions in direct in-stream loads from livestock, land-based loads from urban and agricultural sources, and wildlife loads (Table 11.1, scenario 2).

Table 11.1 Reduction percentages for the Stage I implementation in Straight Creek.

Scenario Number	Percent Reduction in Loading from Existing Condition						Percent Violations	
	Direct Wildlife	NPS Wildlife	Direct Livestock	NPS Pasture/ Livestock	NPS Residential/ Urban	Straight Pipes	GM >126 cfu/ 100mL	Single Sample >235 cfu/ 100mL
1	0	0	0	0	0	0	100.0	84.29
2[1]	0	0	0	0	0	100	0.0	2.19
3	0	0	90	50	50	100	0.0	1.44
4	0	0	100	100	100	100	0.0	0.82
5	10	0	100	99	99	100	0.0	0.82
6	0	10	100	99	99	100	0.0	0.55
7	0	32	100	99	99	100	0.0	0.0
8[2]	0	32	0	80	99	100	0.0	0.0

[1]Stage I implementation scenario.
[2]Final TMDL allocation.

Table 11.2 details the load reductions required for meeting the Stage I Implementation for Straight Creek.

Table 11.2 Source loads at the Straight Creek impairment outlet for Stage I implementation.

Source	Total Annual *E. coli* Loading for Existing Run (cfu/yr)	Total Annual *E. coli* Loading for Allocation Run (cfu/yr)	Percent Reduction
Land Based			
Abandoned Mine Land	3.11E+13	3.11E+13	0
Active Mining	6.07E+12	6.07E+12	0
Barren	5.64E+10	5.64E+10	0
Commercial	8.69E+11	8.69E+11	0
Cropland	2.32E+11	2.32E+11	0
Forest	2.24E+14	2.24E+14	0
Livestock Access	3.33E+11	3.33E+11	0
Pasture	7.57E+12	7.57E+12	0
Reclaimed	4.38E+13	4.38E+13	0
Residential	6.60E+13	6.60E+13	0
Roads	4.66E+12	4.66E+12	0
Water	0.00E+00	0.00E+00	0
Wetland	2.46E+11	2.46E+11	0
Direct			
Livestock	3.55E+10	3.55E+10	0
Wildlife	5.70E+12	5.70E+12	0
Straight Pipes	4.96E+14	0.00E+00	100

11.1.2 Staged Implementation – TDS and Sediment

It is anticipated that AML reclamation and streambank stabilization will be the initial targets of implementation. One way to accelerate reclamation of AML is through remining. As noted on the DMME website (DMME, 2004):

> *"DMME, The Nature Conservancy, Virginia Tech/Powell River Project, and the U. S. Office of Surface Mining combined resources to develop proposals for incentives that will promote economically viable, environmentally beneficial remining operations that reclaim AML sites. Initial meetings led to the development of a Remining Ad Hoc Work Group that includes representatives from industry, other governmental agencies, special interest groups, and citizens of Southwest Virginia. The Ad Hoc Group has identified existing incentives and continues to propose new ones".*

One of the most important existing incentives is the alternative effluent limitations assigned to remining operations with pre-existing pollutant discharges. These regulations (known as the Rahall Amendment) were the result of a 1987 revision to the Federal Clean Water Act (CWA). Alternate effluent discharge limits are allowed in coal mining areas with pre-existing effluent problems. Operators document effluent conditions prior to remining. Upon completion of the remining operation and prior to reclamation bond and permit release, the operator would need to demonstrate that the pollution load from the site is equal to or less than pre-mining pollution load. Because the remining revisions were promulgated after the original TMDL provisions of the CWA, pollution load allocations and implementation plans should be designed to preserve the incentives implicit in the Rahall Amendment. Potential remining site include all abandoned mine land (AML).

Streambank stabilization in conjunction with riparian buffers will be useful in addressing both the TDS and sediment issues. Streambank stabilization will allow the development of a riparian zone, and will also reduce sediment delivery from the eroding streambank. TDS is associated with sediment delivery to the stream and the resulting increase in sediment/water contact. Decreasing streambank erosion problems should consequently have a beneficial impact on TDS as well as sediment levels. Riparian buffers slow surface water movement, allowing sediment to settle out before reaching the stream. In addition, to the degree that surface runoff is allowed to infiltrate as a result of being

detained in the riparian zone, fine particulate matter will be captured in the soil matrix before entering the stream.

Through the remining process in Straight Creek, combined with streambank stabilization and development of riparian buffers, there exists reasonable assurance that the pollution load reductions proposed in the TMDL can be achieved. Some of the best supporting data on pollution load reductions resulting from successful remining operations are included with the EPA's remining document.

In 1998, the Pennsylvania Department of Environmental Protection (PADEP) developed a remining database to determine the success of Pennsylvania's remining program. The database specifically quantifies the extent to which bituminous coal remining sites have reduced pollution loads from the pre-existing conditions. Evaluations of the data were made by comparing pre-mining and post-mining loads at individual discharges for several parameters. The results are included in a report, broken down by stressor or pollutant. The database includes water quality information from more than 200 remining sites. BMPs used at the remining sites were common to surface mining activities throughout the Appalachian region and included daylighting deep mines, regrading, revegetation, and alkaline soil addition. The BMPs did not include chemical treatment, constructed wetlands, or long term treatment mechanisms. The PADEP results document that load reductions on the order of 60 to 70% were measured for pollutants of interest. When the observed pollution reductions associated with the remining process are compared to the modeled load reductions needed to improve Straight Creek, the recommended reductions for the stream appear attainable.

Waste load allocations and pollution load reductions necessary for active mining operations to meet Total Maximum Daily Loads (TMDLs) in watersheds where benthic stressors have been identified as suspended and dissolved solids, may be achieved with sediment control measures and best management practices (BMPs) instead of altered effluent limitations on permitted point source discharges.

Virginia's Coal Surface Mining Reclamation Regulations (CSMRR) require active mining operations to use sediment control measures and BMPs to prevent additional

contributions of solids to stream flow and to minimize erosion to the extent possible. 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.

In addition to the use of sediment control measures and BMPs within the disturbed mine 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 considerate of the TMDL. This may include, but not limited to:

1) Using non-toxic-forming substances in road surfacing;
2) Paving haulroads;
3) Increasing the size of haulroad sumps.

Reduction in the sedimentation and mineralization of runoff attendant to mined land erosion and strata exposure may 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 pollution load reductions included in a TMDL for stream segments and watersheds where benthic stressors have been identified as suspended and dissolved solids. This approach will be

implemented in Virginia in lieu of altered effluent limitations for permitted coal mine point source discharges.

11.2 Link to Ongoing Restoration Efforts

Implementation of this TMDL will be integrated into on-going water quality improvement efforts aimed at restoring water quality in Straight Creek and the Powell River basin. Several BMPs known to be effective in controlling bacteria have also been identified for implementation as part of this effort. For example, management of on-site waste management systems, management of livestock and manure, and pet waste management are among the components of a nonpoint source implementation strategy.

11.3 Reasonable Assurance for Implementation

11.3.1 Follow-up Monitoring - Bacteria

VADEQ will continue monitoring the Straight Creek watershed in accordance with its ambient watershed monitoring program to evaluate reductions in fecal bacteria counts and the effectiveness of TMDL implementation in attainment of water quality standards.

Monitoring station(s) on Straight Creek will continue to be monitored. Watershed monitoring stations are designed to provide complete, census-based coverage of every watershed in Virginia. Two of the major data users in the Commonwealth (VADEQ and VADCR) have indicated that this is an important function for ambient water quality monitoring.

Watershed stations are located at the mouth and within the watershed, based on a census siting scheme. The number of stations in the watershed is determined by the NPS priority ranking, thus focusing our resources on known problem areas. Watersheds are monitored on a rotating basis such that, in the 6-year assessment cycle, all 493 watersheds are monitored. These stations will be sampled at a frequency of once every other month for a two-year period on a 6-year rotating basin basis.

11.3.2 Follow-up Monitoring – Benthic

VADEQ will continue to monitor biological monitoring stations 6BSRA000.11, 6BSRA000.40, 6BSRA002.48, 6BSRA003.62 in Straight Creek as implementation of corrective actions in the watershed occurs so that the Stage I implementation goals are achieved. Monitoring after corrective actions occur allows the most effective use of monitoring resources in the regional office. VADEQ will use data from these monitoring stations to evaluate improvements in the benthic community and the effectiveness of TMDL implementation in attainment of the General Standard.

11.3.3 Regulatory Framework

While Section 303(d) of the Clean Water Act and current EPA 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. 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. The EPA outlines the minimum elements of an approvable implementation plan in its 1999 *Guidance for Water Quality-Based Decisions: The TMDL Process*. The listed elements include implementation actions/management measures, timelines, legal or regulatory controls, time required to attain water quality standards, monitoring plans, and milestones for attaining water quality standards.

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

Once developed, VADEQ will take TMDL implementation plans to the SWCB for approval as the plan for implementing the pollutant allocations and reductions contained in the TMDLs. Also, VADEQ will request SWCB authorization to incorporate the

TMDL implementation plan into the appropriate Water Quality Management Plan (WQMP) in accordance with the CWA's Section 303(e). In response to a Memorandum of Understanding (MOU) between the EPA and VADEQ, VADEQ also submitted a draft Continuous Planning Process to the EPA in which VADEQ 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.

11.3.4 Stormwater Permits

It is the intention of the Commonwealth that the TMDL will be implemented using existing regulations and programs. One of these regulations is the VPDES Permit Regulation (9 VAC 25-31-10 et seq.). Section 9 VAC 25-31-120 describes the requirements for stormwater discharges. Also, federal regulations state in 40 CFR §122.44(k) that National Pollutant Discharge Elimination System (NPDES) permit conditions may consist of *"Best management practices to control or abate the discharge of pollutants when:… (2) Numeric effluent limitations are infeasible…"*.

There are currently no MS4 permits in the Straight Creek watershed.

11.3.5 Implementation Funding Sources

Funding sources for implementations will be identified by VADCR and DMME and the stakeholders. According to DMME's website, "Over 71,000 acres of land in Virginia have been affected by coal mining. It is estimated that it would take approximately 55 years at the present rate of funding and reclamation construction to reclaim just the high priority Abandoned Mine Land (AML) sites" (DMME, 2005). In addition, it would cost more than $300 million to reclaim the AML sites causing environmental degradation. One potential source of funding for TMDL implementation is Section 319 of the Clean Water Act. In response to the federal Clean Water Action Plan, Virginia developed a Unified Watershed Assessment that identifies watershed priorities. Watershed restoration activities, such as TMDL implementation, within these priority watersheds are eligible for Section 319 funding. Increases in Section 319 funding in future years will be targeted towards TMDL implementation and watershed restoration. Additional funding sources may be available through the U. S. Office of Surface Mining.

11.3.6 Addressing Wildlife Contributions

In some streams for which TMDLs have been developed, water quality modeling indicates that, even after removal of all bacteria sources other than wildlife, the stream will not attain standards under all flow regimes at all times. As is the case for Straight Creek, this stream may not be able to attain standards without some reduction in wildlife load. **Virginia and the EPA are not proposing the elimination of wildlife to allow for the attainment of water quality standards.**

Although previous TMDLs for the Commonwealth have not addressed wildlife reductions in first stage goals, some localities have already introduced wildlife management practices. While managing overpopulations of wildlife remains as an option to local stakeholders, the reduction of wildlife or changing a natural background condition is not the intended goal of a TMDL.

To address this issue, Virginia proposed (during its recent triennial water quality standards review) a new "secondary contact" category for protecting the recreational use in state waters. On March 25, 2003, the SWCB adopted criteria for "secondary contact recreation" which means "a water-based form of recreation, the practice of which has a low probability for total body immersion or ingestion of waters (examples include but are not limited to wading, boating and fishing)". These new criteria were approved by the EPA and became effective in February 2004. Additional information can be found at http://www.deq.state.va.us/wqs/rule.html.

In order for the new criteria to apply to a specific stream segment, the primary contact recreational use must be removed. To remove a designated use, the state must demonstrate: 1) that the use is not an existing use, 2) that downstream uses are protected, and 3) that the source of bacterial contamination is natural and uncontrollable by effluent limitations and by implementing cost-effective and reasonable best management practices for nonpoint source control (9 VAC 25-260-10). This, and other, information is collected through a special study called a Use Attainability Analysis (UAA). All site-specific criteria or designated use changes must be adopted as amendments to the water quality

standards regulations. Watershed stakeholders and the EPA will be able to provide comment during this process.

Based on the above, the EPA and Virginia have developed a process to address the wildlife issue. First in this process is the development of a Stage I scenario such as those presented previously in this chapter. The pollutant reductions in the Stage I scenario are targeted only at the controllable, anthropogenic bacteria sources identified in the TMDL, setting aside control strategies for wildlife except for cases of overpopulations. During the implementation of the Stage I scenario, all controllable sources would be reduced to the maximum extent practicable using the iterative approach described in section 11.1 above. VADEQ will reassess water quality in the stream during and subsequent to the implementation of the Stage I scenario to determine if the water quality standard is attained. This effort will also evaluate if the modeling assumptions were correct. If water quality standards are not being met, a UAA may be initiated to reflect the presence of naturally high bacteria levels due to uncontrollable sources. In some cases, the effort may never have to go to the UAA phase because the water quality standard exceedances attributed to wildlife in the model may have been very small and infrequent and within the margin of error.

12. PUBLIC PARTICIPATION

The development of the Powell River TMDL greatly benefited from public involvement. Table 12.1 details the public participation throughout the project. The government kickoff meeting for Straight Creek took place on June 23, 2004 at the Municipal Building in Pennington Gap, Virginia with 18 people in attendance. The agencies represented at the meeting included VADCR, VADEQ, VDOF, DMME, TVA, and MapTech. The kickoff meeting was publicized through direct mailing to local agencies, government, and private companies.

The first public meeting for Straight Creek was held on August 11, 2004 at the Municipal Building in Pennington Gap, Virginia. Twenty-seven people (7 citizens, 8 agency, 3 local officials, 3 mining/coal industry representatives, 5 consultants, 1 news reporter) attended. To publicize the meeting, over 150 invitations and notices were sent out, newspapers and television stations were contacted, and agencies and localities were notified via email. In addition, DMME emailed their contact list of industries and agencies.

Table 12.1 Public participation during TMDL development for the Straight Creek watershed.

Date	Location	Attendance[1]	Type	Format
6/23/04	Municipal Building Pennington Gap, VA	18	Kickoff Meeting	Publicized to government agencies
8/11/04	Municipal Building Pennington Gap, VA	27	1st public	Open to public at large
2/10/2005	St. Charles Elementary School St. Charles, VA	97	Final public	Open to public at large

[1]The number of attendants is estimated from sign up sheets provided at each meeting. These numbers are known to underestimate the actual attendance.

The draft TMDL document was available on the VADEQ website on February 8, 2005 for public review. The final public meeting was publicized by placing a notice in the Virginia Register February 7, 2005 issue. Notice of the meeting also ran in the legal section of the Kingsport Times on January 30, 2005. There were 255 notices of the meeting mailed to watershed landowners, agencies, Lee County locality staff, and other

individuals that attended a previous meeting. Additional individuals were notified by email. Signs were placed on the road along Straight Creek and Stone Creek.

A total of 97 people attended the meeting. Agencies represented were MapTech, VADEQ, DMME, VADCR, TVA, DBSWCD, the Lee County Board, the Lee County Administrator, 2 news reporters (Powell Valley News and Kingsport Times), and the Lee County Litter Control officer. Sixteen attending lived in St. Charles. Over half of the audience worked for either Powell Mountain Coal or Lone Mountain Coal.

The 30-day public comment period was extended to April 13, 2005 in response to stakeholder requests for more time to review the TMDL and more information about the water quality model. Additionally, conference calls between DMME, VADEQ, MapTech, and coal industry representatives resulted in further opportunities for clarification and comment on technical issues beyond that provided at the public meetings. Comments were reviewed and replied to by DMME, VADEQ, and MapTech. The comments resulted in revisions to the Fecal Bacteria and General Standard TMDLs for Callahan Creek and Straight Creek of the Powell River Basin draft document. The revised TMDL document for Straight Creek was posted on the VADEQ website on July 11, 2005.

There was a 30-day public comment period between July 11, 2005 and August 11, 2005 for public comments on the changes made to the Straight Creek TMDL report. Comments were reviewed and replied to by DMME, VADEQ, and MapTech.

Public participation during the implementation plan (IP) development process will include the formation of stakeholders' committee and open public meetings. The stakeholders' committee will have the expressed purpose of formulating the TMDL IP. The committee may consist of, but not be limited to, representatives from the VADEQ, VADCR, VDH, local agricultural community, local urban community, coal company representatives, and local governments. This committee will have responsibility for identifying corrective actions that are founded in practicality, establish a time line to insure expeditious implementation, and set measurable goals and milestones for attaining water quality standards.

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GLOSSARY

Note: All entries in italics are taken from USEPA (1998).

303(d). A section of the Clean Water Act of 1972 requiring states to identify and list water bodies that do not meet the states' water quality standards.

Allocations. *That portion of a receiving water's loading capacity attributed to one of its existing or future pollution sources (nonpoint or point) or to natural background sources. (A wasteload allocation [WLA] is that portion of the loading capacity allocated to an existing or future point source, and a load allocation [LA] is that portion allocated to an existing or future nonpoint source or to natural background levels. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading.)*

Ambient water quality. *Natural concentration of water quality constituents prior to mixing of either point or nonpoint source load of contaminants. Reference ambient concentration is used to indicate the concentration of a chemical that will not cause adverse impact on human health.*

Anthropogenic. *Pertains to the [environmental] influence of human activities.*

Antidegradation Policies*. Policies that are part of each states water quality standards. These policies are designed to protect water quality and provide a method of assessing activities that might affect the integrity of waterbodies.*

Aquatic ecosystem. *Complex of biotic and abiotic components of natural waters. The aquatic ecosystem is an ecological unit that includes the physical characteristics (such as flow or velocity and depth), the biological community of the water column and benthos, and the chemical characteristics such as dissolved solids, dissolved oxygen, and nutrients. Both living and nonliving components of the aquatic ecosystem interact and influence the properties and status of each component.*

Assimilative capacity*. The amount of contaminant load that can be discharged to a specific waterbody without exceeding water quality standards or criteria. Assimilative capacity is used to define the ability of a waterbody to naturally absorb and use a discharged substance without impairing water quality or harming aquatic life.*

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

Bacteria. *Single-celled microorganisms. Bacteria of the coliform group are considered the primary indicators of fecal contamination and are often used to assess water quality.*

Bacterial decomposition. *Breakdown by oxidation, or decay, of organic matter by heterotrophic bacteria. Bacteria use the organic carbon in organic matter as the energy source for cell synthesis.*

Bacterial source tracking (BST). A collection of scientific methods used to track sources of fecal contamination.

Benthic. *Refers to material, especially sediment, at the bottom of an aquatic ecosystem. It can be used to describe the organisms that live on, or in, the bottom of a waterbody.*

Benthic organisms. *Organisms living in, or on, bottom substrates in aquatic ecosystems.*

Best management practices (BMPs). *Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain, generally nonpoint source, pollution control needs. BMPs include structural and nonstructural controls and operation and maintenance procedures.*

Bioassessment. Evaluation of the condition of an ecosystem that uses biological surveys and other direct measurements of the resident biota. **(2)**

Biochemical Oxygen Demand (BOD). Represents the amount of oxygen consumed by bacteria as they break down organic matter in the water.

Biological Integrity. A water body's ability to support and maintain a balanced, integrated adaptive assemblage of organisms with species composition, diversity, and functional organization comparable to that of similar natural, or non-impacted habitat.

Biometric. (Biological Metric) The study of biological phenomena by measurements and statistics.

Biosolids. Biologically treated solids originating from municipal wastewater treatment plants.

Box and whisker plot. A graphical representation of the mean, lower quartile, upper quartile, upper limit, lower limit, and outliers of a data set.

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

Cause. 1. That which produces an effect (a general definition).
2. A stressor or set of stressors that occur at an intensity, duration and frequency of exposure that results in a change in the ecological condition (a SI-specific definition). [2]

Channel. *A natural stream that conveys water; a ditch or channel excavated for the flow of water.*

Chloride. *An atom of chlorine in solution; an ion bearing a single negative charge.*

Clean Water Act (CWA). *The Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972), Public Law 92-500, as amended by Public Law 96-483 and Public Law 97-117, 33 U.S.C. 1251 et seq. The Clean Water Act (CWA) contains a number of provisions to restore and maintain the quality of the nation's water resources. One of these provisions is Section 303(d), which establishes the TMDL program.*

Concentration. *Amount of a substance or material in a given unit volume of solution; usually measured in milligrams per liter (mg/L) or parts per million (ppm).*

Concentration-based limit. *A limit based on the relative strength of a pollutant in a waste stream, usually expressed in milligrams per liter (mg/L).*

Concentration-response model. A quantitative (usually statistical) model of the relationship between the concentration of a chemical to which a population or community of organisms is exposed and the frequency or magnitude of a biological response. (2)

Conductivity. An indirect measure of the presence of dissolved substances within water.

Confluence. The point at which a river and its tributary flow together.

Contamination. *The act of polluting or making impure; any indication of chemical, sediment, or biological impurities.*

Continuous discharge. *A discharge that occurs without interruption throughout the operating hours of a facility, except for infrequent shutdowns for maintenance, process changes, or other similar activities.*

Conventional pollutants. *As specified under the Clean Water Act, conventional contaminants include suspended solids, coliform bacteria, high biochemical oxygen demand, pH, and oil and grease.*

Conveyance. A measure of the of the water carrying capacity of a channel section. It is directly proportional to the discharge in the channel section.

Cost-share program. *A program that allocates project funds to pay a percentage of the cost of constructing or implementing a best management practice. The remainder of the costs is paid by the producer(s).*

Cross-sectional area. *Wet area of a waterbody normal to the longitudinal component of the flow.*

Critical condition. *The critical condition can be thought of as the "worst case" scenario of environmental conditions in the waterbody in which the loading expressed in the TMDL for the pollutant of concern will continue to meet water quality standards. Critical conditions are the combination of environmental factors (e.g., flow, temperature, etc.) that results in attaining and maintaining the water quality criterion and has an acceptably low frequency of occurrence.*

Decay. *The gradual decrease in the amount of a given substance in a given system due to various sink processes including chemical and biological transformation, dissipation to other environmental media, or deposition into storage areas.*

Decomposition. *Metabolic breakdown of organic materials; the formation of by-products of decomposition releases energy and simple organic and inorganic compounds. See also* ***Respiration.***

Designated uses. *Those uses specified in water quality standards for each waterbody or segment whether or not they are being attained.*

Dilution. *The addition of some quantity of less-concentrated liquid (water) that results in a decrease in the original concentration.*

Direct runoff. *Water that flows over the ground surface or through the ground directly into streams, rivers, and lakes.*

Discharge. *Flow of surface water in a stream or canal, or the outflow of groundwater from a flowing artesian well, ditch, or spring. Can also apply to discharge of liquid effluent from a facility or to chemical emissions into the air through designated venting mechanisms.*

Discharge Monitoring Report (DMR). *Report of effluent characteristics submitted by a municipal or industrial facility that has been granted an NPDES discharge permit.*

Discharge permits (under NPDES). *A permit issued by the EPA or a state regulatory agency that sets specific limits on the type and amount of pollutants that a municipality or industry can discharge to a receiving water; it also includes a compliance schedule for achieving those limits. The permit process was established under the National Pollutant Discharge Elimination System, under provisions of the Federal Clean Water Act.*

Dispersion. *The spreading of chemical or biological constituents, including pollutants, in various directions at varying velocities depending on the differential in-stream flow characteristics.*

Dissolved Oxygen (DO). The amount of oxygen in water. DO is a measure of the amount of oxygen available for biochemical activity in a waterbody.

Diurnal. *Actions or processes that have a period or a cycle of approximately one tidal-day or are completed within a 24-hour period and that recur every 24 hours. Also, the occurrence of an activity/process during the day rather than the night.*

DNA. Deoxyribonucleic acid. The genetic material of cells and some viruses.

Domestic wastewater. *Also called sanitary wastewater, consists of wastewater discharged from residences and from commercial, institutional, and similar facilities.*

Drainage basin. *A part of a land area enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into a receiving water. Also referred to as a watershed, river basin, or hydrologic unit.*

Dynamic model. *A mathematical formulation describing and simulating the physical behavior of a system or a process and its temporal variability.*

Dynamic simulation. *Modeling of the behavior of physical, chemical, and/or biological phenomena and their variations over time.*

Ecoregion. A region defined in part by its shared characteristics. These include meteorological factors, elevation, plant and animal speciation, landscape position, and soils.

Ecosystem. *An interactive system that includes the organisms of a natural community association together with their abiotic physical, chemical, and geochemical environment.*

Effluent. *Municipal sewage or industrial liquid waste (untreated, partially treated, or completely treated) that flows out of a treatment plant, septic system, pipe, etc.*

Effluent guidelines. *The national effluent guidelines and standards specify the achievable effluent pollutant reduction that is attainable based upon the performance of treatment technologies employed within an industrial category. The National Effluent Guidelines Program was established with a phased approach whereby industry would first be required to meet interim limitations based on best practicable control technology currently available for existing sources (BPT). The second level of effluent limitations to be attained by industry was referred to as best available technology economically achievable (BAT), which was established primarily for the control of toxic pollutants.*

Effluent limitation. *Restrictions established by a state or EPA on quantities, rates, and concentrations in pollutant discharges.*

Endpoint. *An endpoint (or indicator/target) is a characteristic of an ecosystem that may be affected by exposure to a stressor. Assessment endpoints and measurement endpoints are two distinct types of endpoints commonly used by resource managers. An assessment endpoint is the formal expression of a valued environmental characteristic and should have societal relevance (an indicator). A measurement endpoint is the expression of an observed or measured response to a stress or disturbance. It is a measurable environmental characteristic that is related to the valued environmental characteristic chosen as the assessment endpoint. The numeric criteria that are part of traditional water quality standards are good examples of measurement endpoints (targets).*

Enhancement. *In the context of restoration ecology, any improvement of a structural or functional attribute.*

Erosion. The detachment and transport of soil particles by water and wind. Sediment resulting from soil erosion represents the single largest source of nonpoint pollution in the United States.

Eutrophication. The process of enrichment of water bodies by nutrients. Waters receiving excessive nutrients may become eutrophic, are often undersirable for recreation, and may not support normal fish populations.

Evapotranspiration. The combined effects of evaporation and transpiration on the water balance. Evaporation is water loss into the atmosphere from soil and water surfaces. Transpiration is water loss into the atmosphere as part of the life cycle of plants.

Fate of pollutants*. Physical, chemical, and biological transformation in the nature and changes of the amount of a pollutant in an environmental system. Transformation processes are pollutant-specific. Because they have comparable kinetics, different formulations for each pollutant are not required.*

Fecal Coliform. Indicator organisms (organisms indicating presence of pathogens) associated with the digestive tract.

Feedlot. *A confined area for the controlled feeding of animals. Tends to concentrate large amounts of animal waste that cannot be absorbed by the soil and, hence, may be carried to nearby streams or lakes by rainfall runoff.*

Flux. *Movement and transport of mass of any water quality constituent over a given period of time. Units of mass flux are mass per unit time.*

General Standard. A narrative standard that ensures the general health of state waters. 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 (9VAC25-260-20). (4)

Geometric mean. A measure of the central tendency of a data set that minimizes the effects of extreme values.

GIS. Geographic Information System. A system of hardware, software, data, people, organizations and institutional arrangements for collecting, storing, analyzing and disseminating information about areas of the earth. (Dueker and Kjerne, 1989)

Ground water. *The supply of fresh water found beneath the earths surface, usually in aquifers, which supply wells and springs. Because ground water is a major source of drinking water, there is growing concern over contamination from leaching agricultural or industrial pollutants and leaking underground storage tanks.*

HSPF. Hydrological Simulation Program – Fortran. A computer simulation tool used to mathematically model nonpoint source pollution sources and movement of pollutants in a watershed.

Hydrograph*. A graph showing variation of stage (depth) or discharge in a stream over a period of time.*

***Hydrologic cycle**. The circuit of water movement from the atmosphere to the earth and its return to the atmosphere through various stages or processes, such as precipitation, interception, runoff, infiltration, storage, evaporation, and transpiration.*

***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.*

Impairment. A detrimental effect on the biological integrity of a water body that prevents attainment of the designated use.

IMPLND. An impervious land segment in HSPF. It is used to model land covered by impervious materials, such as pavement.

***Indicator.** A measurable quantity that can be used to evaluate the relationship between pollutant sources and their impact on water quality.*

***Indicator organism**. An organism used to indicate the potential presence of other (usually pathogenic) organisms. Indicator organisms are usually associated with the other organisms, but are usually more easily sampled and measured.*

Indirect causation. The induction of effects through a series of cause-effect relationships, so that the impaired resource may not even be exposed to the initial cause.

Indirect effects. Changes in a resource that are due to a series of cause-effect relationships rather than to direct exposure to a contaminant or other stressor.

***Infiltration capacity**. The capacity of a soil to allow water to infiltrate into or through it during a storm.*

***In situ.** In place; in situ measurements consist of measurements of components or processes in a full-scale system or a field, rather than in a laboratory.*

Interflow. Runoff that travels just below the surface of the soil.

Isolate. An inbreeding biological population that is isolated from similar populations by physical or other means.

***Leachate.** Water that collects contaminants as it trickles through wastes, pesticides, or fertilizers. Leaching can occur in farming areas, feedlots, and landfills and can result in hazardous substances entering surface water, ground water, or soil.*

Limits (upper and lower). The lower limit equals the lower quartile – 1.5x(upper quartile – lower quartile), and the upper limit equals the upper quartile + 1.5x(upper quartile – lower quartile). Values outside these limits are referred to as outliers.

***Loading, Load, Loading rate**. The total amount of material (pollutants) entering the system from one or multiple sources; measured as a rate in weight per unit time.*

Load allocation (LA). *The portion of a receiving waters loading capacity attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished (40 CFR 130.2(g)).*

Loading capacity (LC). *The greatest amount of loading a water can receive without violating water quality standards.*

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 (CWA Section 303(d)(1)(C)). The MOS is normally incorporated into the conservative assumptions used to develop TMDLs (generally within the calculations or models) and approved by the EPA either individually or in state/EPA agreements. If the MOS needs to be larger than that which is allowed through the conservative assumptions, additional MOS can be added as a separate component of the TMDL (in this case, quantitatively, a TMDL = LC = WLA + LA + MOS).*

Mass balance. *An equation that accounts for the flux of mass going into a defined area and the flux of mass leaving the defined area. The flux in must equal the flux out.*

Mass loading. *The quantity of a pollutant transported to a waterbody.*

Mean. The sum of the values in a data set divided by the number of values in the data set.

Metrics. Indices or parameters used to measure some aspect or characteristic of a water body's biological integrity. The metric changes in some predictable way with changes in water quality or habitat condition.

MGD. Million gallons per day. A unit of water flow, whether discharge or withdraw.

Mitigation. *Actions taken to avoid, reduce, or compensate for the effects of environmental damage. Among the broad spectrum of possible actions are those that restore, enhance, create, or replace damaged ecosystems.*

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

Monitoring. *Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.*

Mood's Median Test. A nonparametric (distribution-free) test used to test the equality of medians from two or more populations.

Narrative criteria*. Nonquantitative guidelines that describe the desired water quality goals.*

National Pollutant Discharge Elimination System (NPDES). *The national program for issuing, modifying, revoking and re-issuing, terminating, monitoring, and enforcing permits, and imposing and enforcing pretreatment requirements, under sections 307, 402, 318, and 405 of the Clean Water Act.*

Natural waters. *Flowing water within a physical system that has developed without human intervention, in which natural processes continue to take place.*

Nitrogen. An essential nutrient to the growth of organisms. Excessive amounts of nitrogen in water can contribute to abnormally high growth of algae, reducing light and oxygen in aquatic ecosystems.

Nonpoint source. *Pollution that 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.*

Numeric targets*. A measurable value determined for the pollutant of concern, which, if achieved, is expected to result in the attainment of water quality standards in the listed waterbody.*

Numerical model*.* Model that approximates a solution of governing partial differential equations, which describe a natural process. The approximation uses a numerical discretization of the space and time components of the system or process.

Nutrient. An element or compound essential to life, including carbon, oxygen, nitrogen, phosphorus, and many others: as a pollutant, any element or compound, such as phosphorus or nitrogen, that in excessive amounts contributes to abnormally high growth of algae, reducing light and oxygen in aquatic ecosystems.

Organic matter. *The organic fraction that includes plant and animal residue at various stages of decomposition, cells and tissues of soil organisms, and substances synthesized by the soil population. Commonly determined as the amount of organic material contained in a soil or water sample.*

Parameter. A numerical descriptive measure of a population. Since it is based on the observations of the population, its value is almost always unknown.

Peak runoff*. The highest value of the stage or discharge attained by a flood or storm event; also referred to as flood peak or peak discharge.*

PERLND. A pervious land segment in HSPF. It is used to model a particular land use segment within a subwatershed (e.g. pasture, urban land, or crop land).

Permit. *An authorization, license, or equivalent control document issued by the EPA or an approved federal, state, or local agency to implement the requirements of an environmental regulation; e.g., a permit to operate a wastewater treatment plant or to operate a facility that may generate harmful emissions.*

Permit Compliance System (PCS). *Computerized management information system that contains data on NPDES permit-holding facilities. PCS keeps extensive records on more than 65,000 active water-discharge permits on sites located throughout the nation. PCS tracks permit, compliance, and enforcement status of NPDES facilities.*

Phased/staged approach. *Under the phased approach to TMDL development, load allocations and wasteload allocations are calculated using the best available data and information recognizing the need for additional monitoring data to accurately characterize sources and loadings. The phased approach is typically employed when nonpoint sources dominate. It provides for the implementation of load reduction strategies while collecting additional data.*

Phosphorus. An essential nutrient to the growth of organisms. Excessive amounts of phosphorus in water can contribute to abnormally high growth of algae, reducing light and oxygen in aquatic ecosystems.

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.*

Pollutant. *Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water. (CWA section 502(6)).*

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.*

Postaudit. *A subsequent examination and verification of a model's predictive performance following implementation of an environmental control program.*

Privately owned treatment works*. Any device or system that is (a) used to treat wastes from any facility whose operator is not the operator of the treatment works and (b) not a publicly owned treatment works.*

Public comment period*. The time allowed for the public to express its views and concerns regarding action by the EPA or states (e.g., a* Federal Register *notice of a proposed rule-making, a public notice of a draft permit, or a Notice of Intent to Deny).*

Publicly owned treatment works (POTW). *Any device or system used in the treatment (including recycling and reclamation) of municipal sewage or industrial wastes of a liquid nature that is owned by a state or municipality. This definition includes sewers, pipes, or other conveyances only if they convey wastewater to a POTW providing treatment.*

Quartile. The 25th, 50th, and 75th percentiles of a data set. A percentile (p) of a data set ordered by magnitude is the value that has at most p% of the measurements in the data set below it, and (100-p)% above it. The 50th quartile is also known as the median. The 25th and 75th quartiles are referred to as the lower and upper quartiles, respectively.

Rapid Bioassessment Protocol II (RBP II). A suite of measurements based on a quantitative assessment of benthic macroinvertebrates and a qualitative assessment of their habitat. RBP II scores are compared to a reference condition or conditions to determine to what degree a water body may be biologically impaired.

Reach. Segment of a stream or river.

Receiving waters. *Creeks, streams, rivers, lakes, estuaries, ground-water formations, or other bodies of water into which surface water and/or treated or untreated waste are discharged, either naturally or in man-made systems.*

Reference Conditions. The chemical, physical, or biological quality or condition exhibited at either a single site or an aggregation of sites that are representative of non-impaired conditions for a watershed of a certain size, land use distribution, and other related characteristics. Reference conditions are used to describe reference sites.

Re-mining. Extracting resoures from land previously mined. This method is often used to reclaim abandoned mine areas.

Reserve capacity*. Pollutant loading rate set aside in determining stream waste load allocation, accounting for uncertainty and future growth.*

Residence time. *Length of time that a pollutant remains within a section of a stream or river. The residence time is determined by the streamflow and the volume of the river reach or the average stream velocity and the length of the river reach.*

Restoration*. Return of an ecosystem to a close approximation of its presumed condition prior to disturbance.*

Riparian areas. *Areas bordering streams, lakes, rivers, and other watercourses. These areas have high water tables and support plants that require saturated soils during all or part of the year. Riparian areas include both wetland and upland zones.*

Riparian zone*. The border or banks of a stream. Although this term is sometimes used interchangeably with floodplain, the riparian zone is generally regarded as relatively narrow compared to a floodplain. The duration of flooding is generally much shorter, and the timing less predictable, in a riparian zone than in a river floodplain.*

Roughness coefficient*. A factor in velocity and discharge formulas representing the effects of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.*

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

Seasonal Kendall test. A statistical tool used to test for trends in data, which is unaffected by seasonal cycles. (Gilbert, 1987)

Sediment. In the context of water quality, soil particles, sand, and minerals dislodged from the land and deposited into aquate systems as a result of erosion.

Septic system. *An on-site system designed to treat and dispose of domestic sewage. A typical septic system consists of a tank that receives waste from a residence or business and a drain field or subsurface absorption system consisting of a series of percolation lines for the disposal of the liquid effluent. Solids (sludge) that remain after decomposition by bacteria in the tank must be pumped out periodically.*

Sewer. *A channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream. Sanitary sewers carry household, industrial, and commercial waste. Storm sewers carry runoff from rain or snow. Combined sewers handle both.*

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.*

Slope. *The degree of inclination to the horizontal. Usually expressed as a ratio, such as 1:25 or 1 on 25, indicating one unit vertical rise in 25 units of horizontal distance, or in a decimal fraction (0.04), degrees (2 degrees 18 minutes), or percent (4 percent).*

Source. An origination point, area, or entity that releases or emits a stressor. A source can alter the normal intensity, frequency, or duration of a natural attribute, whereby the attribute then becomes a stressor.

Spatial segmentation. *A numerical discretization of the spatial component of a system into one or more dimensions; forms the basis for application of numerical simulation models.*

Staged Implementation. A process that allows for the evaluation of the adequacy of the TMDL in achieving the water quality standard. As stream monitoring continues to occur, staged or phased implementation allows for water quality improvements to be recorded as they are being achieved. It also provides a measure of quality control, and it helps to ensure that the most cost-effective practices are implemented first.

Stakeholder. Any person with a vested interest in the TMDL development.

Standard. In reference to water quality (e.g. 200 cfu/100 mL geometric mean limit).

Standard deviation. A measure of the variability of a data set. The positive square root of the variance of a set of measurements.

Standard error. The standard deviation of a distribution of a sample statistic, esp. when the mean is used as the statistic.

Statistical significance. An indication that the differences being observed are not due to random error. The p-value indicates the probability that the differences are due to random error (i.e. a low p-value indicates statistical significance).

Steady-state model. *Mathematical model of fate and transport that uses constant values of input variables to predict constant values of receiving water quality concentrations. Model variables are treated as not changing with respect to time.*

Storm runoff*. Storm water runoff, snowmelt runoff, and surface runoff and drainage; rainfall that does not evaporate or infiltrate the ground because of impervious land surfaces or a soil infiltration rate lower than rainfall intensity, but instead flows onto adjacent land or into waterbodies or is routed into a drain or sewer system.*

Streamflow. *Discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than "runoff" since streamflow may be applied to discharge whether or not it is affected by diversion or regulation.*

Stream Reach. A straight portion of a stream.

Stream restoration. *Various techniques used to replicate the hydrological, morphological, and ecological features that have been lost in a stream because of urbanization, farming, or other disturbance.*

Stressor. Any physical, chemical, or biological entity that can induce an adverse response. [2]

Surface area*. The area of the surface of a waterbody; best measured by planimetry or the use of a geographic information system.*

Surface runoff. *Precipitation, snowmelt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants.*

Surface water*. All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.) and all springs, wells, or other collectors directly influenced by surface water.*

Suspended Solids. Usually fine sediments and organic matter. Suspended solids limit sunlight penetration into the water, inhibit oxygen uptake by fish, and alter aquatic habitat.

***Technology-based standards**. Effluent limitations applicable to direct and indirect sources that are developed on a category-by-category basis using statutory factors, not including water quality effects.*

Timestep. An increment of time in modeling terms. The smallest unit of time used in a mathematical simulation model (e.g. 15-minutes, 1-hour, 1-day).

***Topography.** The physical features of a geographic surface area including relative elevations and the positions of natural and man-made features.*

Total Dissolved Solids (TDS). A measure of the concentration of dissolved inorganic chemicals in water.

***Total Maximum Daily Load (TMDL).** The sum of the individual wasteload allocations (WLAs) for point sources, load allocations (LAs) 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.*

TMDL Implementation Plan. A document required by Virginia statute detailing the suite of pollution control measures needed to renediate an impaired stream segment. The plans are also required to include a schedule of actions, costs, and monitoring. Once implemented, the plan should result in the previously impaired water meeting water quality standards and achieving a "fully supporting" use support status.

***Transport of pollutants (in water).** Transport of pollutants in water involves two main processes: (1) advection, resulting from the flow of water, and (2) dispersion, or transport due to turbulence in the water.*

TRC. Total Residual Chlorine. A measure of the effectiveness of chlorinating treated waste water effluent.

***Tributary.** A lower order-stream compared to a receiving waterbody. "Tributary to" indicates the largest stream into which the reported stream or tributary flows.*

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 processes under investigation. A validated model will have also been tested to ascertain whether it accurately and correctly solves the equations being used to define the system simulation.*

Variance. A measure of the variability of a data set. The sum of the squared deviations (observation – mean) divided by (number of observations) – 1.

VADACS. Virginia Department of Agriculture and Consumer Services.

VADCR. Virginia Department of Conservation and Recreation.

VADEQ. Virginia Department of Environmental Quality.

DMLR. Virginia Department of mine Land Reclamation.

DMME. Virginia Department of Mines, Minerals, and Energy.

VDH. Virginia Department of Health.

Wasteload allocation (WLA). *The portion of a receiving waters' 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 (40 CFR 130.2(h)).*

Wastewater. *Usually refers to effluent from a sewage treatment plant. See also Domestic wastewater.*

Wastewater treatment*. Chemical, biological, and mechanical procedures applied to an industrial or municipal discharge or to any other sources of contaminated water to remove, reduce, or neutralize contaminants.*

Water quality*. The biological, chemical, and physical conditions of a waterbody. It is a measure of a waterbody's ability to support beneficial uses.*

Water quality-based permit*. A permit with an effluent limit more stringent than one based on technology performance. Such limits might be necessary to protect the designated use of receiving waters (e.g., recreation, irrigation, industry, or water supply).*

Water quality criteria*. Levels of water quality expected to render a body of water suitable for its designated use, composed of numeric and narrative criteria. Numeric criteria are scientifically derived ambient concentrations developed by the EPA or states for various pollutants of concern to protect human health and aquatic life. Narrative criteria are statements that describe the desired water quality goal. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.*

Water quality standard. *Law or regulation that consists of the beneficial designated use or uses of a waterbody, the numeric and narrative water quality criteria that are necessary to protect the use or uses of that particular waterbody, and an antidegradation 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.*

WQIA. Water Quality Improvement Act.

APPENDIX A

FREQUENCY ANALYSIS OF WATER QUALITY SAMPLING DATA

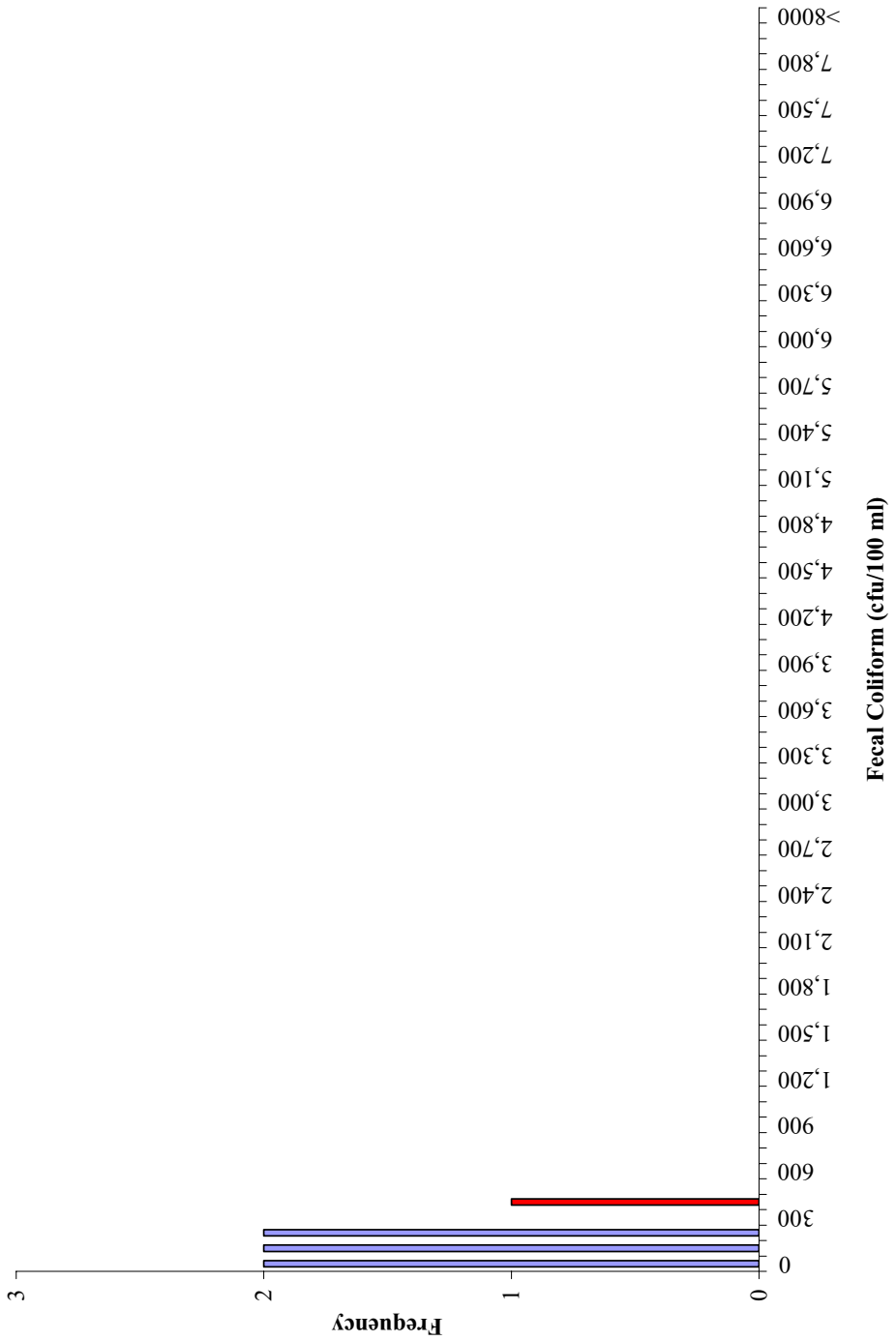

Figure A.1 Frequency analysis of fecal coliform concentrations at station 6BMIK000.07 in the Mud Lick impairment for period June 2002 to June 2003.

*Red indicates a value which violates the listing standard of 400 cfu/100 mL.

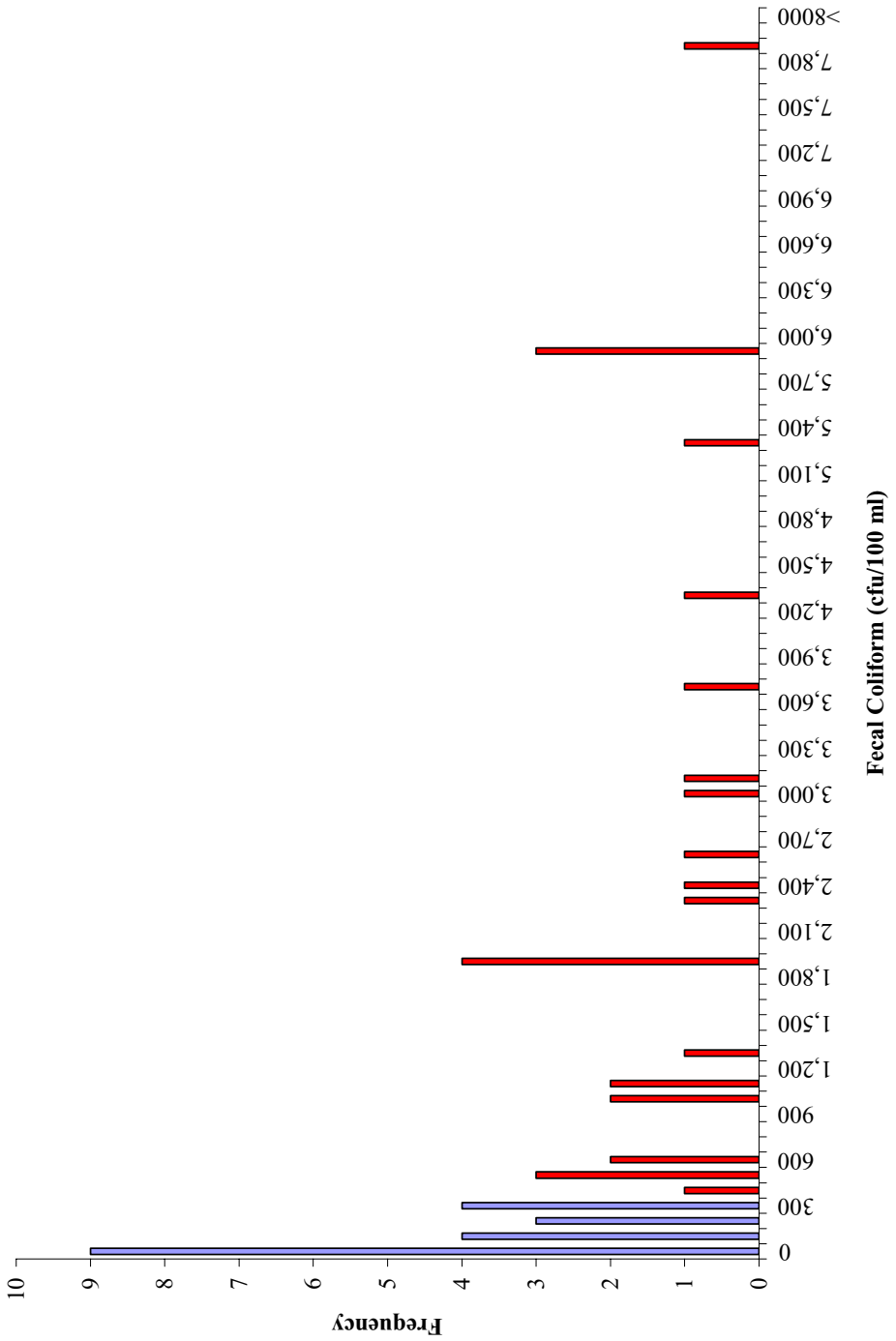

Figure A.2 Frequency analysis of fecal coliform concentrations at station 6BSRA001.11 in the Straight Creek impairment for period July 1990 to March 2001.
Red indicates a value which violates the listing standard of 400 cfu/100 mL.

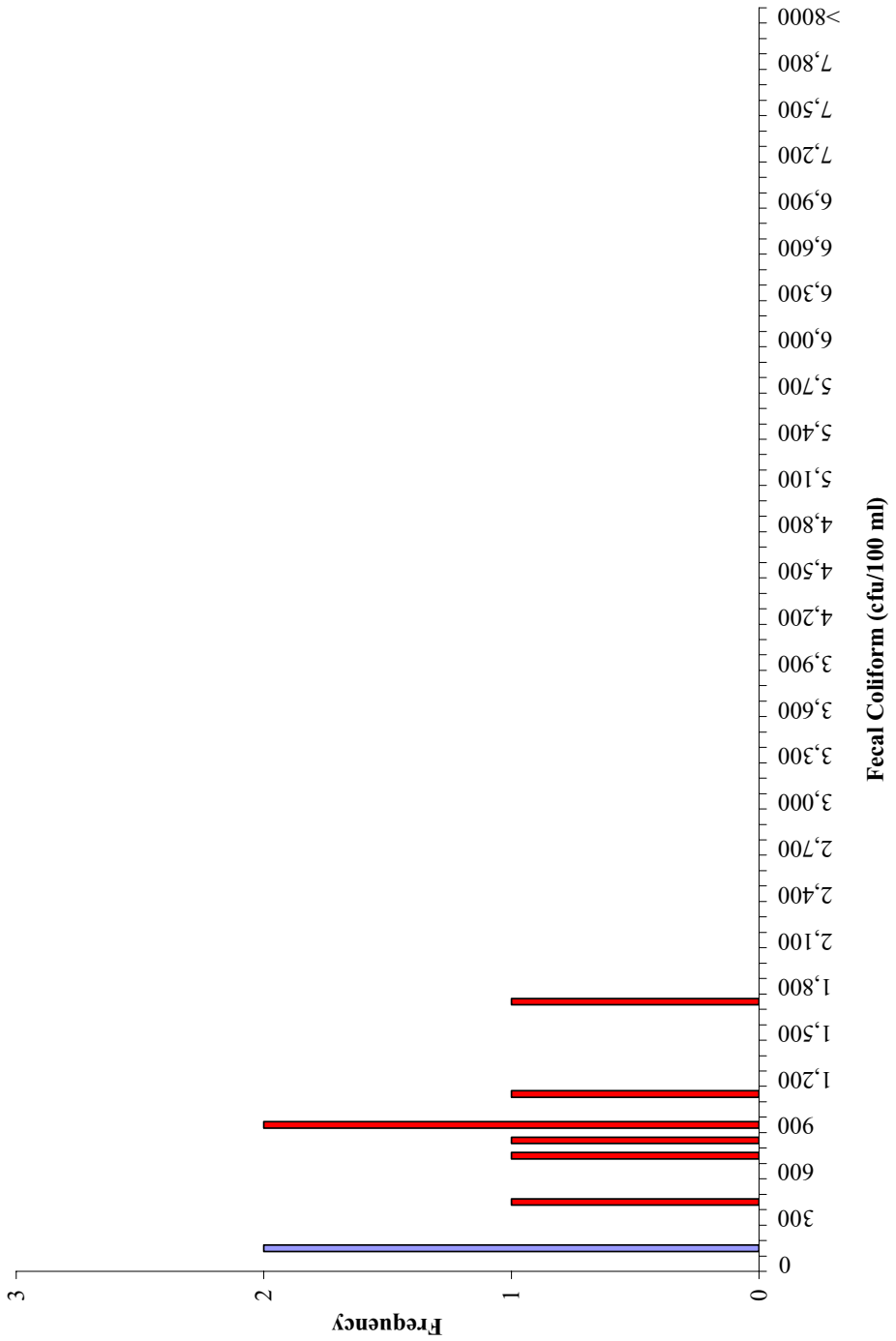

Figure A.3 Frequency analysis of fecal coliform concentrations at station 6BSRA003.22 in the Straight Creek impairment for period July 2003 to March 2004.
Red indicates a value which violates the listing standard of 400 cfu/100 mL.

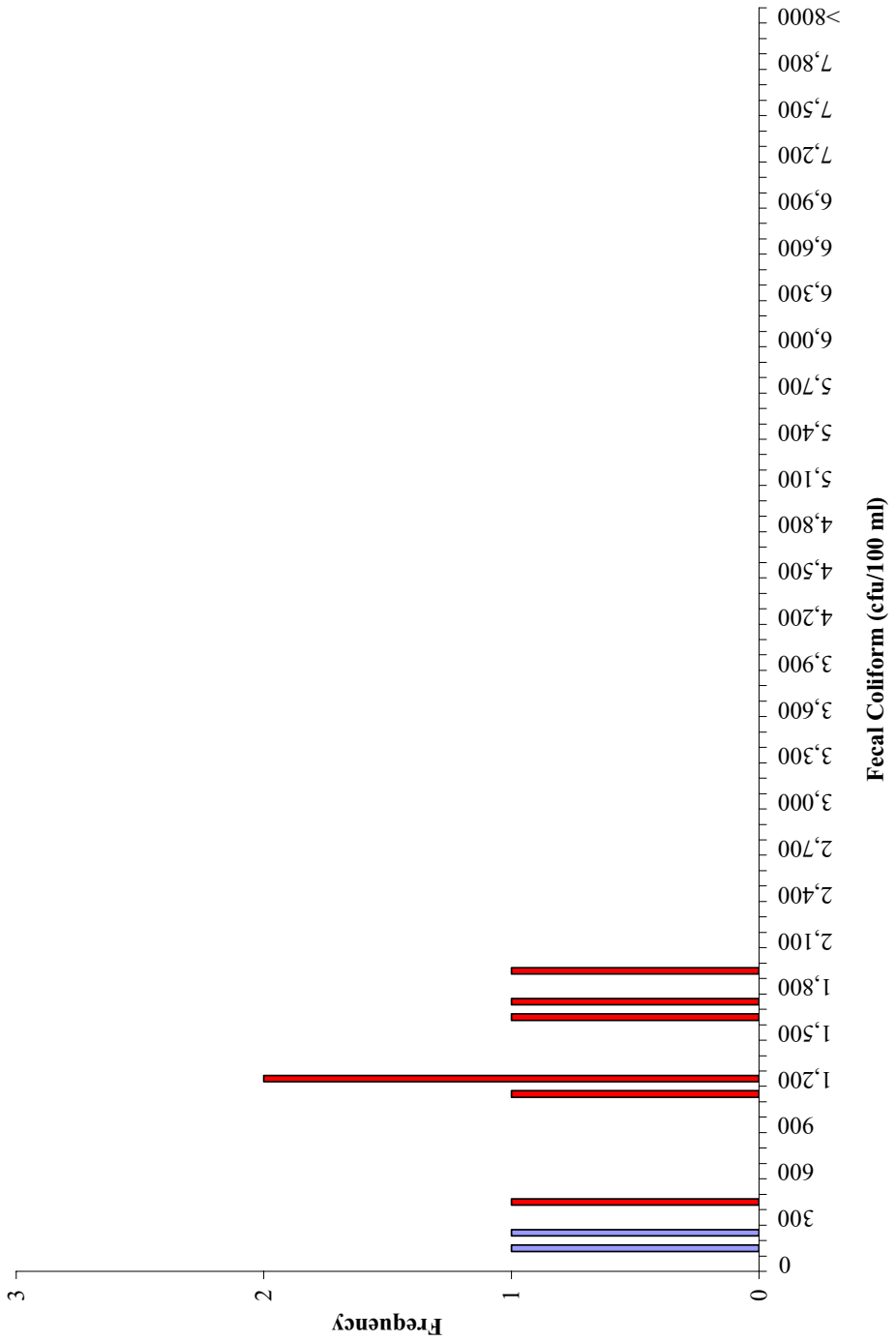

Figure A.4 Frequency analysis of fecal coliform concentrations at station 6BSRA004.16 in the Straight Creek impairment for period July 2003 to March 2004.
Red indicates a value which violates the listing standard of 400 cfu/100 mL.

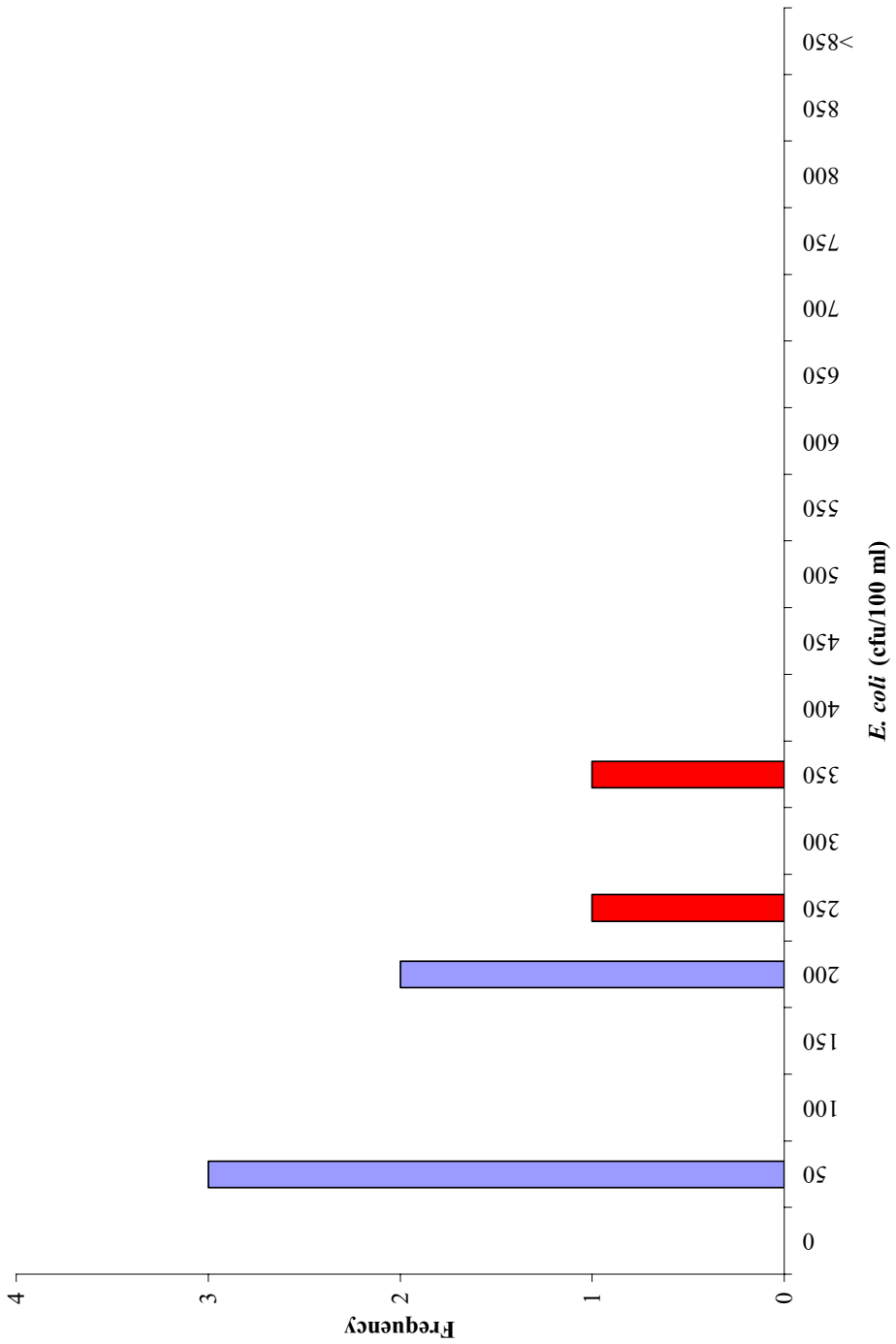

Figure A.5 Frequency analysis of *E. coli* concentrations at station 6BMIK000.07 in the Mud Lick impairment for period June 2002 to June 2003.

*Red indicates a value which violates the listing standard of 235 cfu/100 mL.

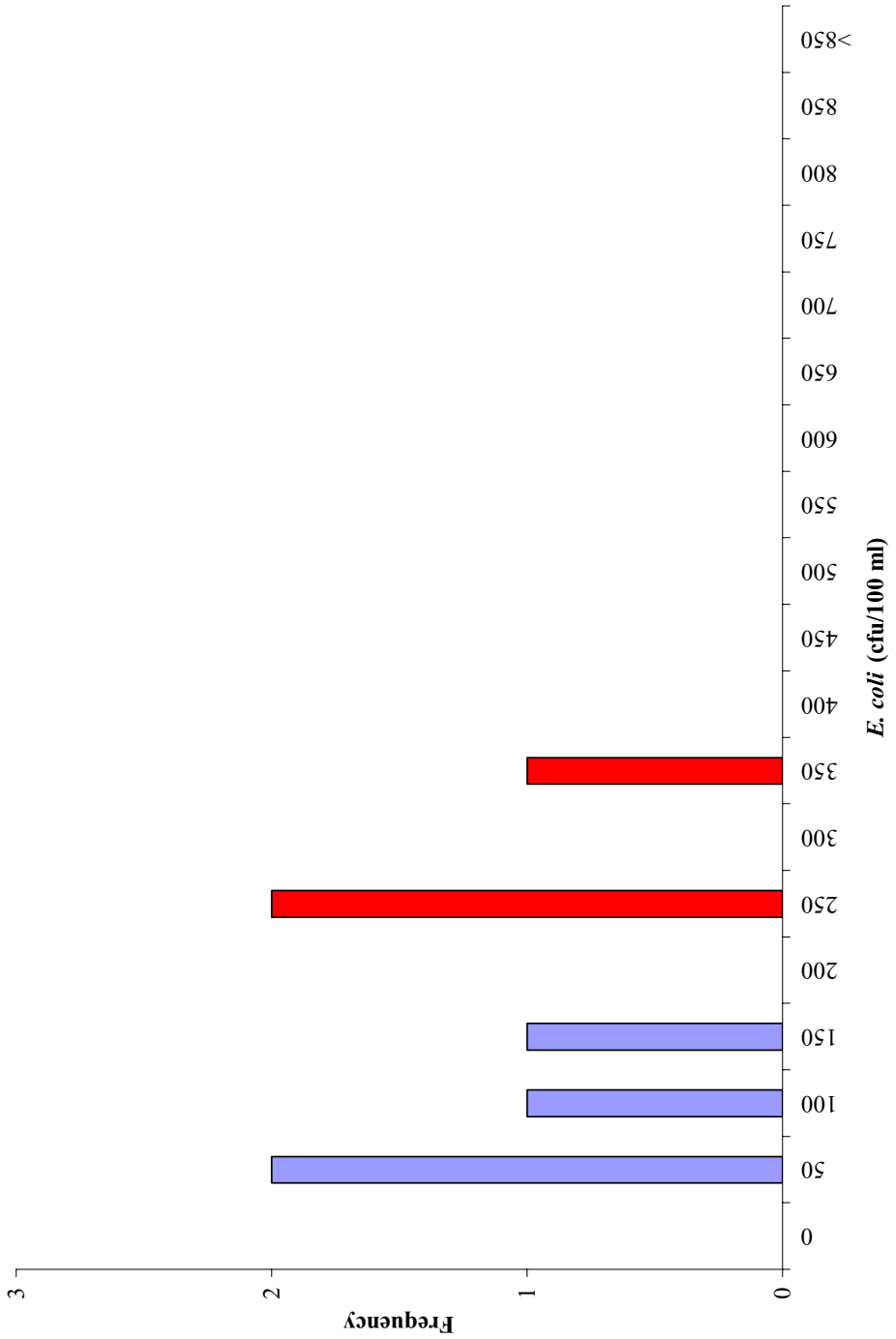

Figure A.6 Frequency analysis of *E. coli* concentrations at station 6BPIG000.04 in the Pigeon Creek impairment for period June 2002 to June 2003.

*Red indicates a value which violates the listing standard of 235 cfu/100 mL.

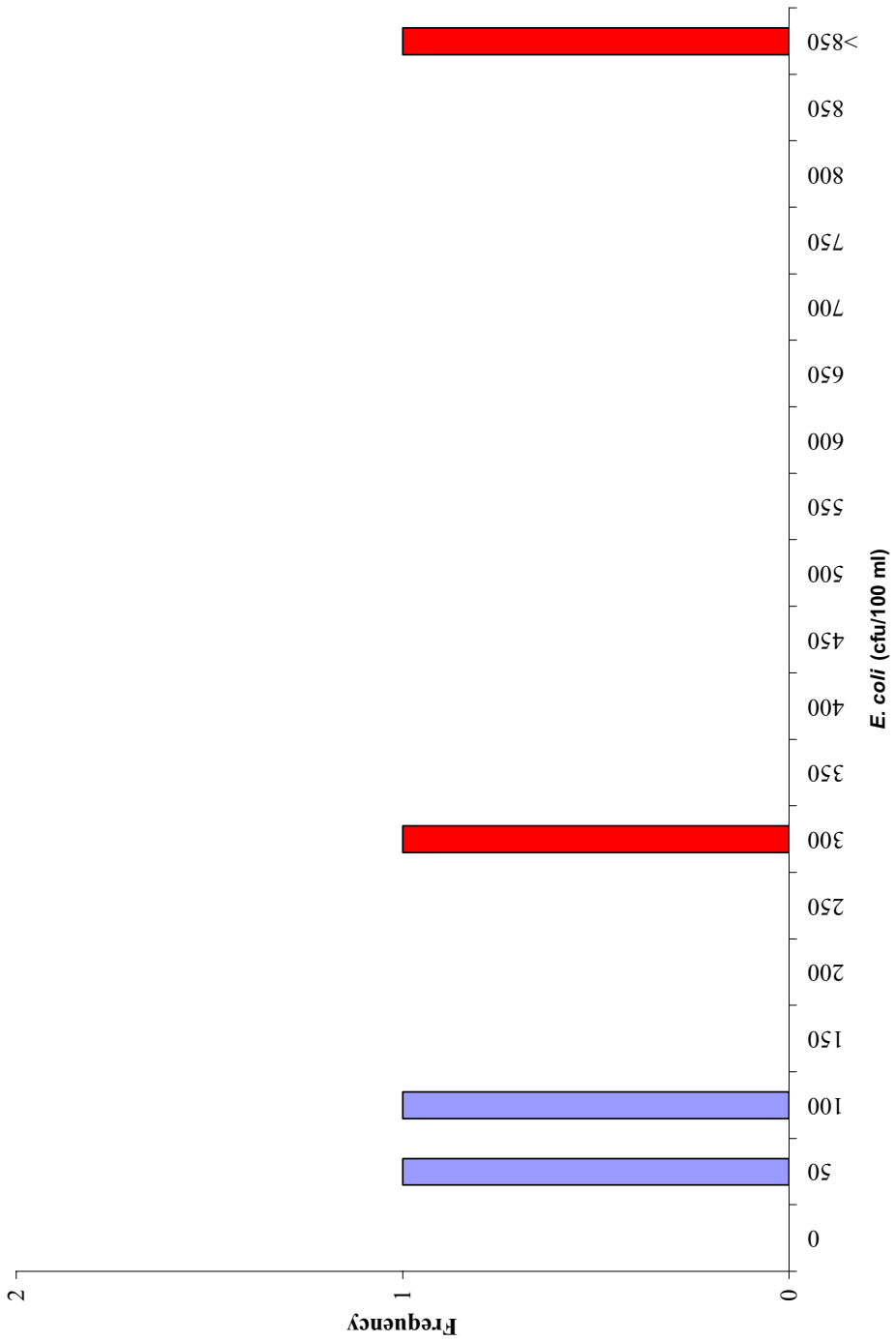

Figure A.7 Frequency analysis of *E. coli* concentrations at station 6BSRA000.10 in the Straight Creek impairment for period August 2003 to February 2004.

*Red indicates a value which violates the listing standard of 235 cfu/100 mL.

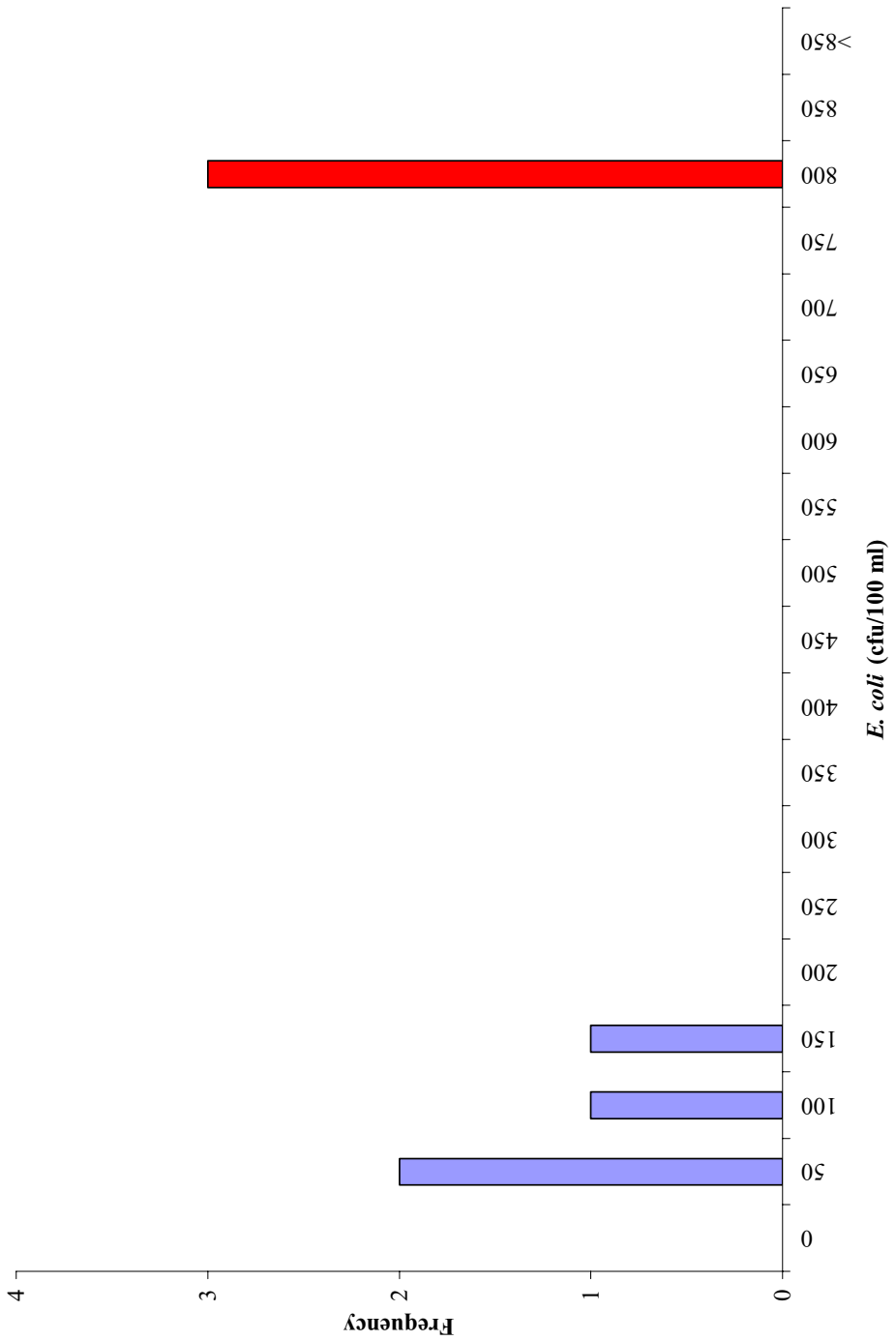

Figure A.8 Frequency analysis of *E. coli* concentrations at station 6BSRA001.11 in the Straight Creek impairment for period March 2000 to March 2001.
*Red indicates a value which violates the listing standard of 235 cfu/100 mL.

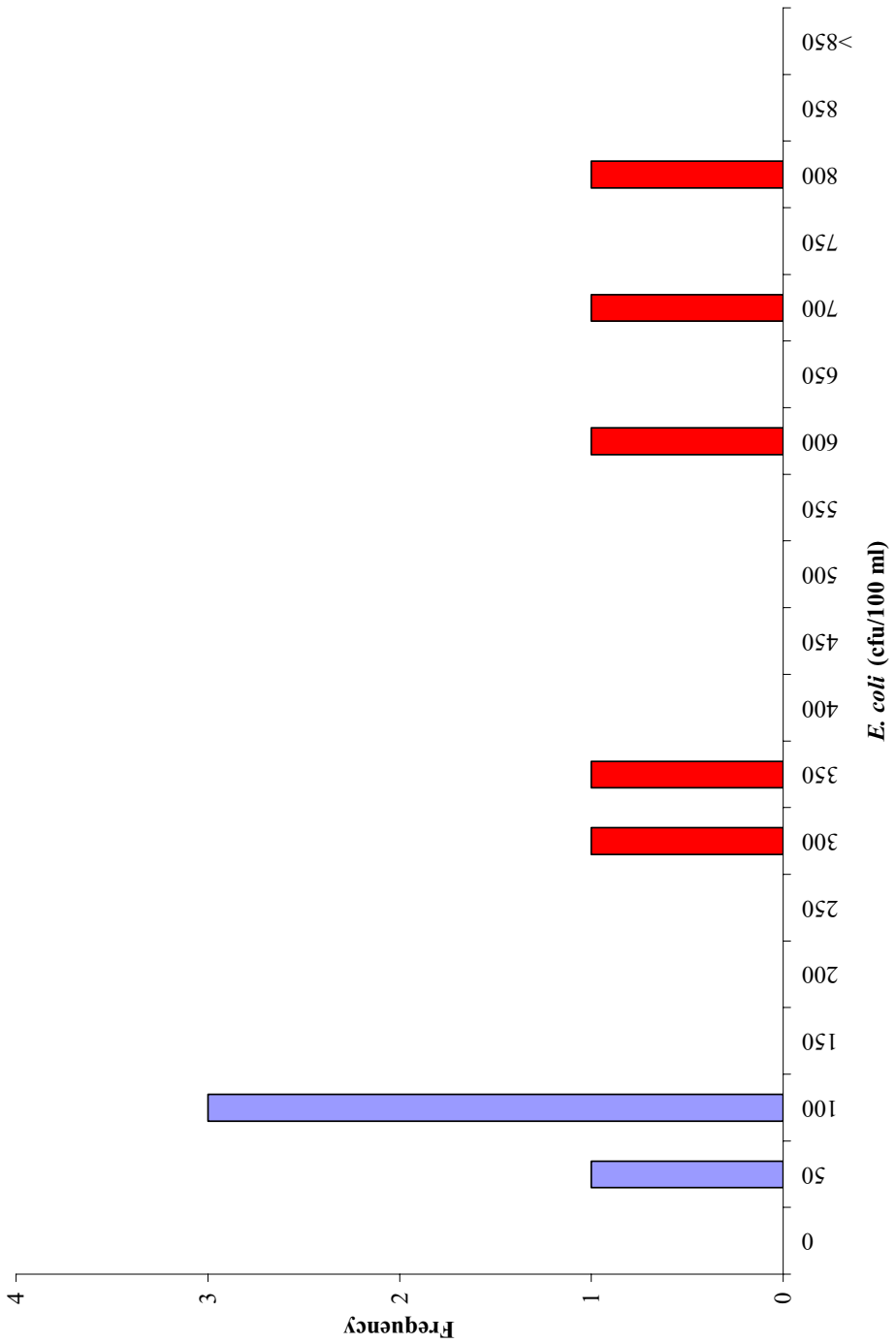

Figure A.9 Frequency analysis of *E. coli* concentrations at station 6BSRA003.22 in the Straight Creek impairment for period July 2003 to March 2004.

*Red indicates a value which violates the listing standard of 235 cfu/100 mL.

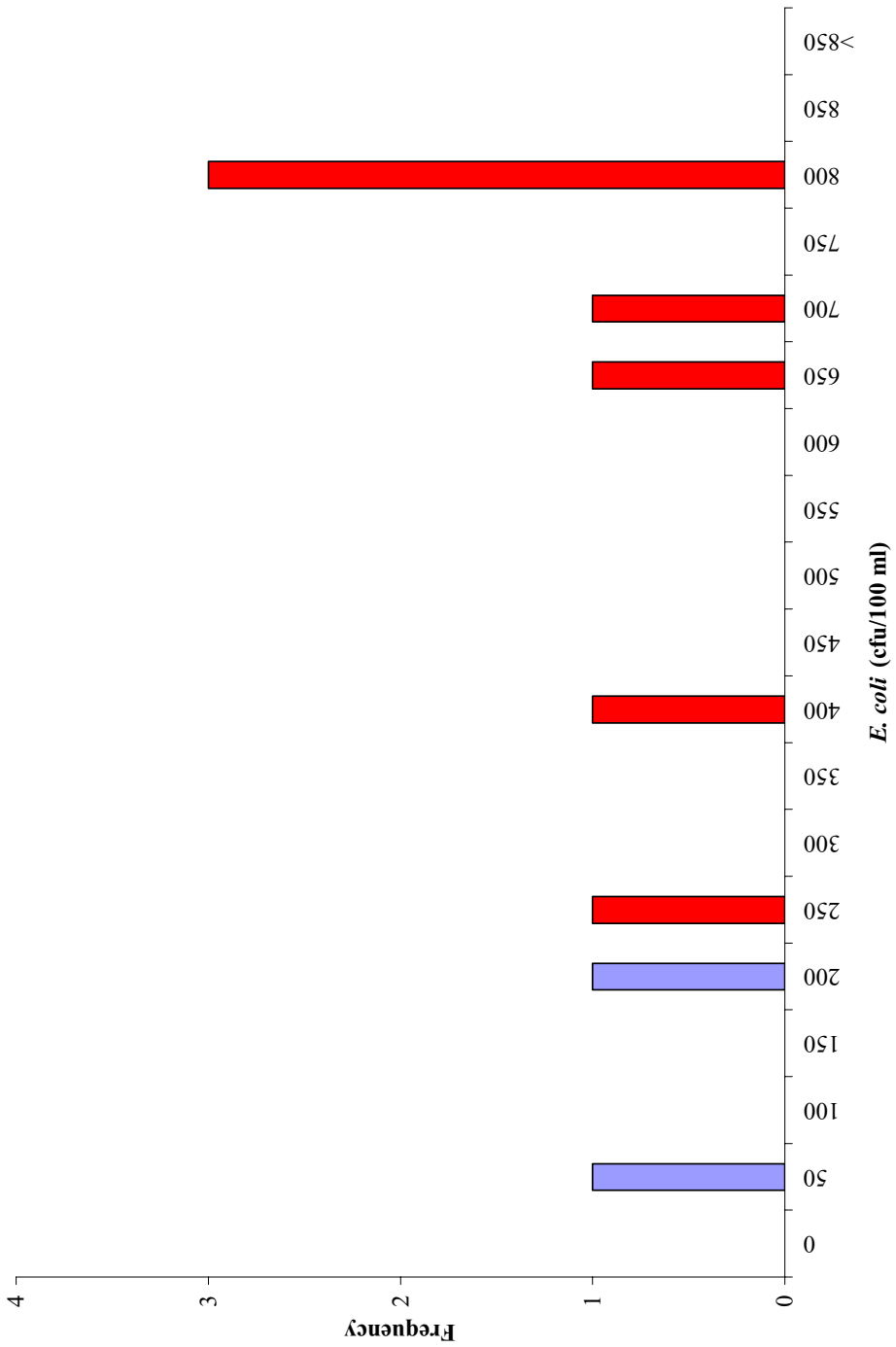

Figure A.10 Frequency analysis of *E. coli* concentrations at station 6BSRA004.16 in the Straight Creek impairment for period July 2003 to March 2004.

*Red indicates a value which violates the listing standard of 235 cfu/100 mL

APPENDIX B

FECAL COLIFORM LOADS IN EXISTING CONDITIONS

Table B. 1 Current conditions of land applied fecal coliform load by land-use for the Straight Creek watershed (subwatersheds 6-9).

Land use	Active Mine (cfu)	Abandoned Mine Land (cfu)	Barren (cfu)	Commercial (cfu)	Cropland (cfu)	Forest (cfu)
January	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
February	4.66E+11	2.39E+12	4.32E+09	6.67E+10	1.78E+10	1.72E+13
March	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
April	4.99E+11	2.56E+12	4.63E+09	7.15E+10	1.90E+10	1.84E+13
May	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
June	4.99E+11	2.56E+12	4.63E+09	7.15E+10	1.90E+10	1.84E+13
July	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
August	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
September	4.99E+11	2.56E+12	4.63E+09	7.15E+10	1.90E+10	1.84E+13
October	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
November	4.99E+11	2.56E+12	4.63E+09	7.15E+10	1.90E+10	1.84E+13
December	5.16E+11	2.64E+12	4.79E+09	7.38E+10	1.97E+10	1.90E+13
Annual Total Loads (cfu/yr)	6.07E+12	3.11E+13	5.64E+10	8.69E+11	2.32E+11	2.24E+14

Table B.1 Current conditions of land applied fecal coliform load by land-use for the Straight Creek watershed (subwatersheds 6-9), (cont.)

Land use	Livestock Access (cfu)	Pasture/Hay (cfu)	Reclaimed Mine Land (cfu)	Residential (cfu)	Roads (cfu)	Wetland (cfu)
January	1.81E+10	6.56E+11	3.72E+12	6.26E+12	3.96E+11	2.09E+10
February	1.64E+10	5.92E+11	3.36E+12	5.54E+12	3.57E+11	1.89E+10
March	2.43E+10	6.48E+11	3.72E+12	5.89E+12	3.96E+11	2.09E+10
April	3.11E+10	6.18E+11	3.60E+12	5.58E+12	3.83E+11	2.02E+10
May	3.22E+10	6.38E+11	3.72E+12	5.65E+12	3.96E+11	2.09E+10
June	3.71E+10	6.1E+11	3.60E+12	5.35E+12	3.83E+11	2.02E+10
July	3.83E+10	6.31E+11	3.72E+12	5.28E+12	3.96E+11	2.09E+10
August	3.83E+10	6.31E+11	3.72E+12	5.28E+12	3.96E+11	2.09E+10
September	3.11E+10	6.18E+11	3.60E+12	5.11E+12	3.83E+11	2.02E+10
October	2.43E+10	6.48E+11	3.72E+12	5.16E+12	3.96E+11	2.09E+10
November	2.35E+10	6.27E+11	3.60E+12	5.11E+12	3.83E+11	2.02E+10
December	1.81E+10	6.56E+11	3.72E+12	5.77E+12	3.96E+11	2.09E+10
Annual Total Loads (cfu/yr)	3.33E+11	7.57E+12	4.38E+13	6.60E+13	4.66E+12	2.46E+11

Table B. 2 Monthly, directly deposited fecal coliform loads in each reach of the Straight Creek watershed (subwatersheds 6-9).

Reach	Source	Jan (cfu)	Feb (cfu)	Mar (cfu)	Apr (cfu)	May (cfu)	Jun (cfu)
6	Human/Pet	9.72E+12	8.78E+12	9.72E+12	9.41E+12	9.72E+12	9.41E+12
	Livestock	1.98E+08	1.79E+08	2.64E+08	3.83E+08	3.95E+08	4.46E+08
	Wildlife	1.04E+11	9.38E+10	1.04E+11	1.01E+11	1.04E+11	1.01E+11
7	Human/Pet	6.79E+12	6.14E+12	6.79E+12	6.58E+12	6.79E+12	6.58E+12
	Livestock	9.30E+03	8.40E+03	1.24E+04	1.80E+04	1.86E+04	2.10E+04
	Wildlife	8.00E+10	7.23E+10	8.00E+10	7.75E+10	8.00E+10	7.75E+10
8	Human/Pet	1.72E+13	1.55E+13	1.72E+13	1.66E+13	1.72E+13	1.66E+13
	Livestock	3.95E+08	3.57E+08	5.27E+08	7.65E+08	7.91E+08	8.93E+08
	Wildlife	1.41E+11	1.27E+11	1.41E+11	1.36E+11	1.41E+11	1.36E+11
9	Human/Pet	8.41E+12	7.60E+12	8.41E+12	8.14E+12	8.41E+12	8.14E+12
	Livestock	1.21E+09	1.10E+09	1.62E+09	2.35E+09	2.43E+09	2.74E+09
	Wildlife	1.59E+11	1.44E+11	1.59E+11	1.54E+11	1.59E+11	1.54E+11

Table B.2 Monthly, directly deposited fecal coliform loads in each reach of the Straight Creek watershed (subwatersheds 6-9) (cont.).

Reach	Source	Jul (cfu)	Aug (cfu)	Sep (cfu)	Oct (cfu)	Nov (cfu)	Dec (cfu)
6	Human/Pet	9.72E+12	9.72E+12	9.41E+12	9.72E+12	9.41E+12	9.72E+12
	Livestock	4.61E+08	4.61E+08	3.83E+08	2.64E+08	2.55E+08	1.98E+08
	Wildlife	1.04E+11	1.04E+11	1.01E+11	1.04E+11	1.01E+11	1.04E+11
7	Human/Pet	6.79E+12	6.79E+12	6.58E+12	6.79E+12	6.58E+12	6.79E+12
	Livestock	2.17E+04	2.17E+04	1.80E+04	1.24E+04	1.20E+04	9.30E+03
	Wildlife	8.00E+10	8.00E+10	7.75E+10	8.00E+10	7.75E+10	8.00E+10
8	Human/Pet	1.72E+13	1.72E+13	1.66E+13	1.72E+13	1.66E+13	1.72E+13
	Livestock	9.23E+08	9.23E+08	7.65E+08	5.27E+08	5.10E+08	3.95E+08
	Wildlife	1.41E+11	1.41E+11	1.36E+11	1.41E+11	1.36E+11	1.41E+11
9	Human/Pet	8.41E+12	8.41E+12	8.14E+12	8.41E+12	8.14E+12	8.41E+12
	Livestock	2.83E+09	2.83E+09	2.35E+09	1.62E+09	1.57E+09	1.21E+09
	Wildlife	1.59E+11	1.59E+11	1.54E+11	1.59E+11	1.54E+11	1.59E+11

Table B.3 Existing annual loads from direct-deposition sources for the Straight Creek watershed (subwatersheds 6-9).

Source	Annual Total Loads (cfu)
Human	
Straight pipes	4.96E+14
Livestock	
Beef	1.17E+10
Horse	2.38E+10
Other Cattle	2.38E+06
Wildlife	
Beaver	7.65E+09
Deer	2.18E+10
Duck	6.16E+08
Goose	5.57E+11
Muskrat	4.81E+12
Raccoon	3.05E+11
Turkey	8.63E+06
Total	**5.02E+14**

Table B. 4 Existing annual loads from land-based sources for the Straight Creek watershed (subwatersheds 6-9).

Source	Abandoned Mine Land (cfu)	Active Mine (cfu)	Commercial (cfu)	Cropland (cfu)	Forest (cfu)	Pasture/Hay (cfu)	Livestock Access (cfu)
Human							
Septic failures	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pet							
Cat	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Dog	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rooster	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Duck	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Goose	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Turkey	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Livestock							
Beef	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.21E+12	7.00E+10
Horse	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.52E+12	2.15E+11
Other Cattle	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.51E+08	1.97E+07
Wildlife							
Beaver	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Deer	5.18E+12	4.89E+11	0.00E+00	2.70E+10	3.74E+13	1.11E+11	2.52E+09
Duck	1.55E+09	3.56E+08	8.27E+07	1.34E+07	1.12E+10	4.46E+07	4.72E+06
Goose	2.13E+12	4.89E+11	1.14E+11	1.84E+10	1.53E+13	6.13E+10	6.48E+09
Muskrat	1.00E+13	2.30E+12	5.34E+11	8.66E+10	7.20E+13	2.88E+11	3.05E+10
Raccoon	1.38E+13	2.79E+12	2.22E+11	9.95E+10	9.93E+13	3.79E+11	8.75E+09
Turkey	2.06E+09	1.94E+08	0.00E+00	2.68E+06	1.49E+10	1.10E+07	2.50E+05
Total	3.11E+13	6.07E+12	8.70E+11	2.32E+11	2.24E+14	7.57E+12	3.33E+11

Table B.4 Existing annual loads from land-based sources for the Straight Creek watershed (subwatersheds 6-9) (cont.).

Source	Barren (cfu)	Reclaimed Mine Land (cfu)	Residential (cfu)	Roads (cfu)	Water (cfu)	Wetland (cfu)
Human						
Septic failures	0.00E+00	0.00E+00	2.69E+13	0.00E+00	0.00E+00	0.00E+00
Pet						
Cat	0.00E+00	0.00E+00	2.42E+07	0.00E+00	0.00E+00	0.00E+00
Dog	0.00E+00	0.00E+00	2.71E+13	0.00E+00	0.00E+00	0.00E+00
Rooster	0.00E+00	0.00E+00	1.01E+12	0.00E+00	0.00E+00	0.00E+00
Duck	0.00E+00	0.00E+00	1.74E+09	0.00E+00	0.00E+00	0.00E+00
Goose	0.00E+00	0.00E+00	4.43E+12	0.00E+00	0.00E+00	0.00E+00
Turkey	0.00E+00	0.00E+00	2.33E+09	0.00E+00	0.00E+00	0.00E+00
Livestock						
Beef	0.00E+00	3.88E+13	0.00E+00	0.00E+00	1.17E+10	0.00E+00
Horse	0.00E+00	4.76E+12	0.00E+00	0.00E+00	2.38E+10	0.00E+00
Other Cattle	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+06	0.00E+00
Wildlife						
Beaver	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.65E+09	0.00E+00
Deer	0.00E+00	4.49E+10	8.31E+10	2.94E+11	0.00E+00	1.13E+10
Duck	2.91E+06	1.27E+07	5.91E+08	3.94E+08	0.00E+00	2.26E+07
Goose	3.99E+09	1.75E+10	8.11E+11	5.41E+11	0.00E+00	3.11E+10
Muskrat	1.88E+10	8.23E+10	3.81E+12	2.54E+12	0.00E+00	1.46E+11
Raccoon	3.36E+10	1.17E+11	1.90E+12	1.28E+12	0.00E+00	5.71E+10
Turkey	0.00E+00	1.78E+07	0.00E+00	1.15E+08	0.00E+00	4.50E+06
Total	5.64E+10	4.38E+13	6.60E+13	4.66E+12	4.32E+10	2.46E+11

APPENDIX C

IN-STREAM WATER CHEMISTRY DATA

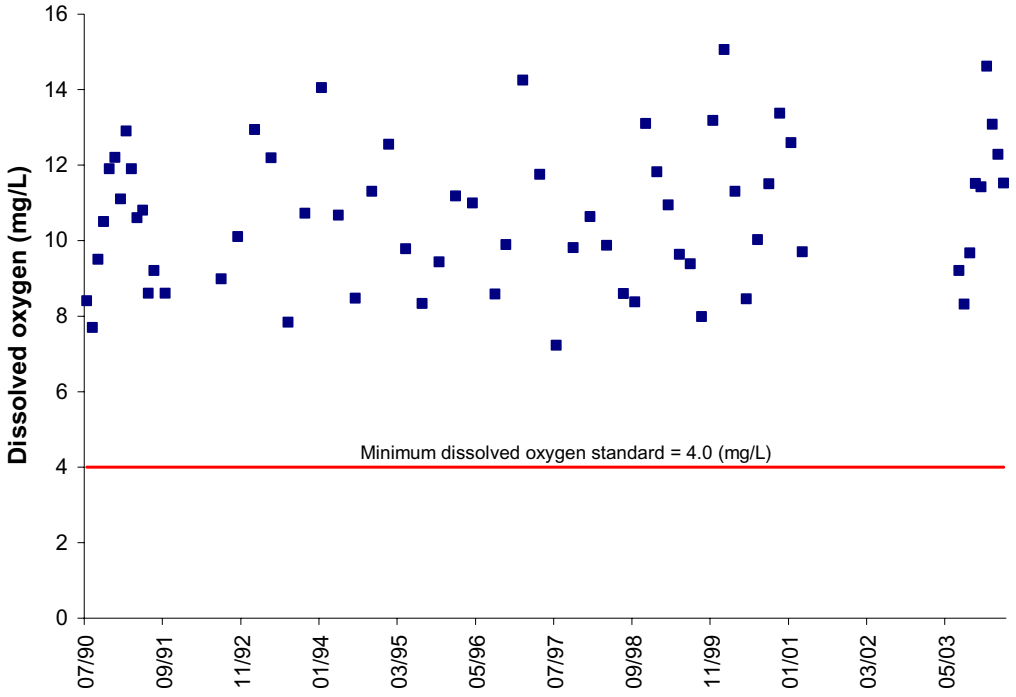

Figure C.1 Dissolved oxygen concentrations at VADEQ station 6BSRA001.11.

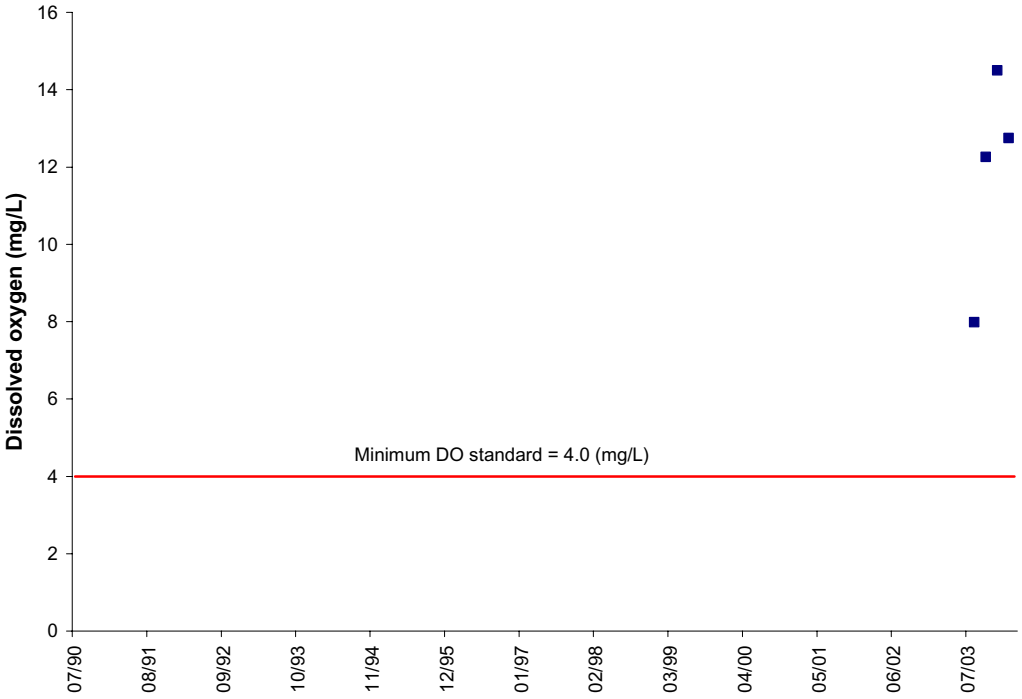

Figure C.2 Dissolved oxygen concentrations at VADEQ station 6BSRA000.10

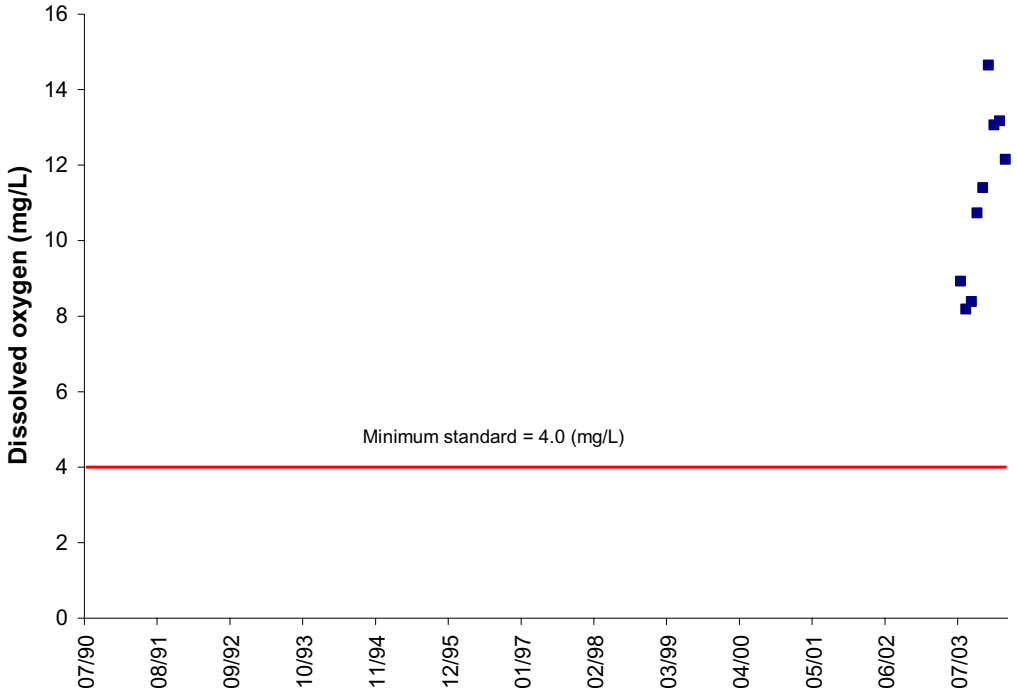

Figure C.3 Dissolved oxygen concentrations at VADEQ station 6BSRA003.22.

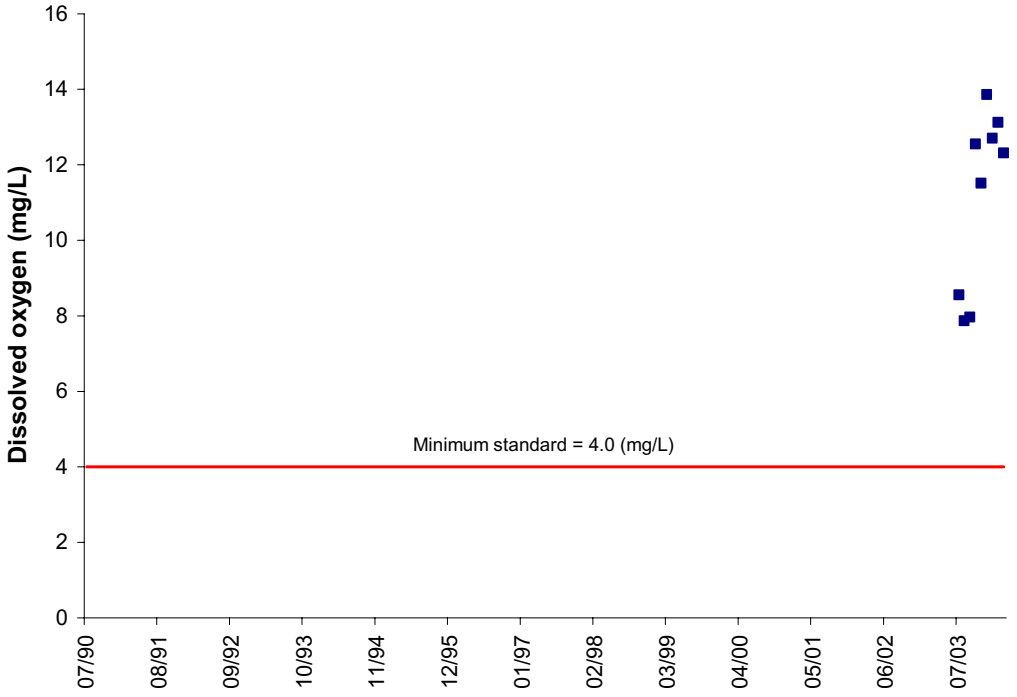

Figure C.4 Dissolved oxygen concentrations at VADEQ station 6BSRA004.16.

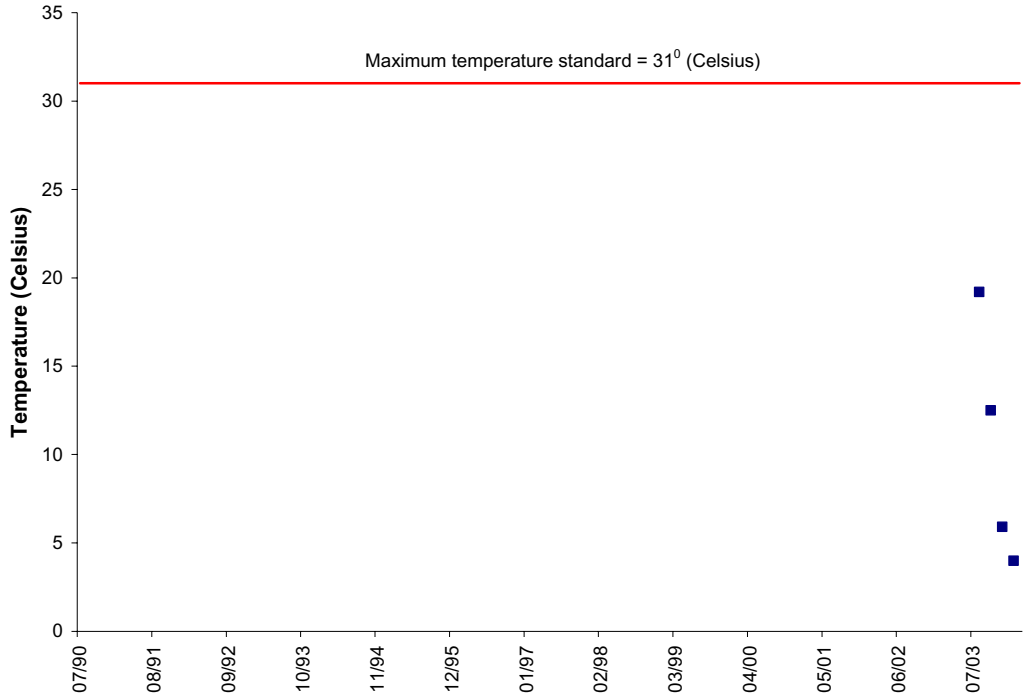

Figure C.5 Temperature values at VADEQ station 6BSRA000.10.

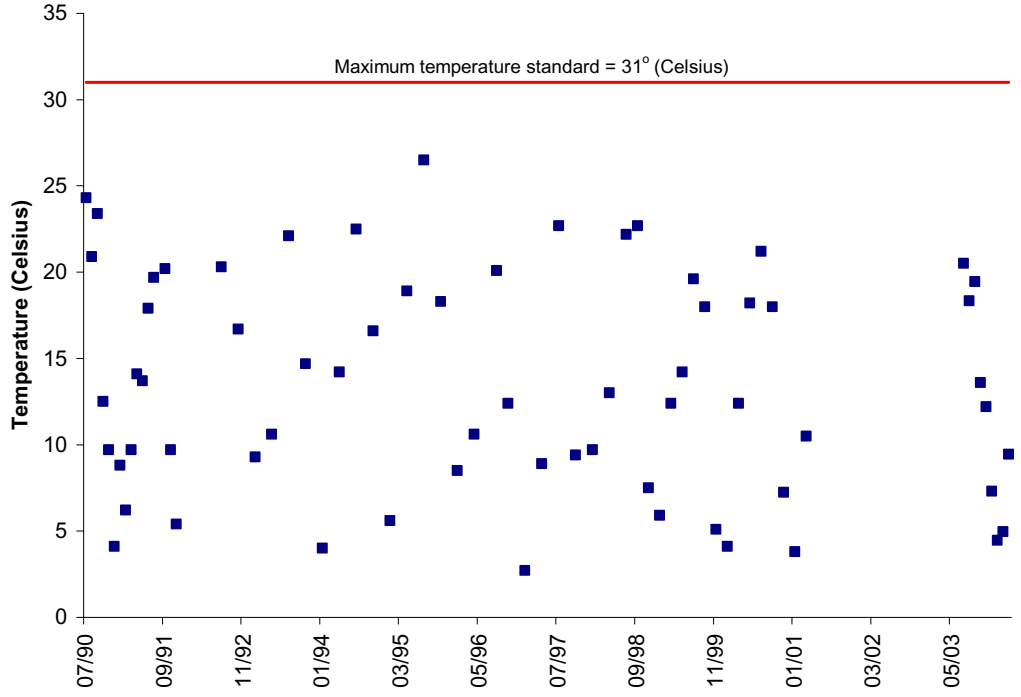

Figure C.6 Temperature values at VADEQ station 6BSRA001.11.

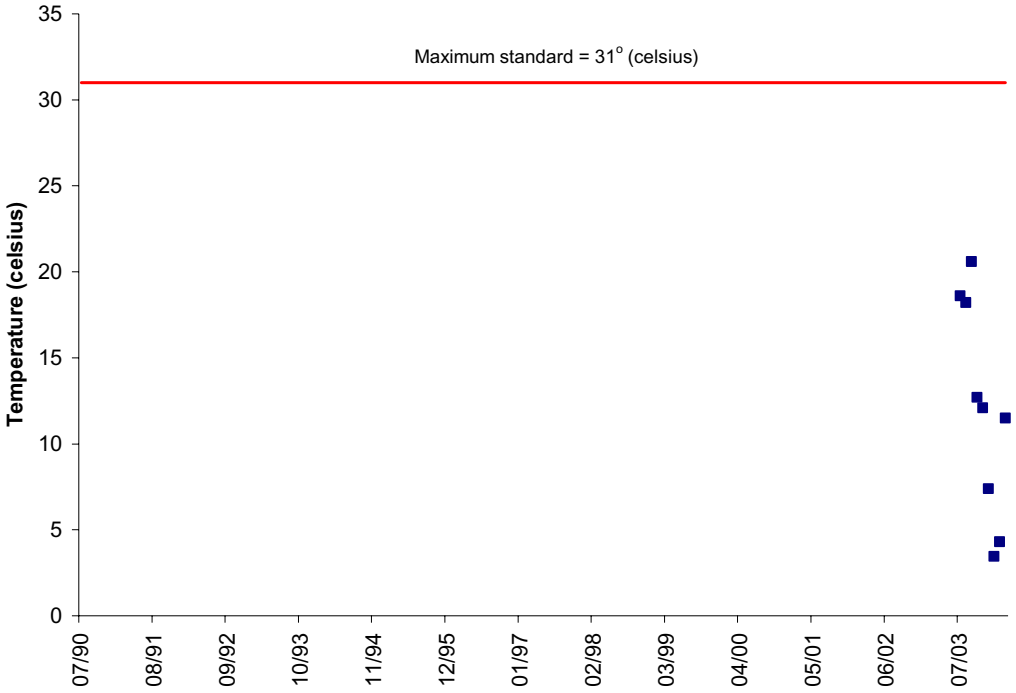

Figure C.7 Temperature values at VADEQ station 6BSRA003.22.

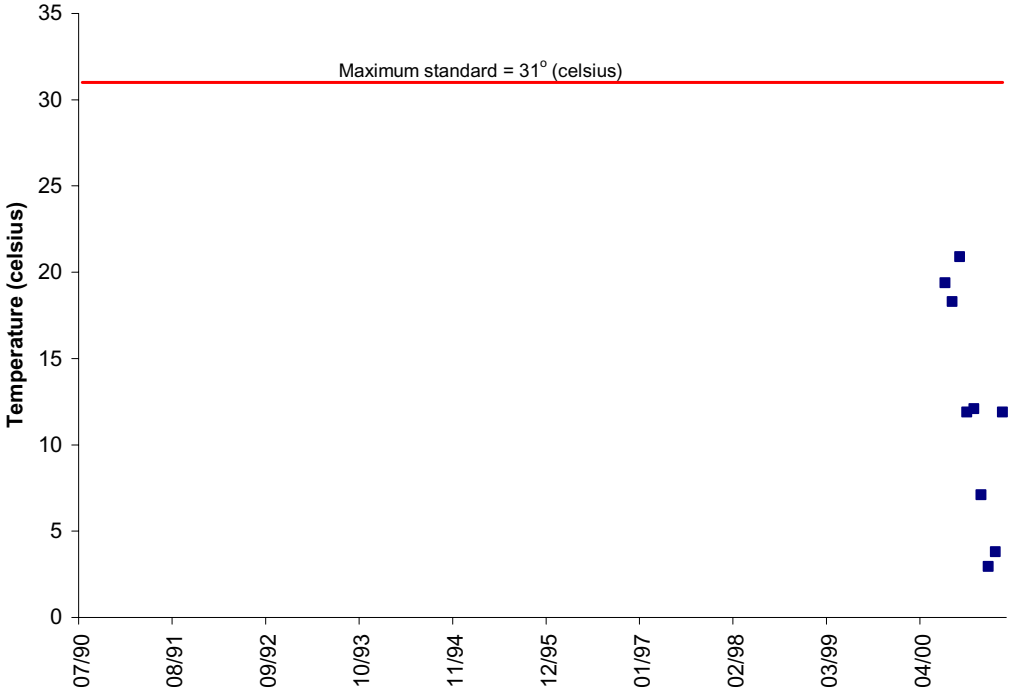

Figure C.8 Temperature values at VADEQ station 6BSRA004.16.

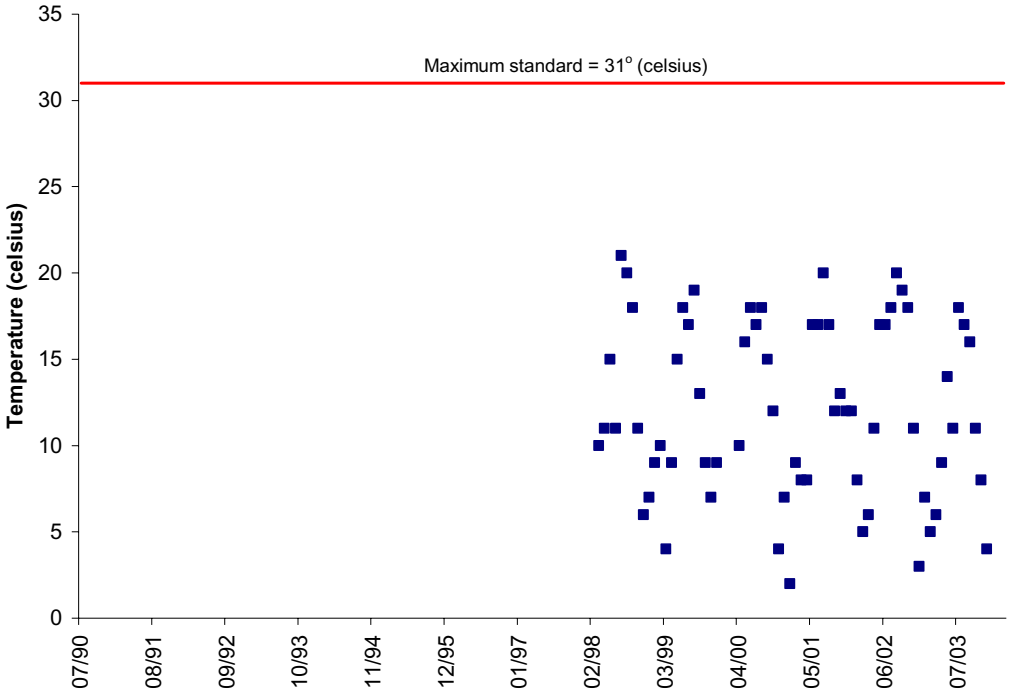

Figure C.9 Temperature values at DMME MPID 0002877.

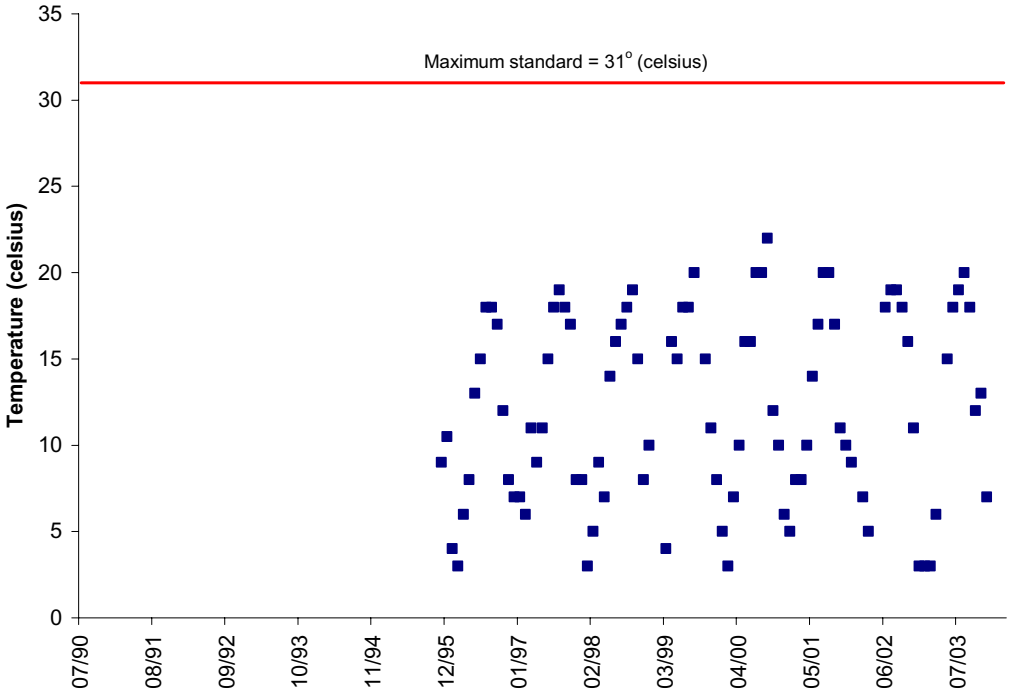

Figure C.10 Temperature values at DMME MPID 1020127.

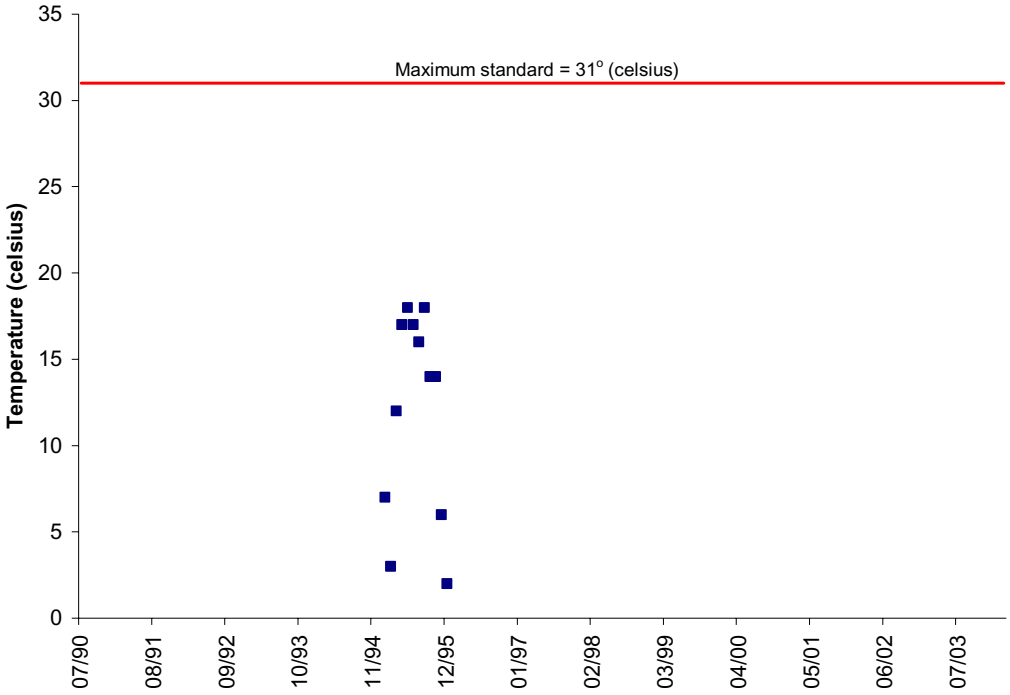

Figure C.11 Temperature values at DMME MPID 1020209.

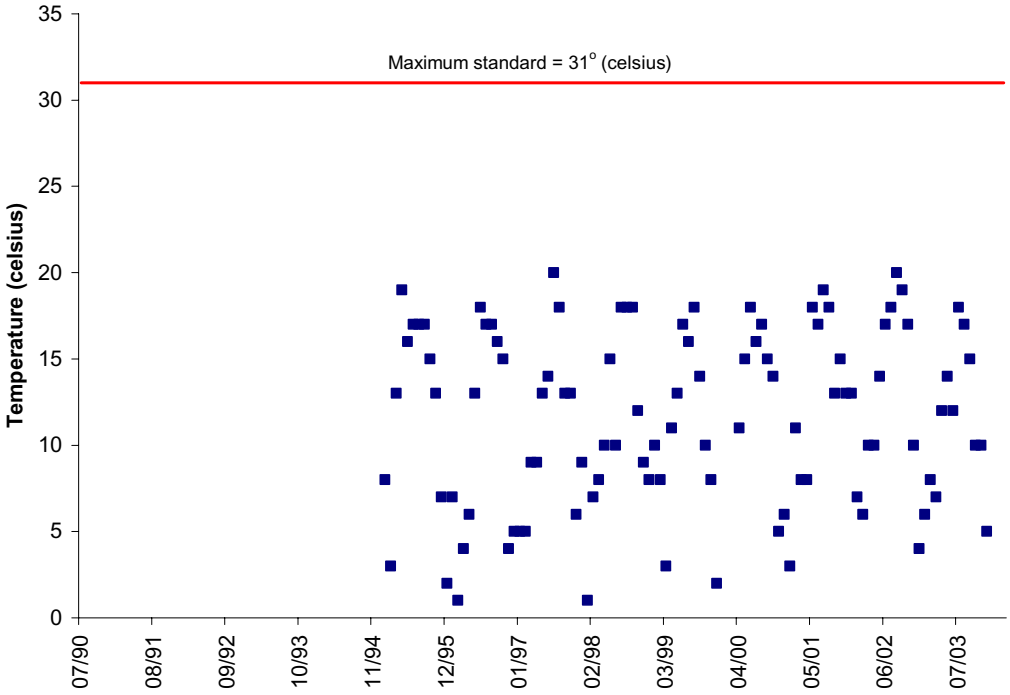

Figure C.12 Temperature values at DMME MPID 1020225.

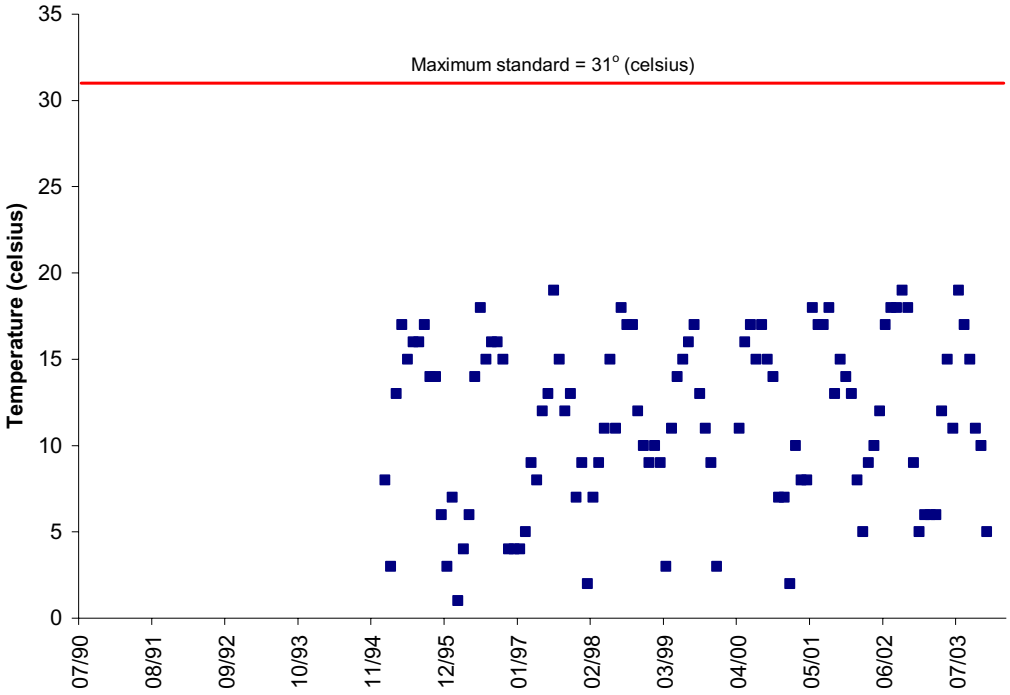

Figure C.13 Temperature values at DMME MPID 1020226.

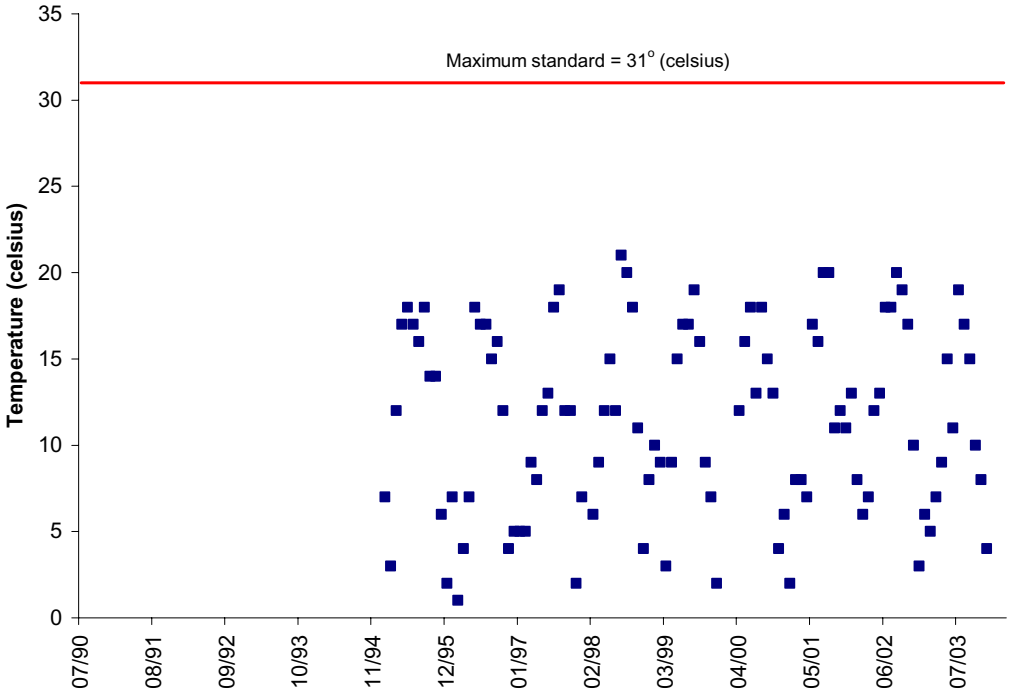

Figure C.14 Temperature values at DMME MPID 1020237.

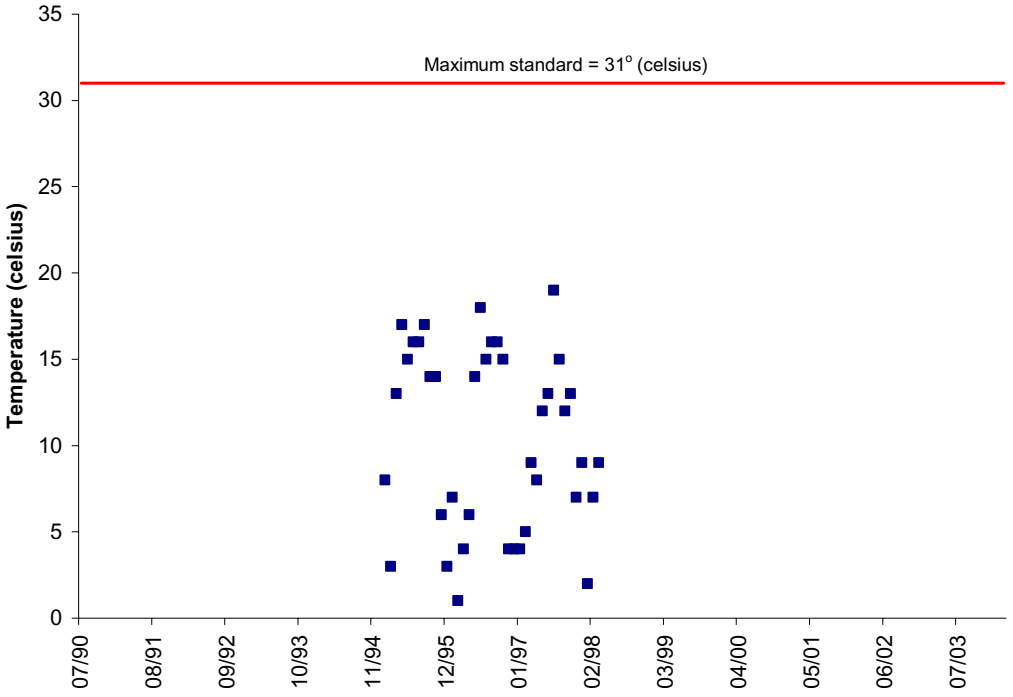

Figure C.15 Temperature values at DMME MPID 1020241.

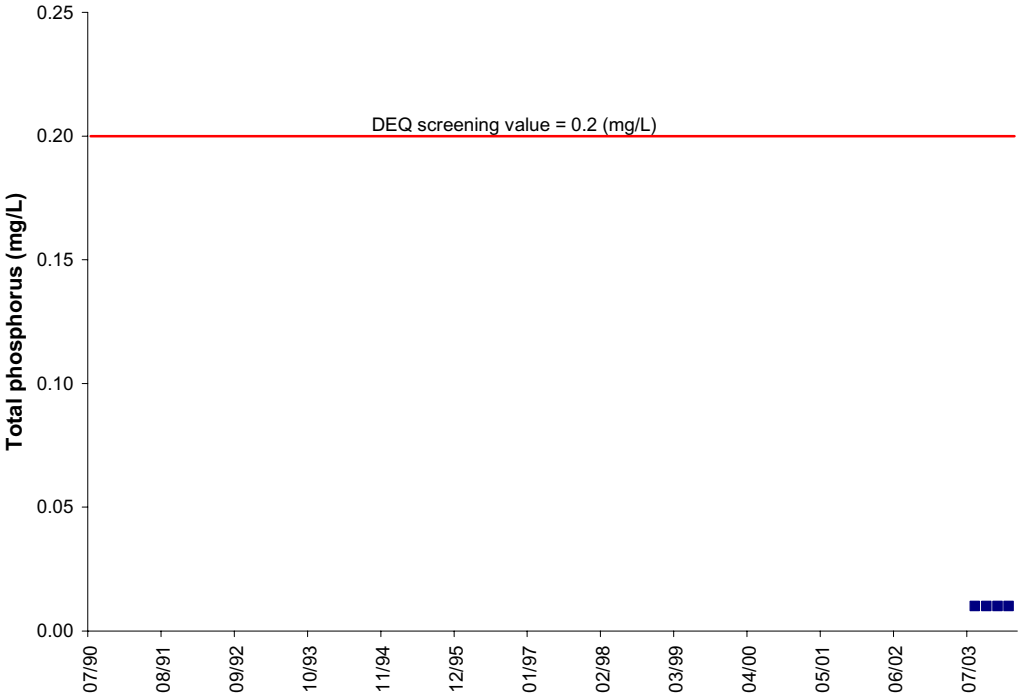

Figure C.16 TP concentrations at VADEQ station 6BSRA000.10.

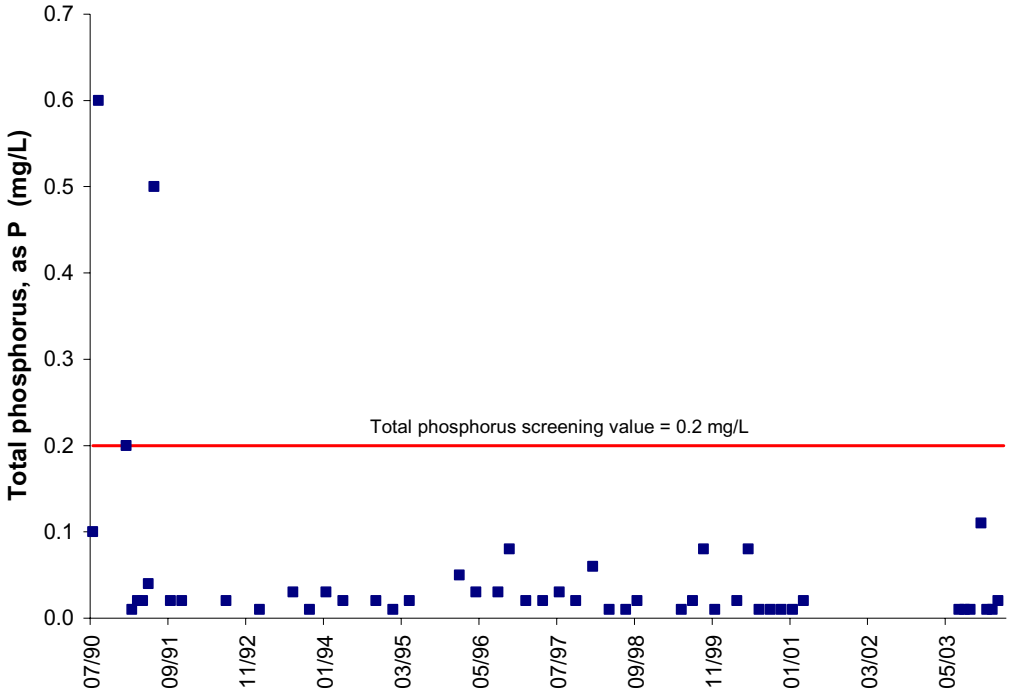

Figure C.17 TP concentrations at VADEQ station 6BSRA001.11.

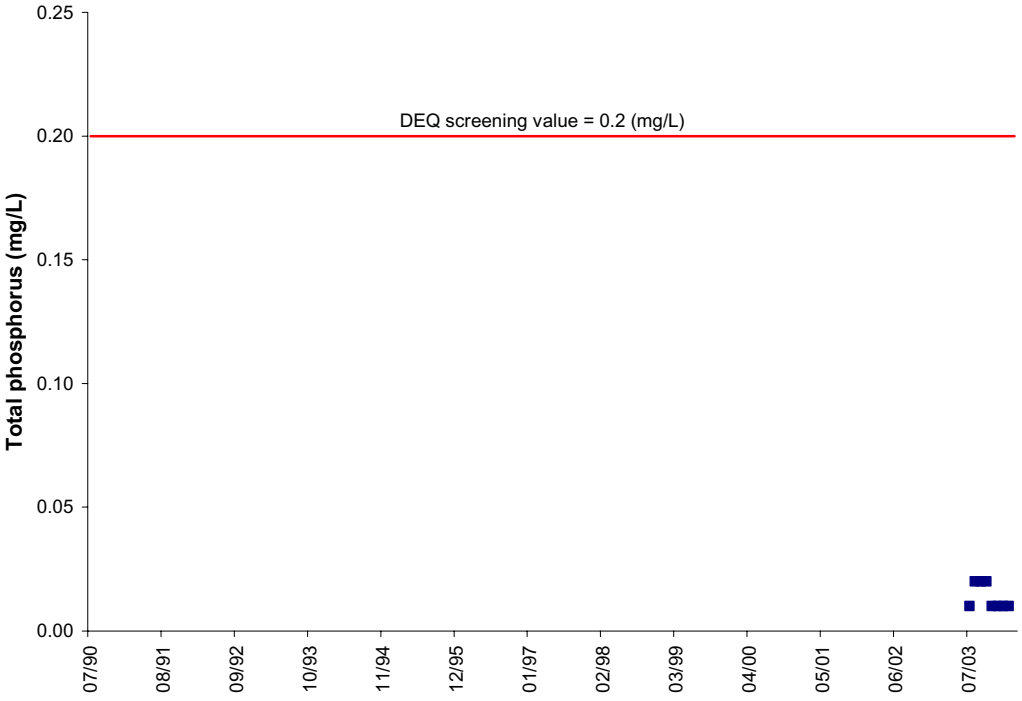

Figure C.18 TP concentrations at VADEQ station 6BSRA003.22.

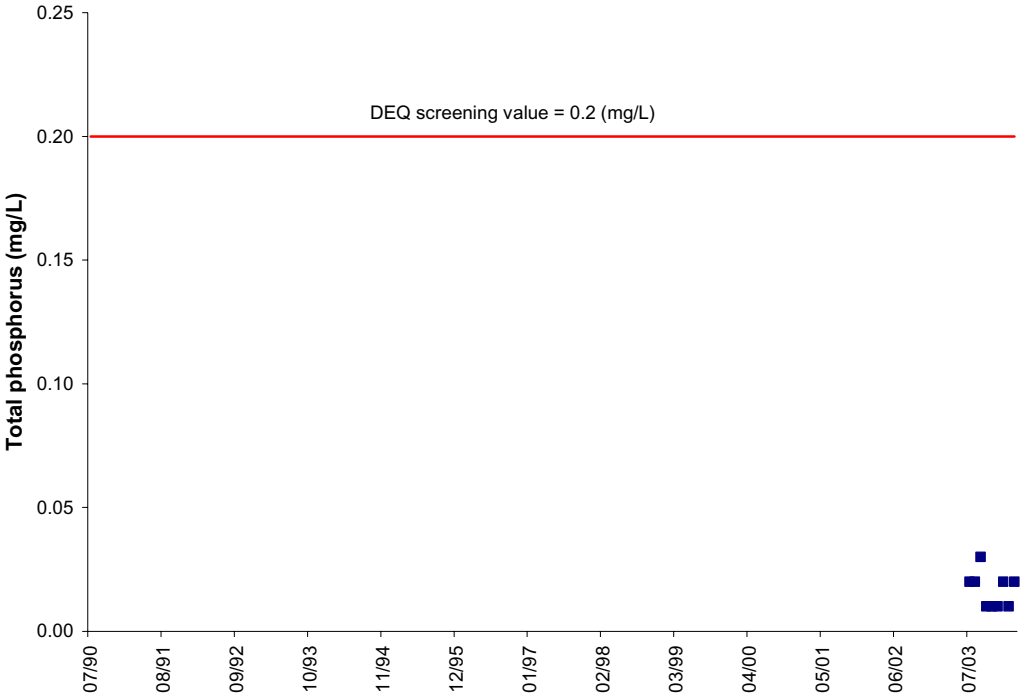

Figure C.19 TP concentrations at VADEQ station 6BSRA004.16.

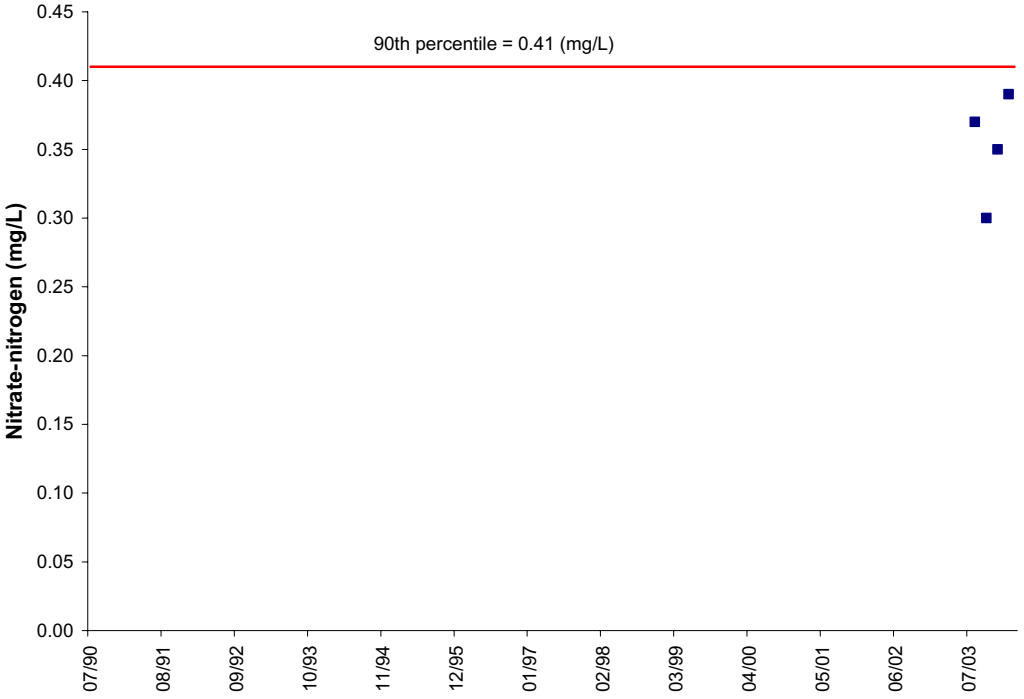

Figure C.20 NO3-N concentrations at VADEQ station 6BSRA000.10.

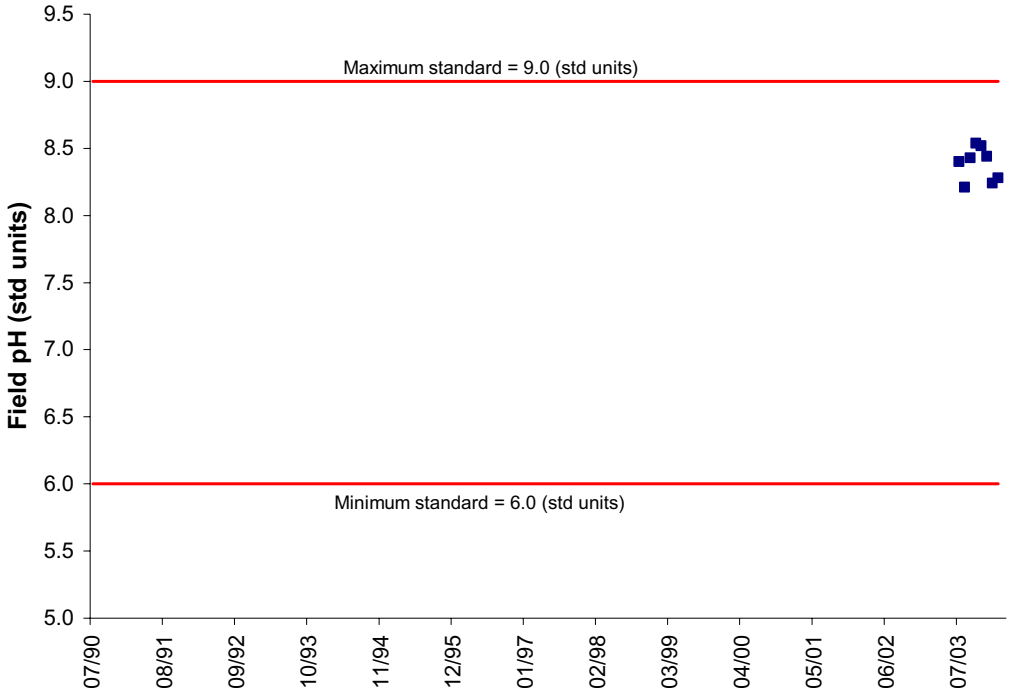

Figure C.21 Field pH values at VADEQ station 6BSRA003.22.

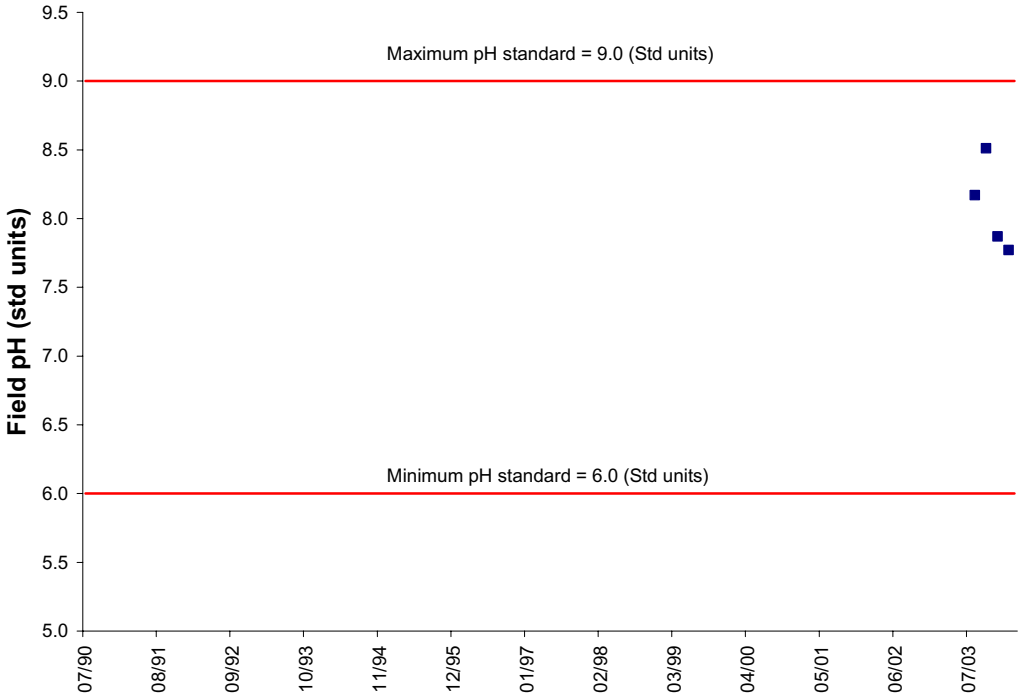

Figure C.22 Field pH values at VADEQ station 6BSRA000.10.

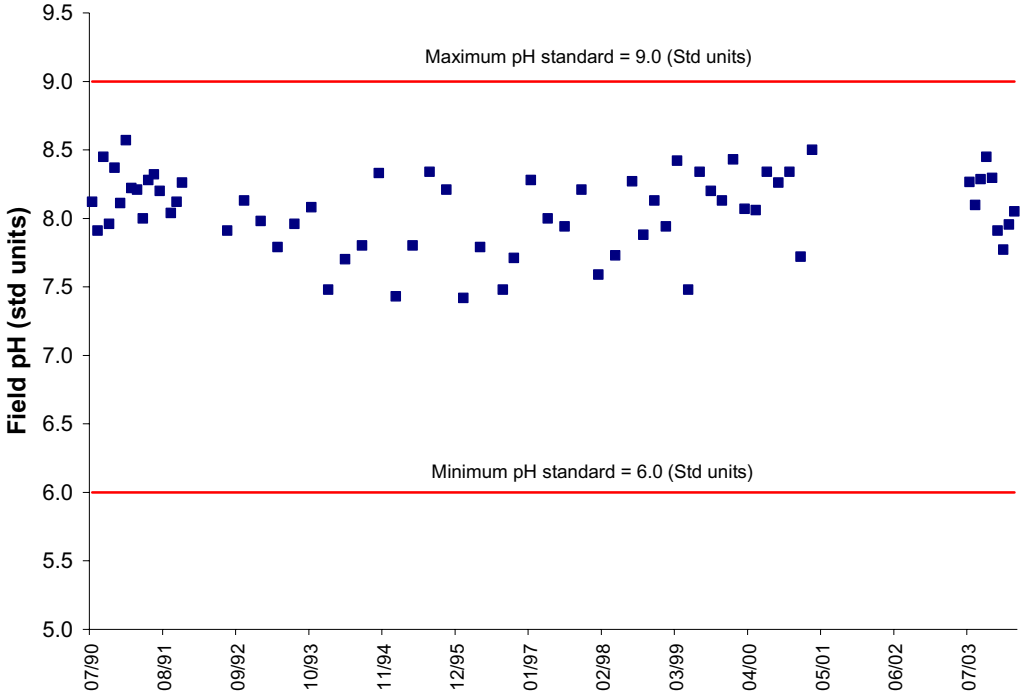

Figure C.23 Field pH values at VADEQ station 6BSRA001.11.

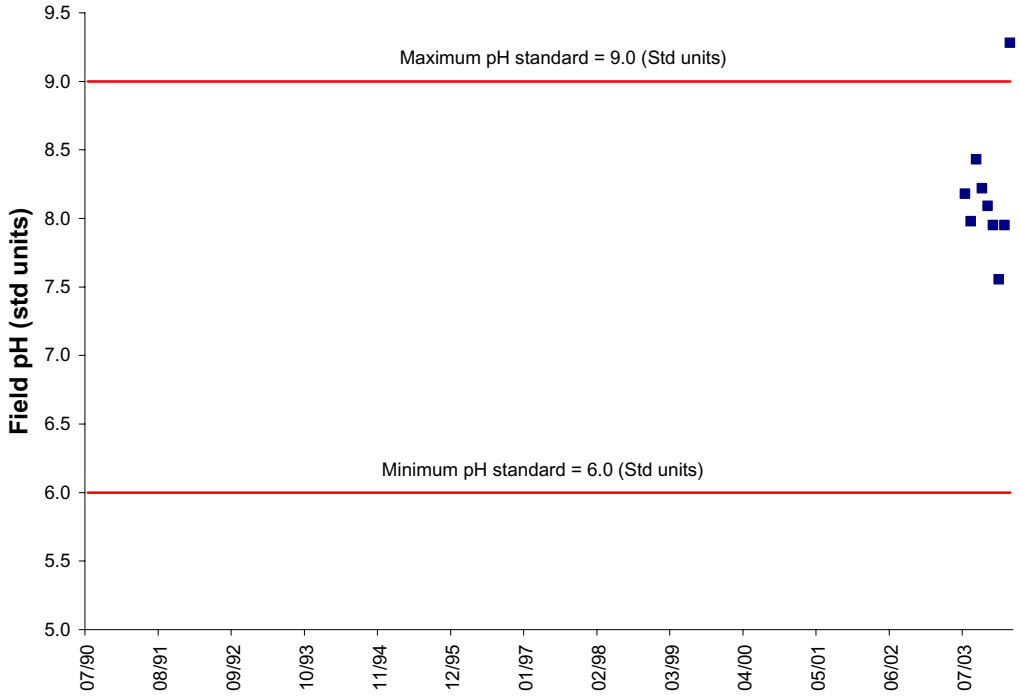

Figure C.24 Field pH values at VADEQ station 6BSRA004.16.

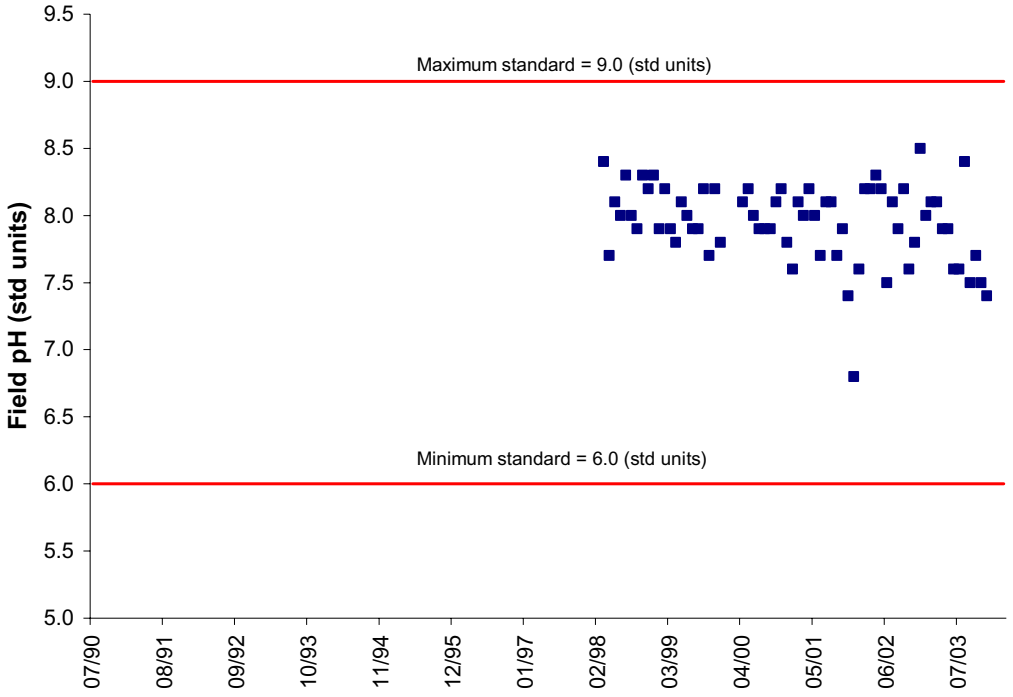

Figure C.25 Field pH values at DMME MPID 0002877.

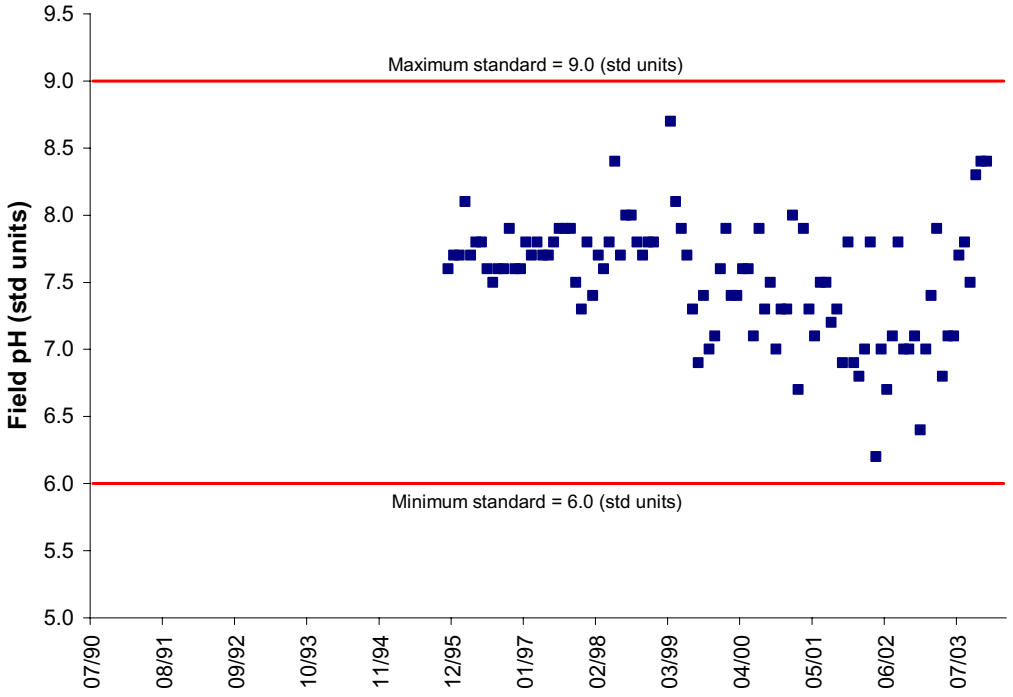

Figure C.26 Field pH values at DMME MPID 1020127.

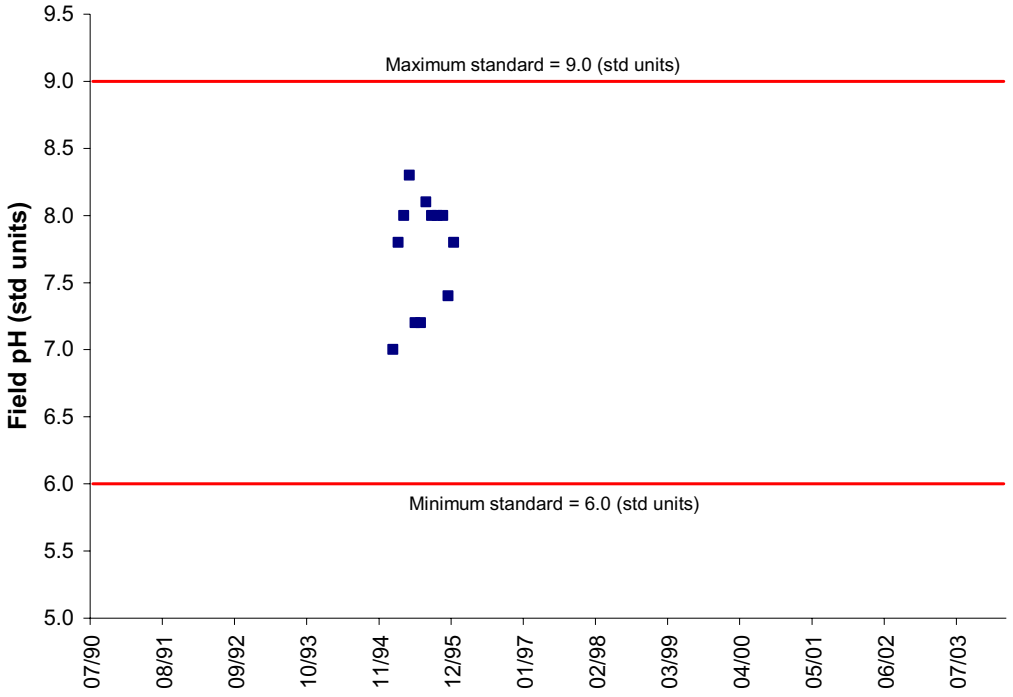

Figure C.27 Field pH values at DMME MPID 1020209.

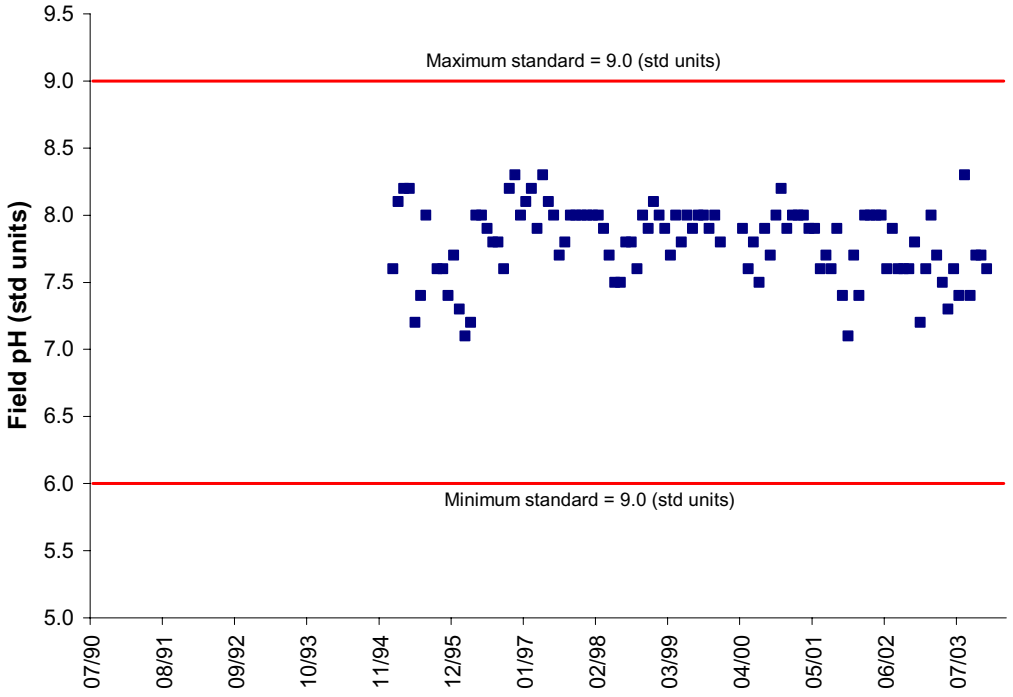

Figure C.28 Field pH values at DMME MPID 1020225.

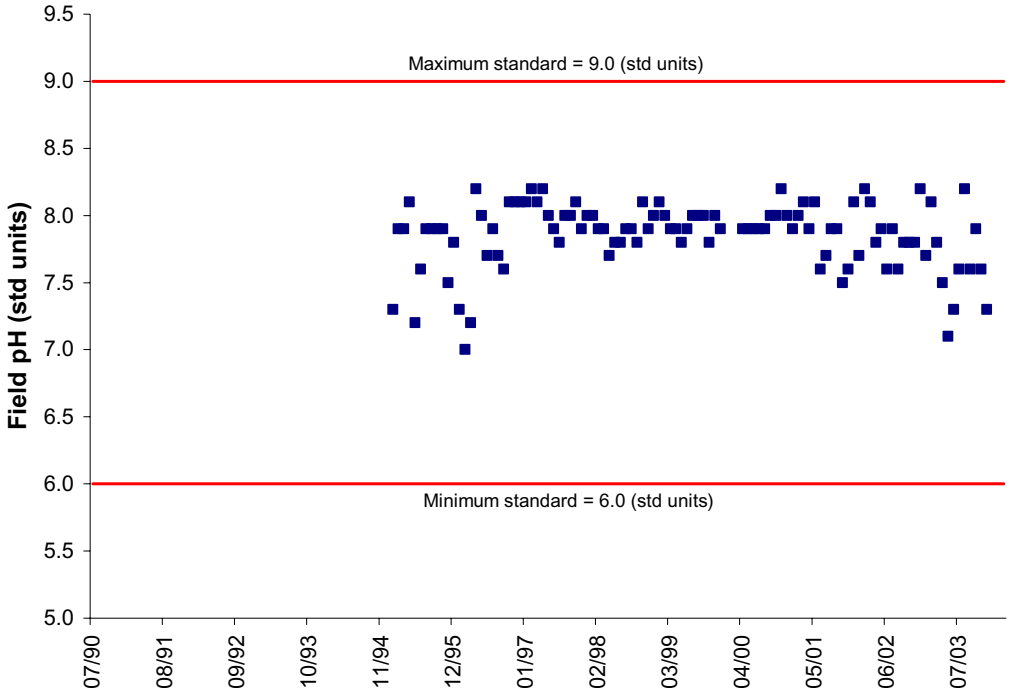

Figure C.29 Field pH values at DMME MPID 1020226.

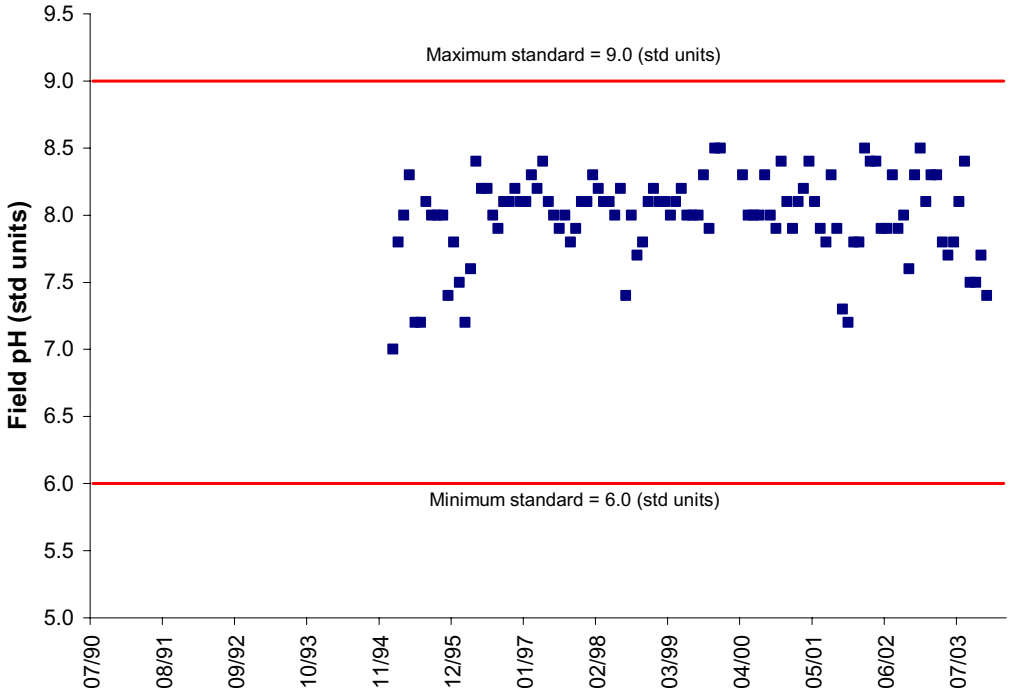

Figure C.30 Field pH values at DMME MPID 1020237.

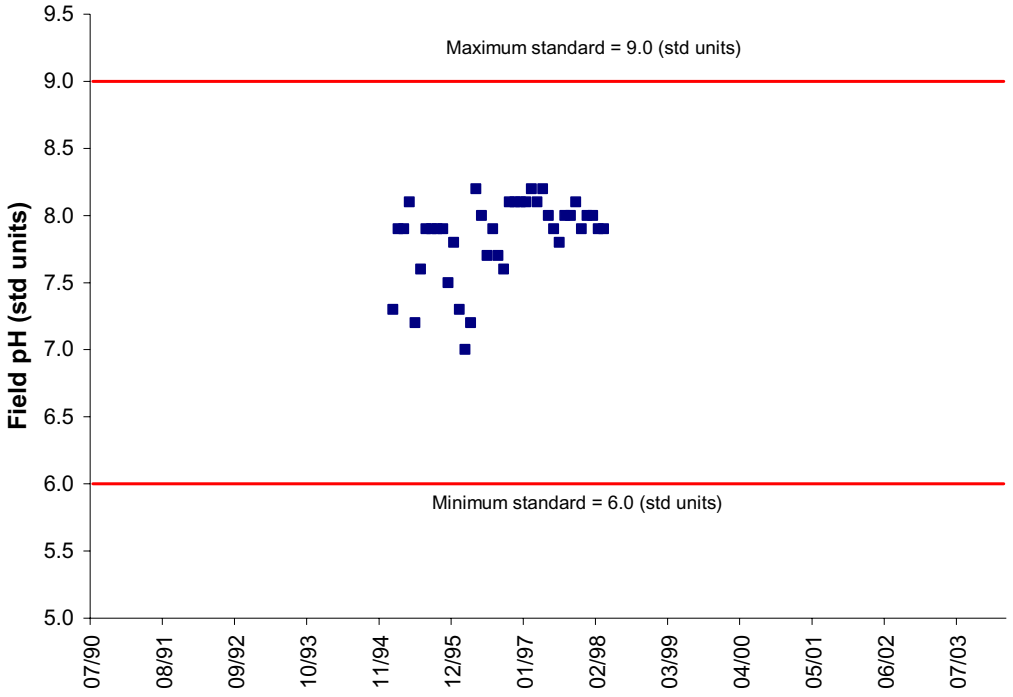

Figure C.31 Field pH values at DMME MPID 1020241.

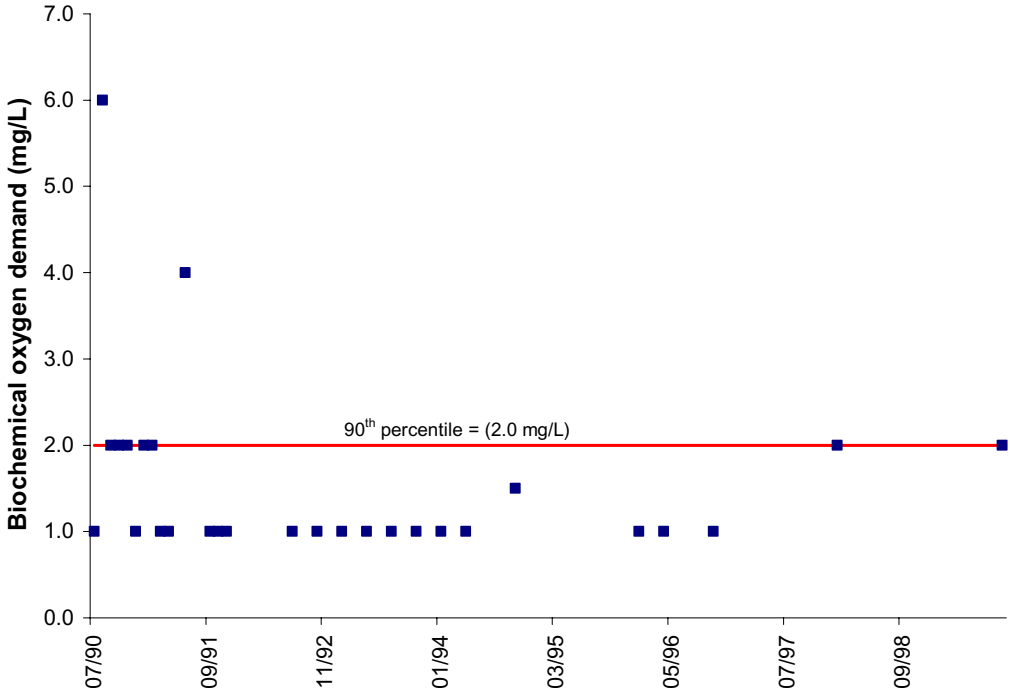

Figure C.32 BOD_5 concentrations at VADEQ station 6BSRA001.11.

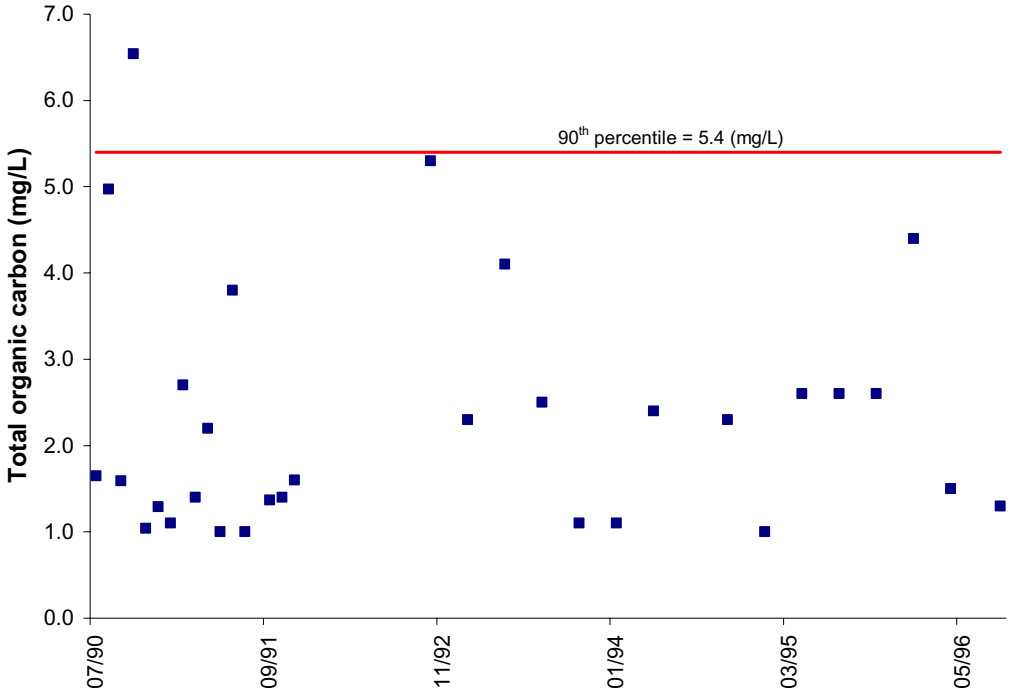

Figure C.33 TOC concentrations at VADEQ station 6BSRA001.11.

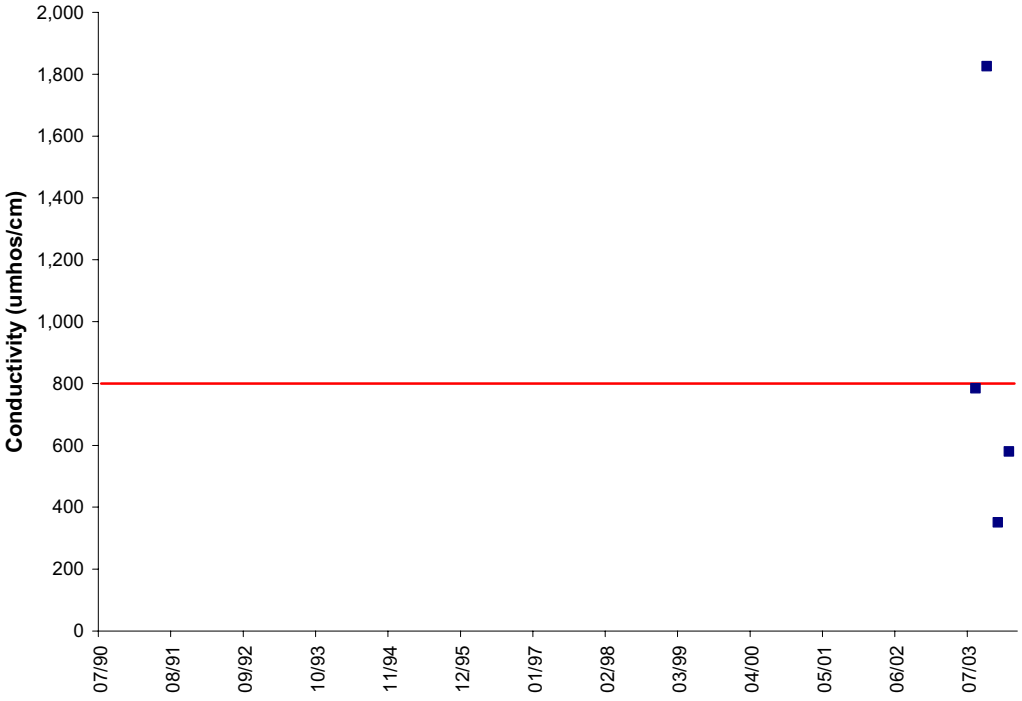

Figure C.34 Conductivity values at VADEQ station 6BSRA000.10.

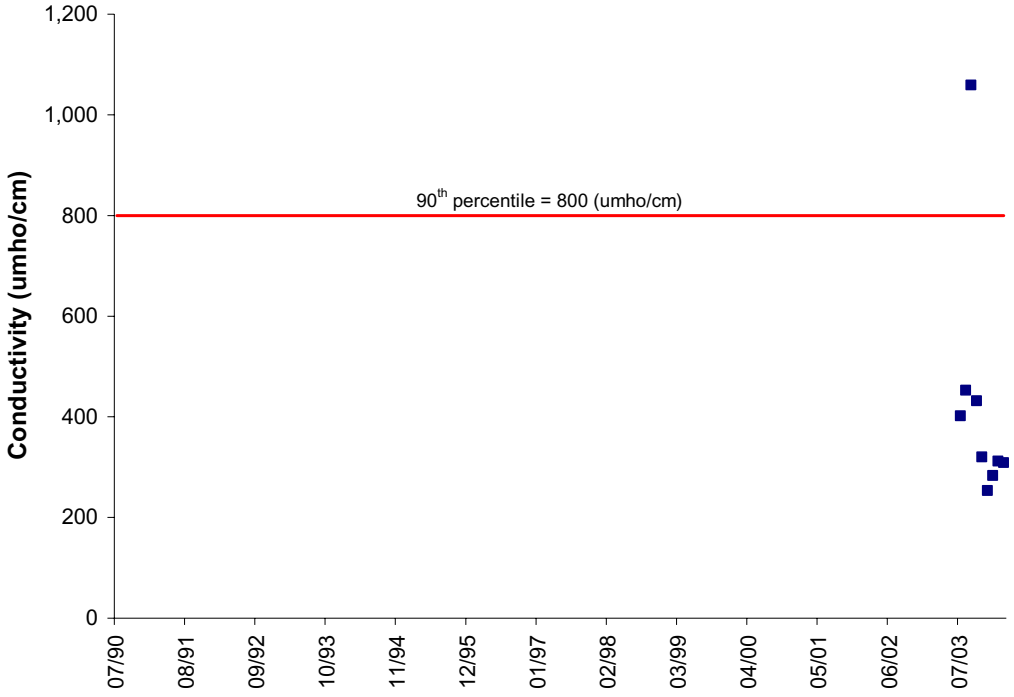

Figure C.35 Conductivity values at VADEQ station 6BSRA004.16.

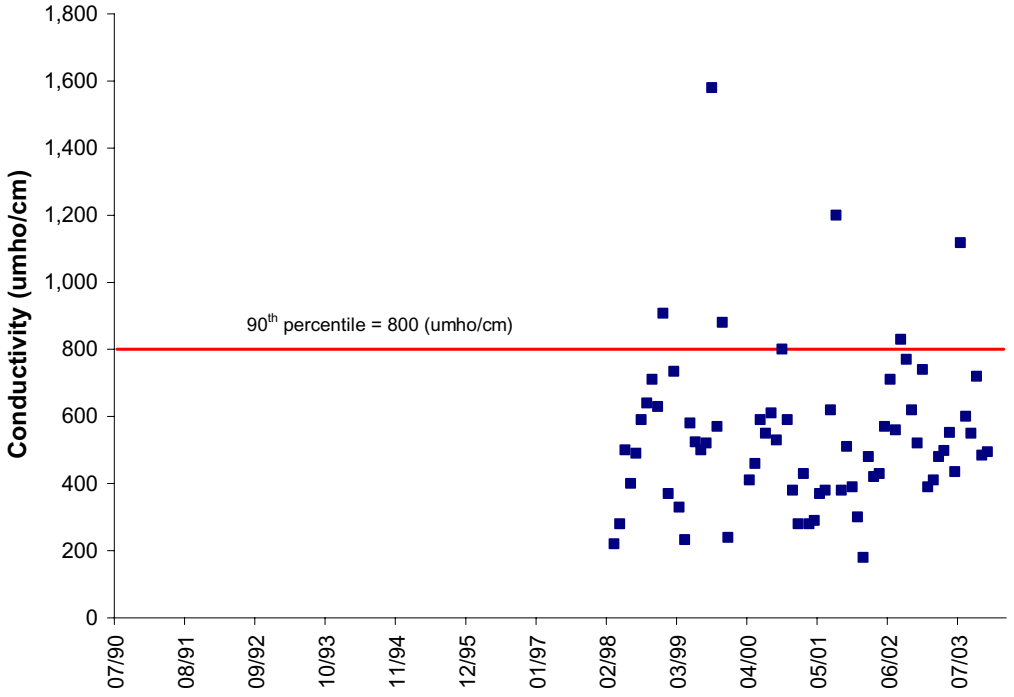

Figure C.36 Conductivity values at DMME MPID 0002877.

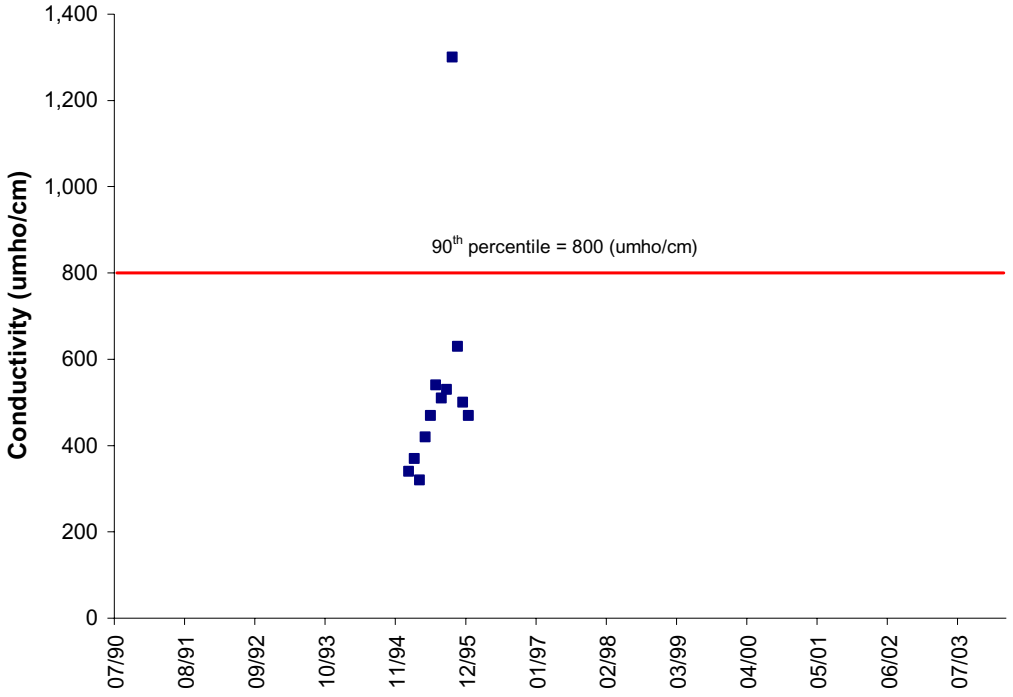

Figure C.37 Conductivity values at DMME MPID 1020209.

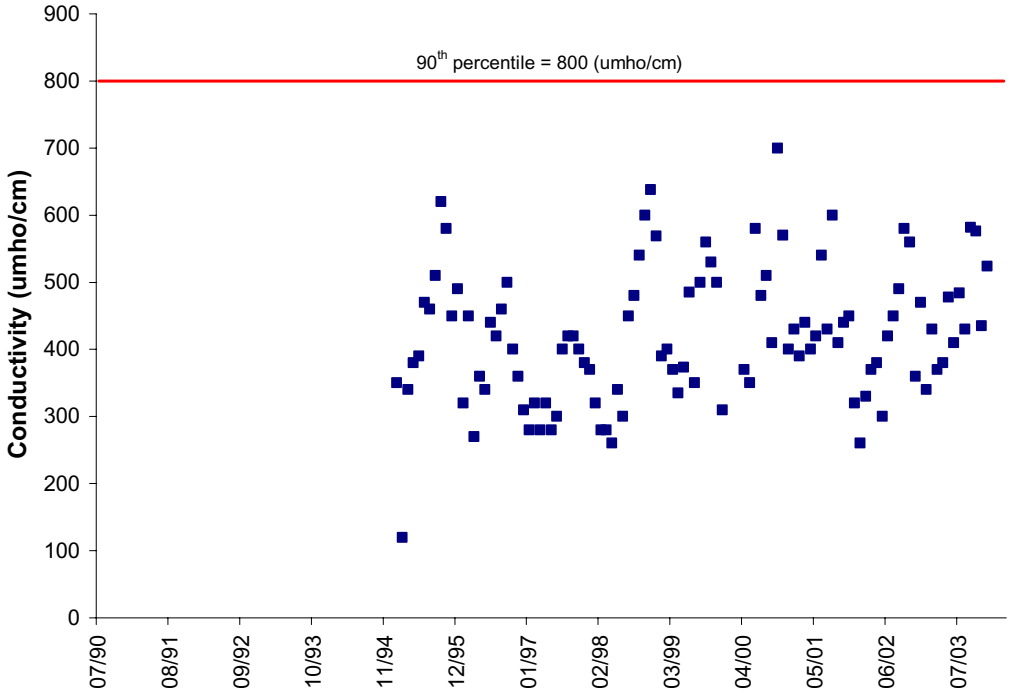

Figure C.38 Conductivity values at DMME MPID 1020225.

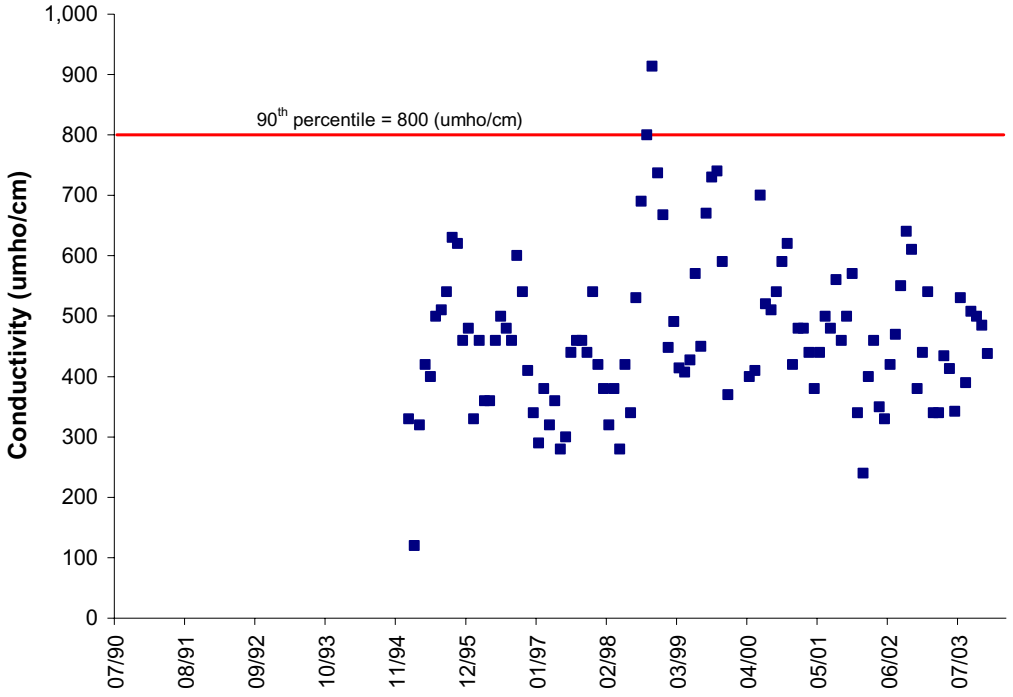

Figure C.39 Conductivity values at DMME MPID 1020226.

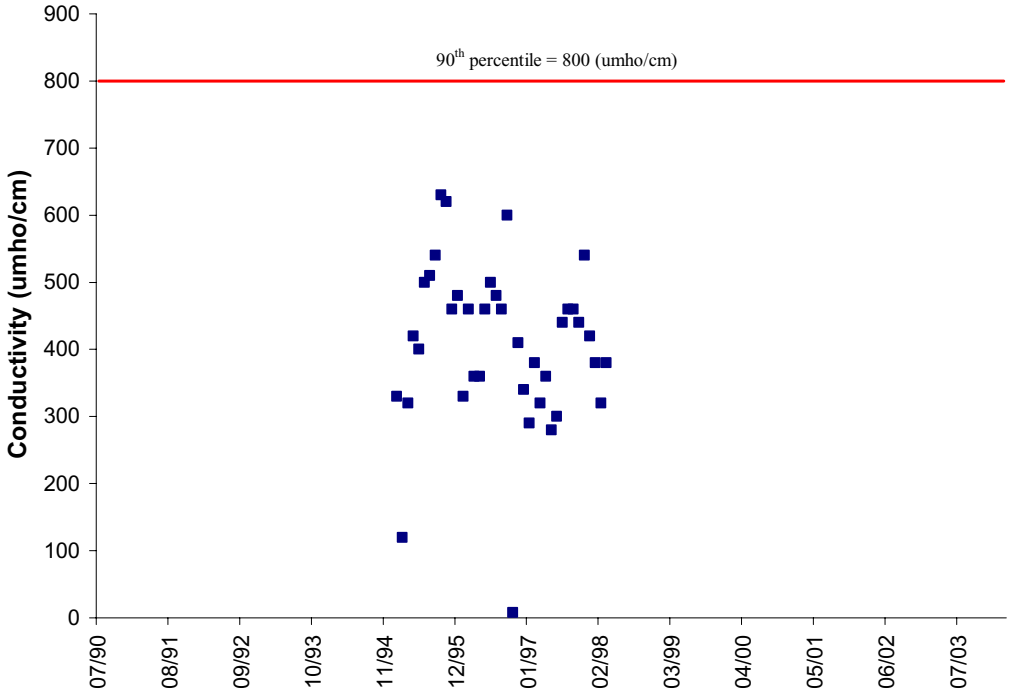

Figure C.40 Conductivity values at DMME MPID 1020241.

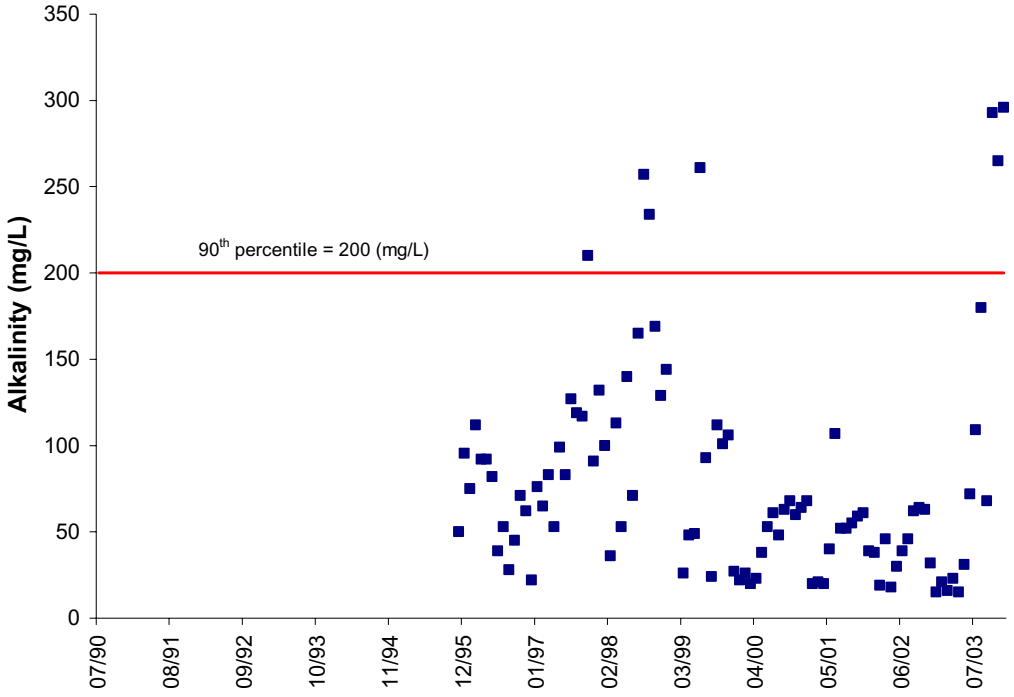

Figure C.41 Alkalinity concentrations at DMME MPID 1020127.

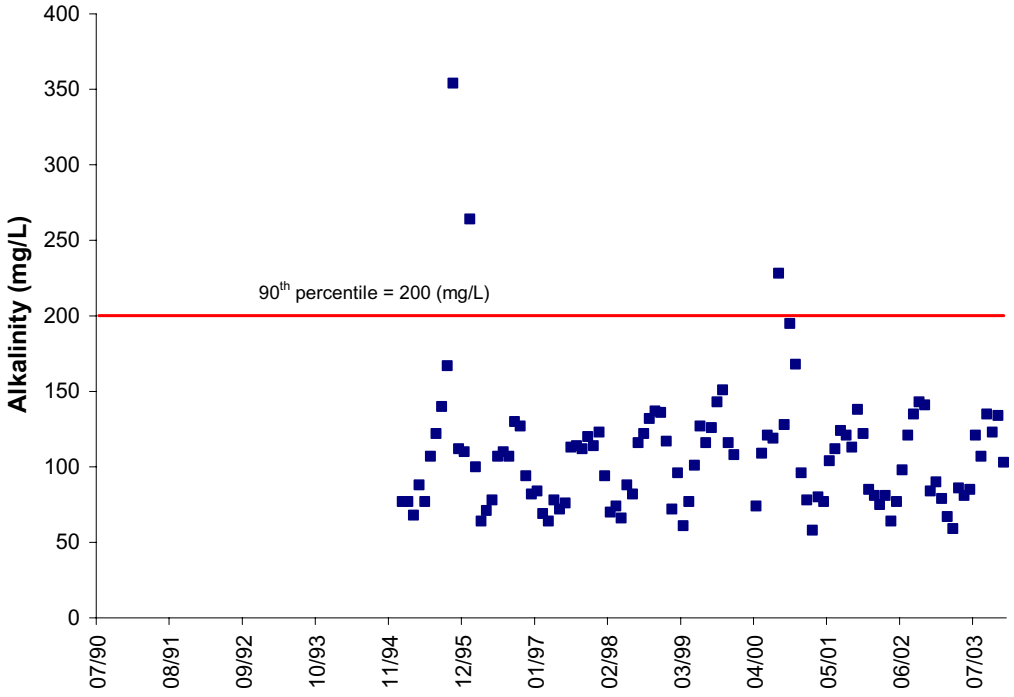

Figure C.42 Alkalinity concentrations at DMME MPID 1020225.

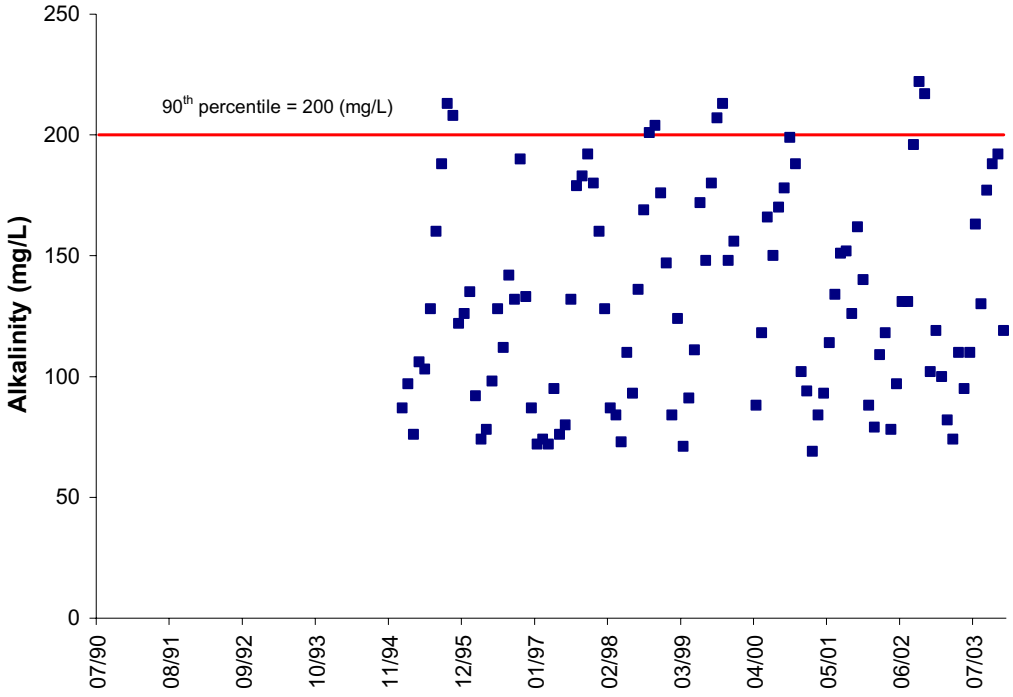

Figure C.43 Alkalinity concentrations at DMME MPID 1020226.

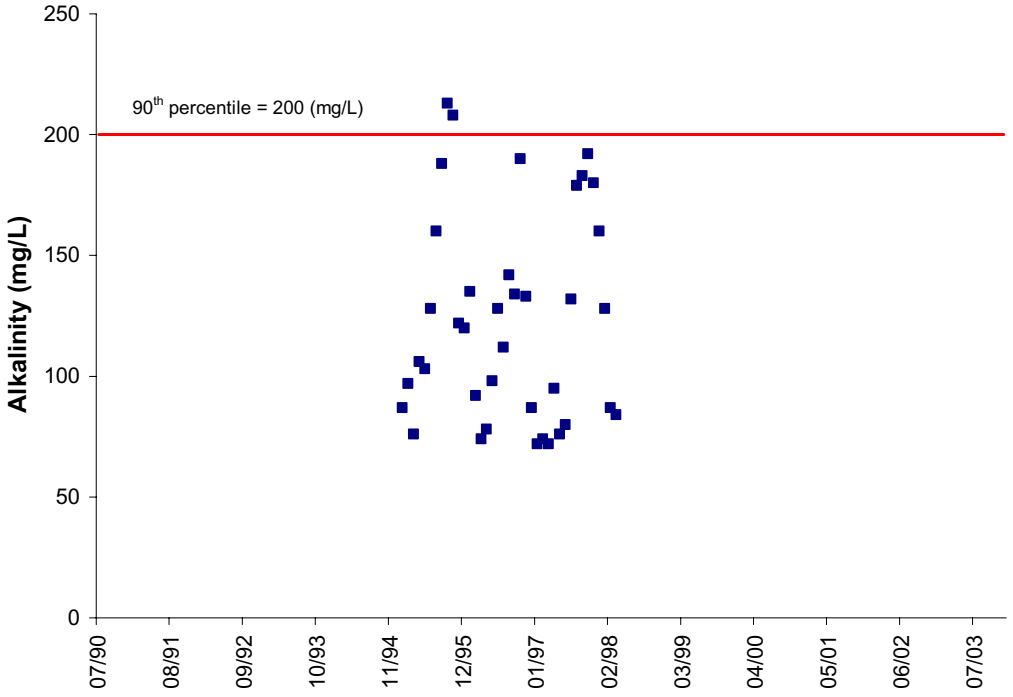

Figure C.44 Alkalinity concentrations at DMME MPID 1020241.

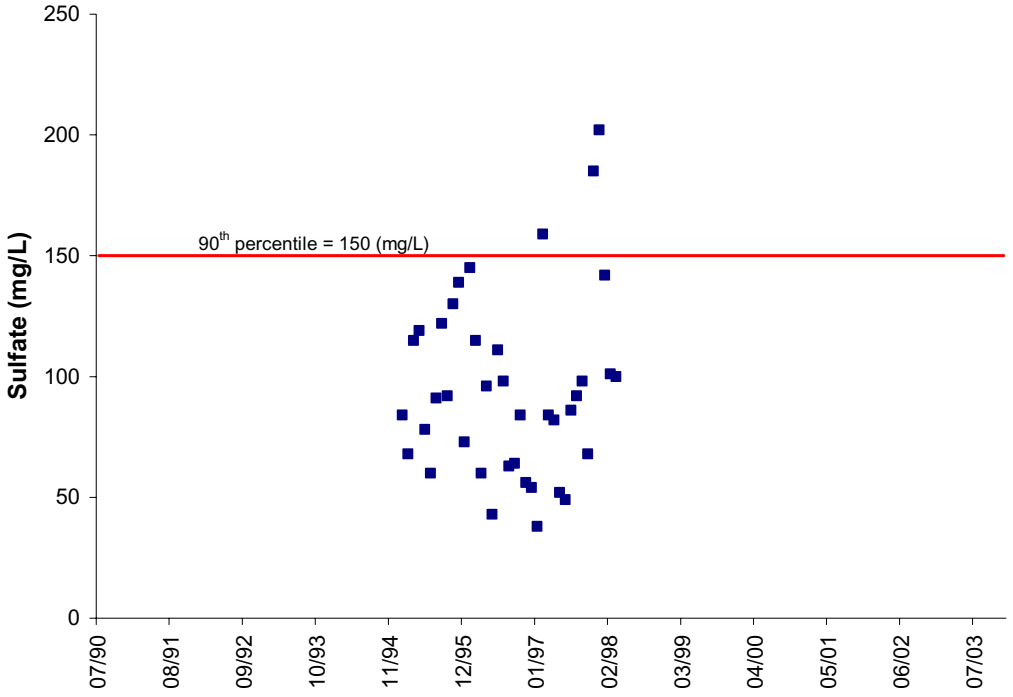

Figure C.45 Sulfate concentrations at DMME MPID 1020241.

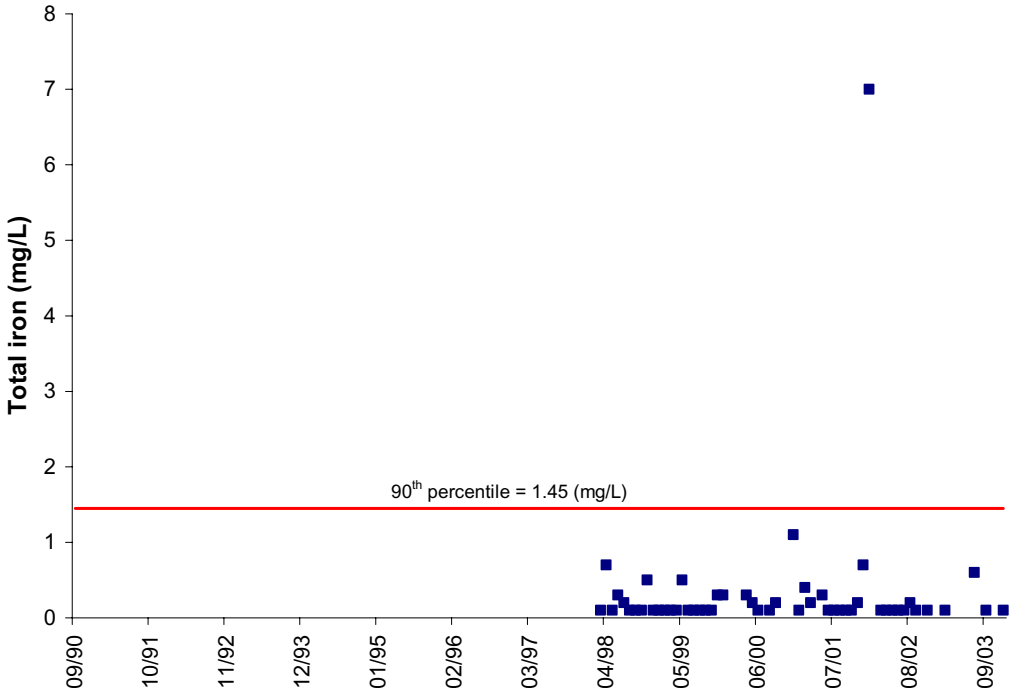

Figure C.46 Total iron concentrations at DMME MPID 0002877.

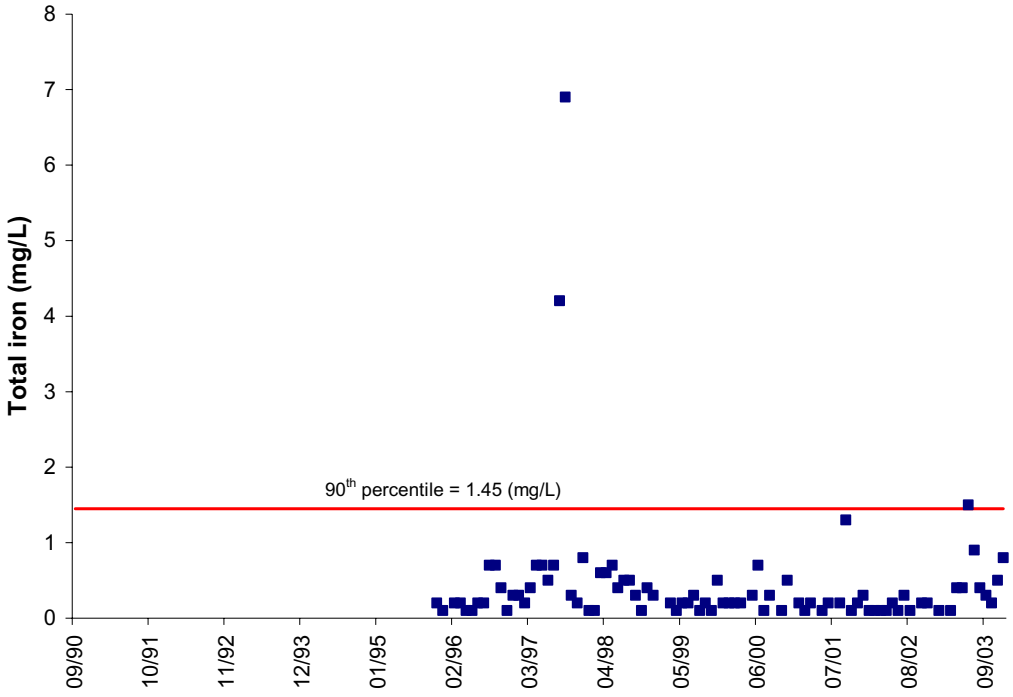

Figure C.47 Total iron concentrations at DMME MPID 1020127.

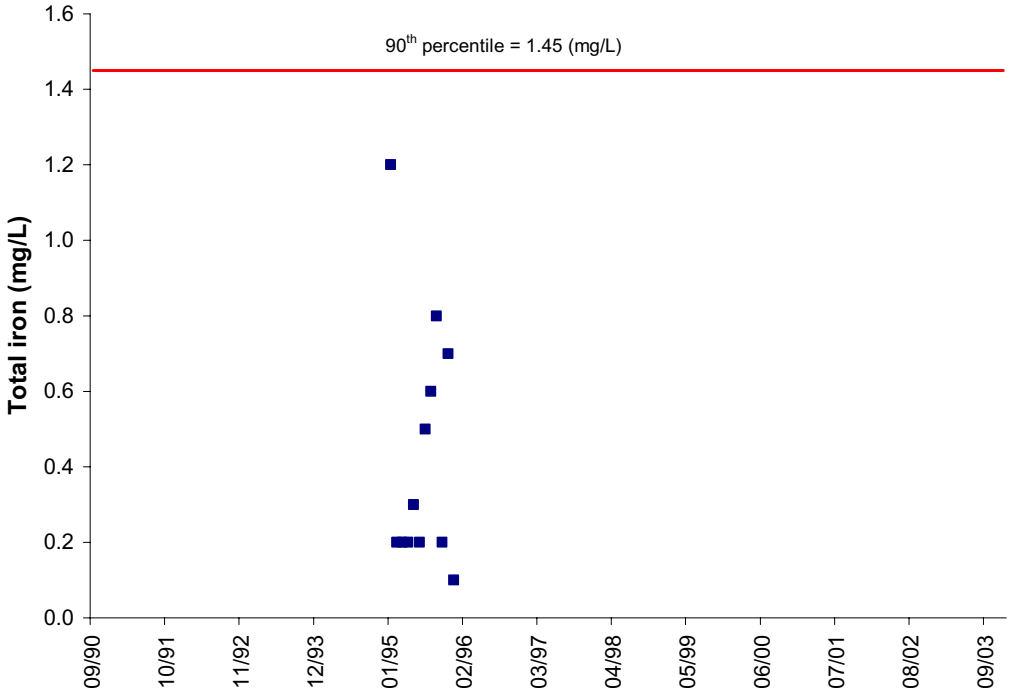

Figure C.48 Total iron concentrations at DMME MPID 1020209.

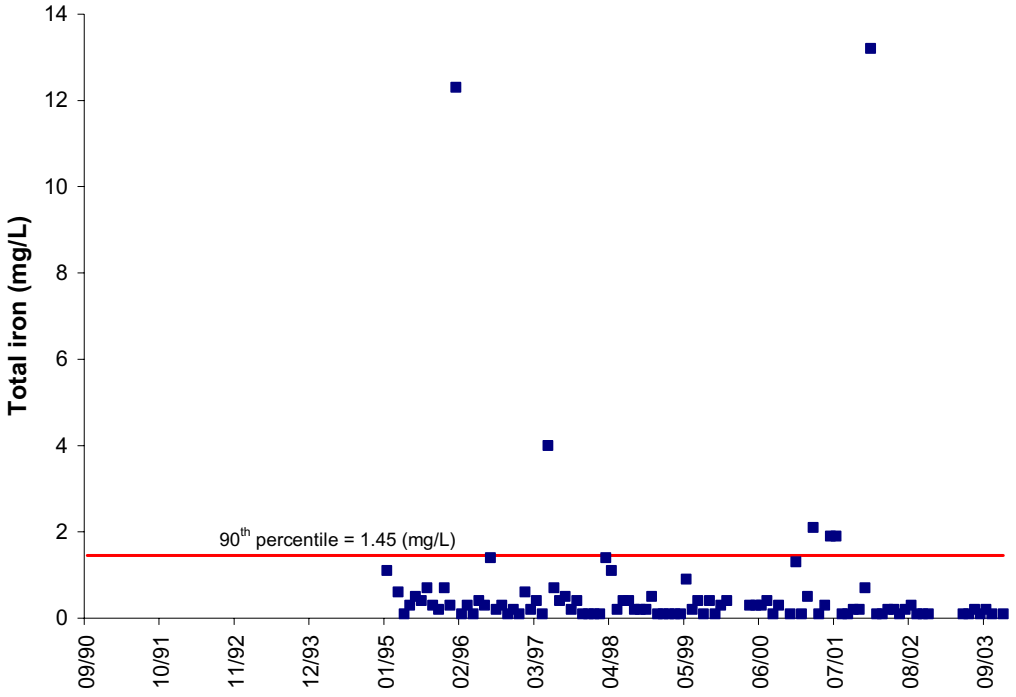

Figure C.49 Total iron concentrations at DMME MPID 1020225.

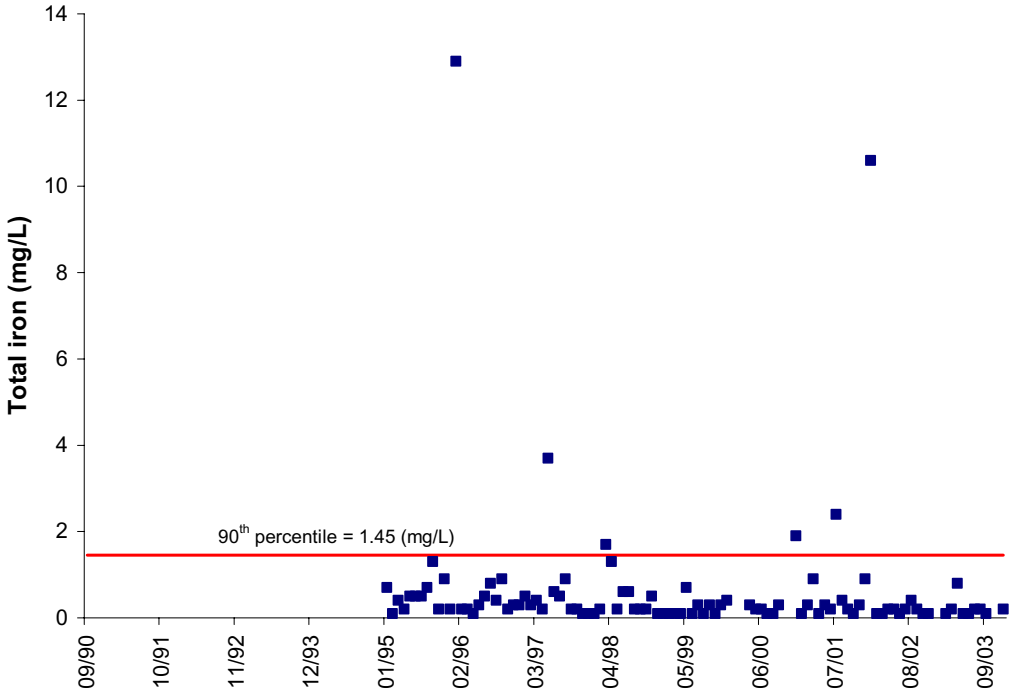

Figure C.50 Total iron concentrations at DMME MPID 1020226.

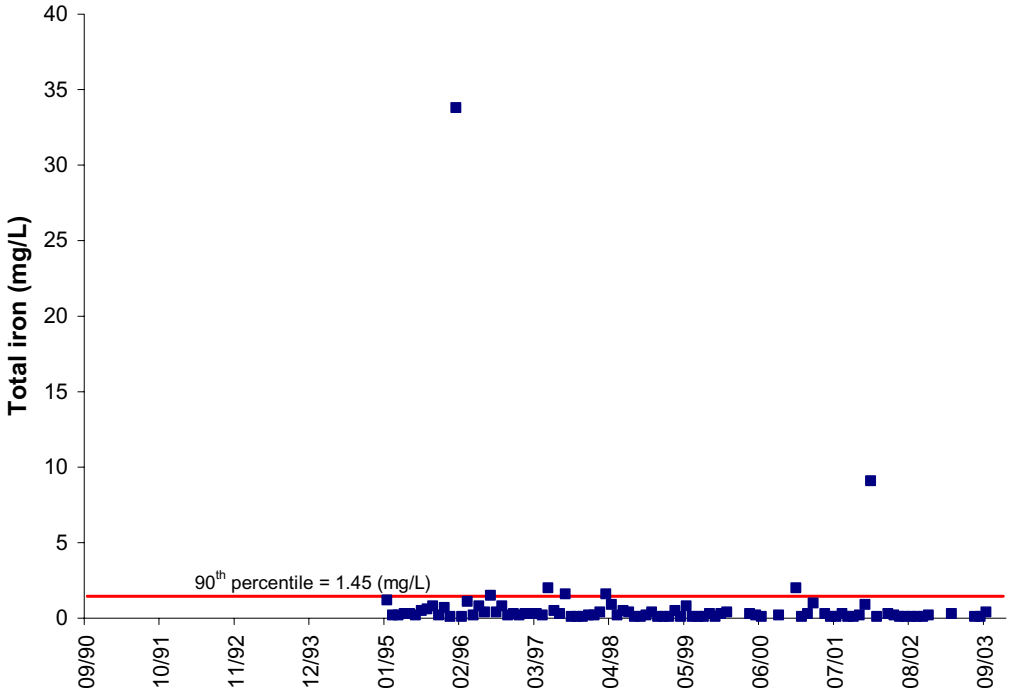

Figure C.51 Total iron concentrations at DMME MPID 1020237.

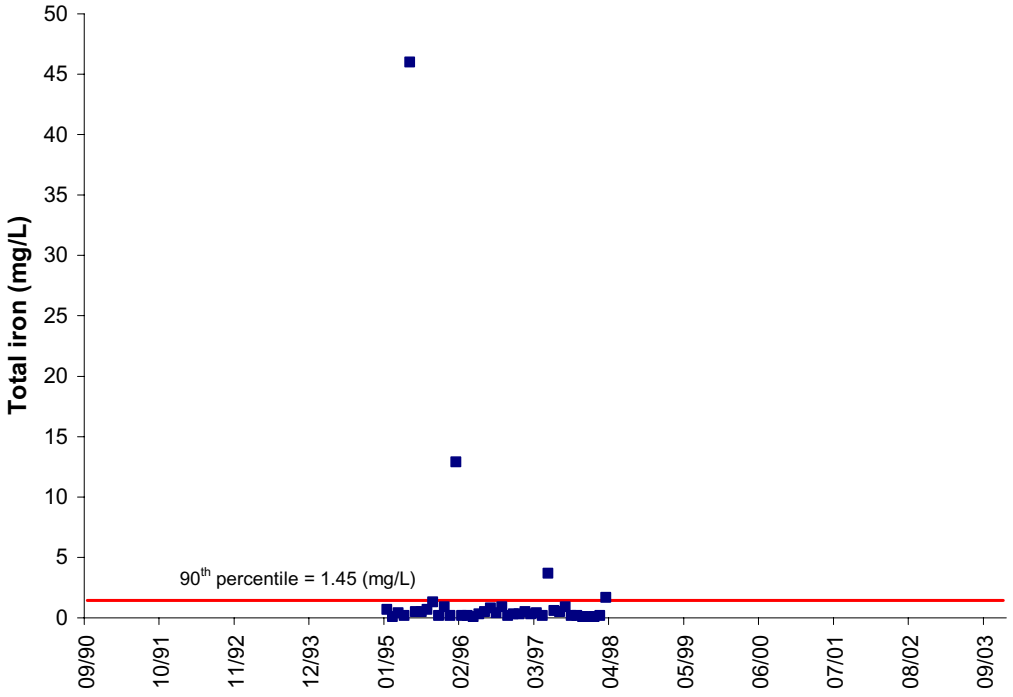

Figure C.52 Total iron concentrations at DMME MPID 1020241.

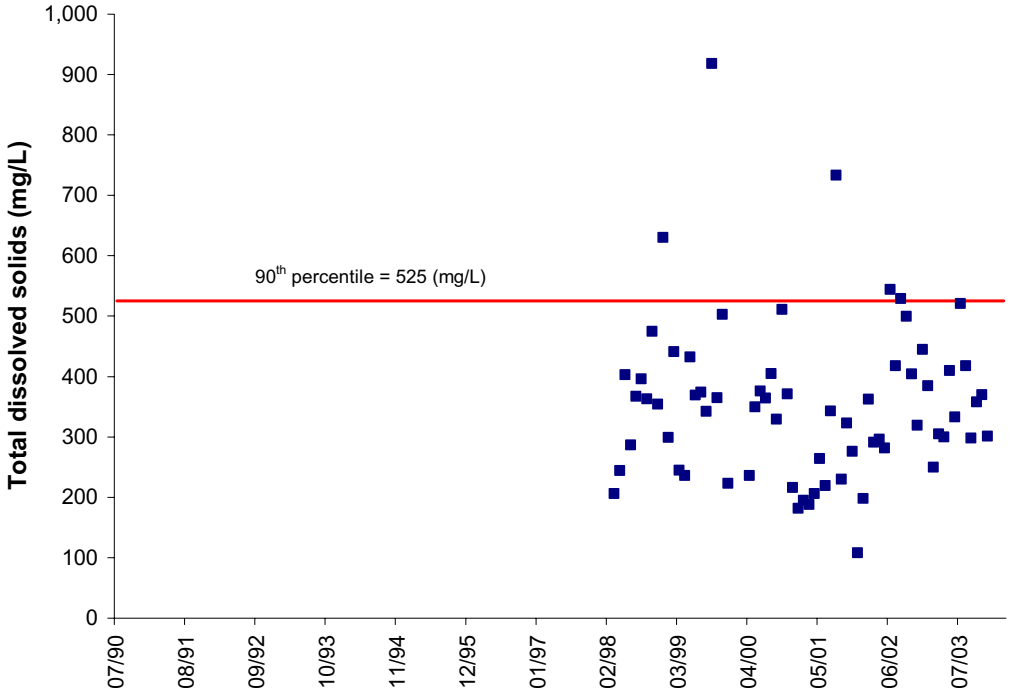

Figure C.53 Total dissolved solids concentrations at DMME MPID 0002877.

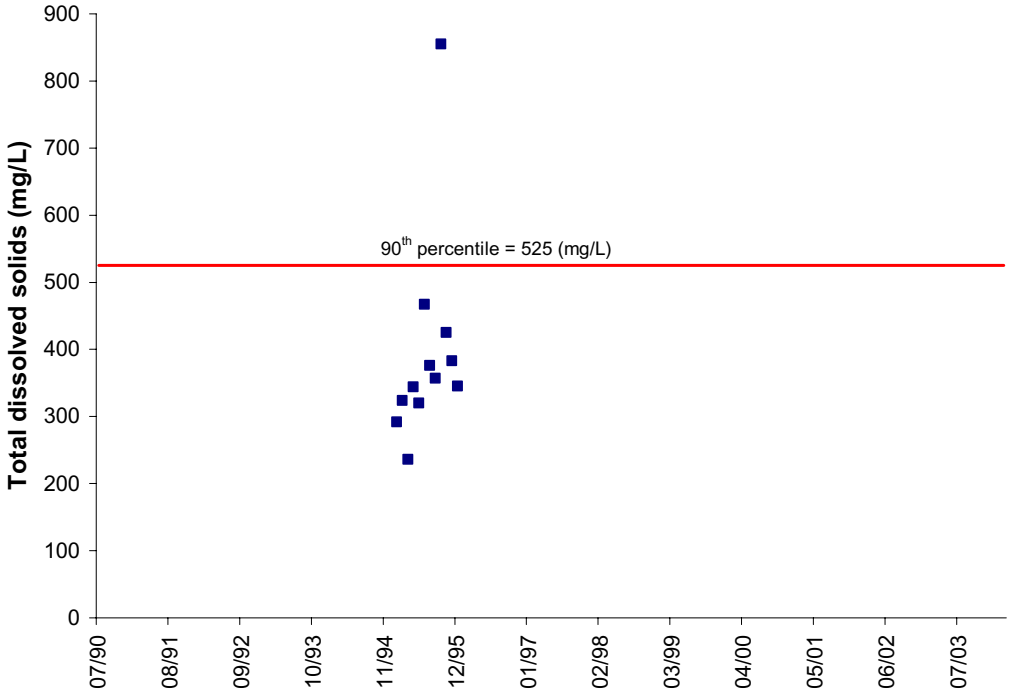

Figure C.54 Total dissolved solids concentrations at DMME MPID 1020209.

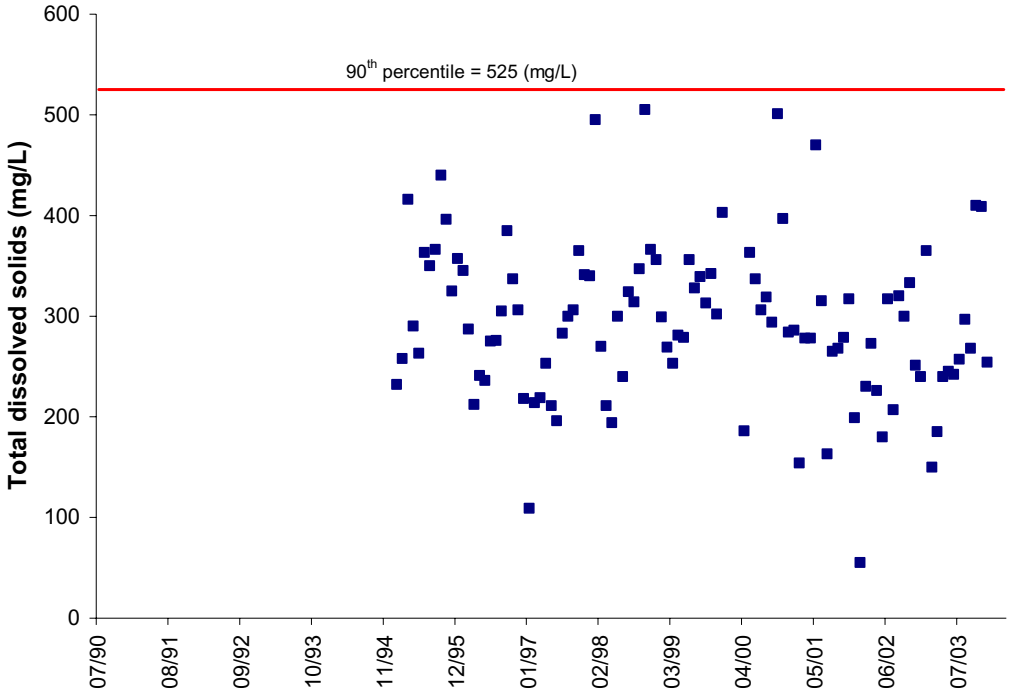

Figure C.55 Total dissolved solids concentrations at DMME MPID 1020225.

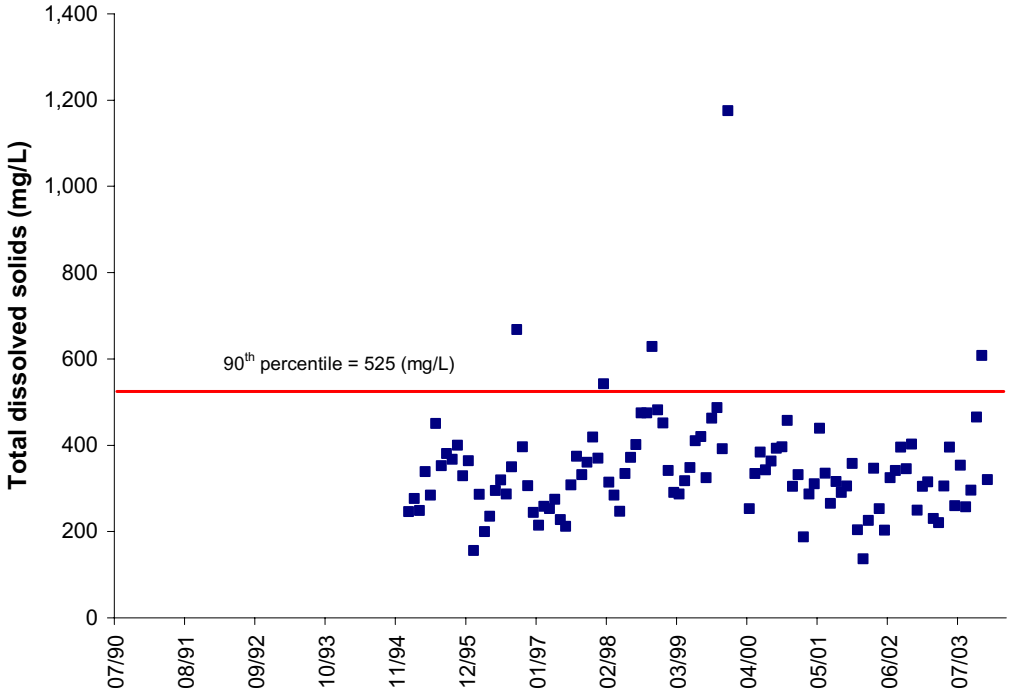

Figure C.56 Total dissolved solids concentrations at DMME MPID 1020226.

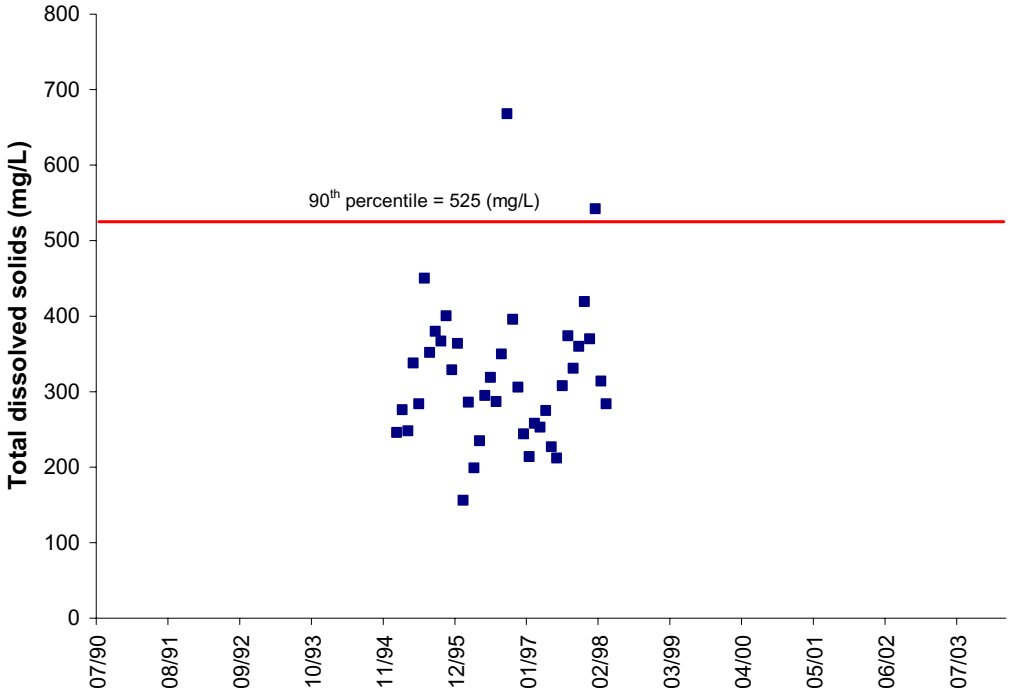

Figure C.57 Total dissolved solids concentrations at DMME MPID 1020241.

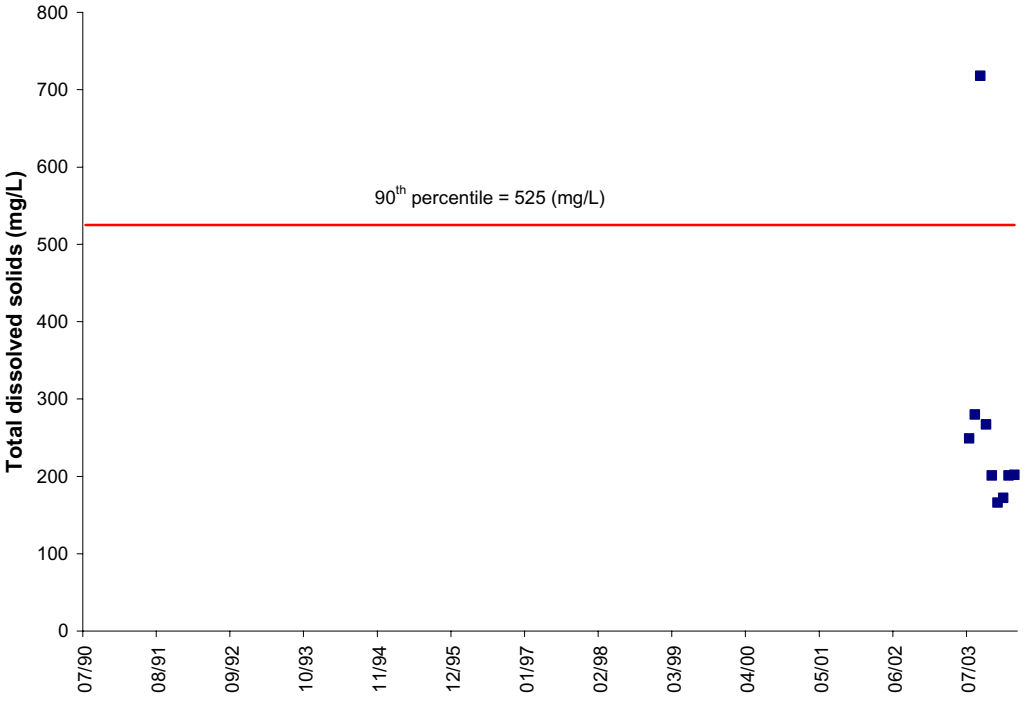

Figure C.58 TDS concentrations at VADEQ station 6BSRA004.16.

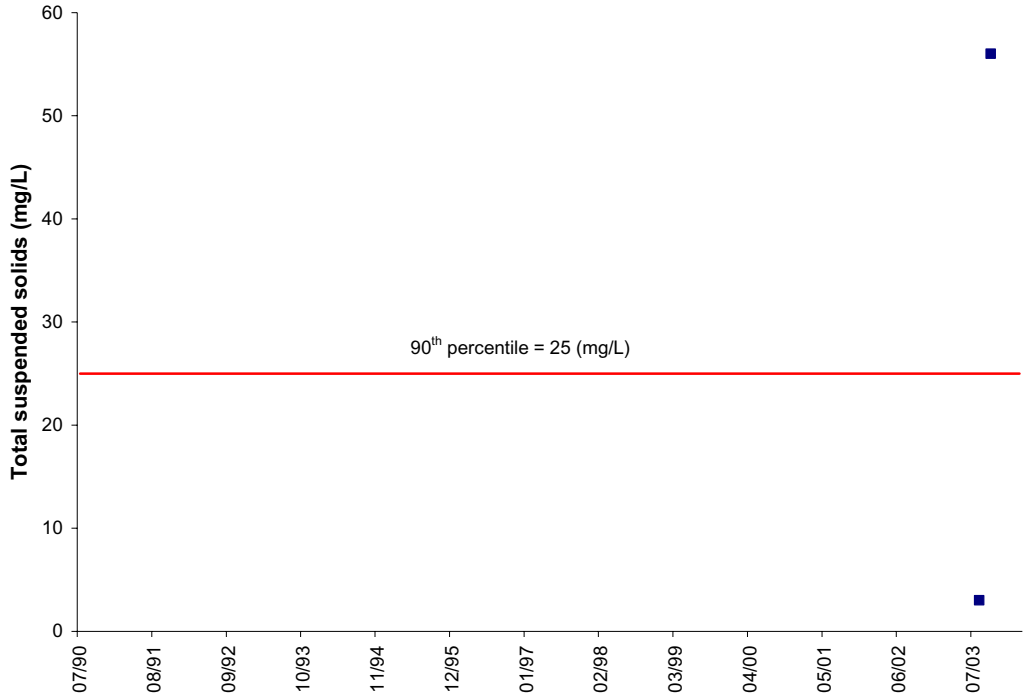

Figure C.59 TSS concentrations at VADEQ station 6BSRA003.22.

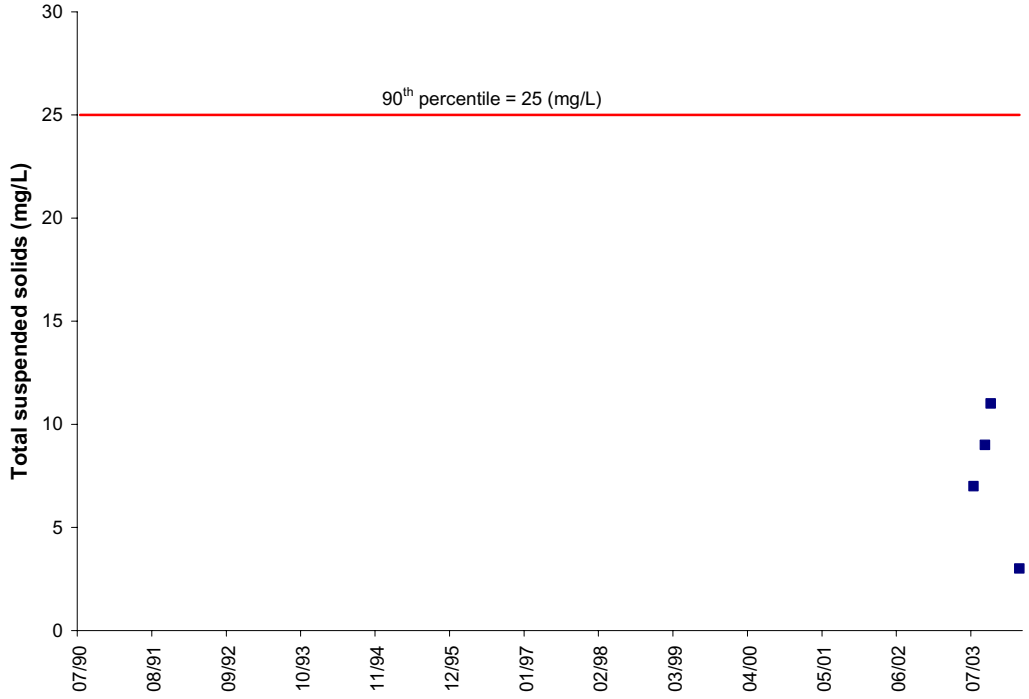

Figure C.60 TSS concentrations at VADEQ station 6BSRA004.16.

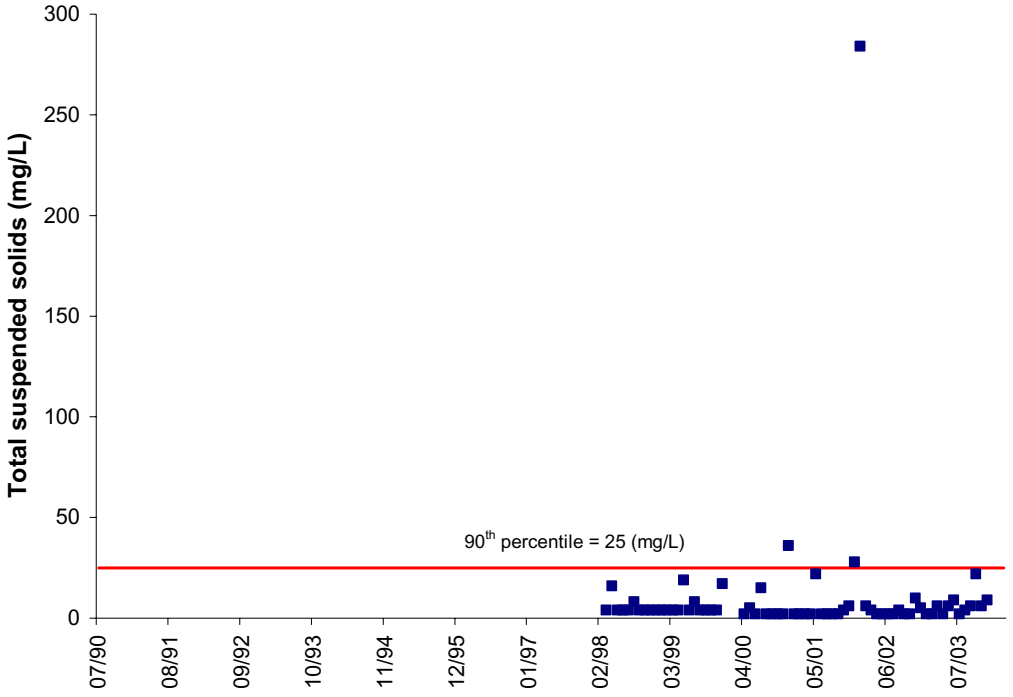

Figure C.61 Total suspended solids concentrations at DMME MPID 0002877.

Table C.1 VADEQ special study organics sediment data in Straight Creek.

Date			8/13/97	6/18/02
PARAM*	**PEC***	**VA 99th Percentile**	**6BSRA001.34**	**6BSRA001.11**
Total PAH[1]	22,800		4,503.30	4,275.44
High MW PAH	NA			1,923.89
Low MW PAH	NA			2,351.55
Naphthalene	561		146.35	275.70
Methylnaphthalene, 2-		83		511.22
Methylnaphthalene, 1-	NA		152.81	348.35
biphenyl	NA		84.85	34.29
NAP d-Methyl	NA		17.57	241.63
naphthylene ace~	NA		24.53	2.85
naphthene ace~	NA			20.52
NAP t-Methyl	NA		78.95	178.52
Fluorine	536		22.98	34.93
Phenanthrene	1,170		271.05	459.33
Anthracene	845		29.03	35.99
PHH 1-Methyl	NA		167.30	208.22
Fluoranthene	2,230		490.50	211.98
Pyrene	1,520		387.92	206.31
Benz(a)Anthracene	1,050		150.88	146.34
Chrysene	1,290		197.13	182.27
Fluoranthene benzo(b)	NA		118.63	224.02
Fluoranthene benzo(k)	NA		67.36	133.69
pyrene benzo(e)	NA		92.87	206.43
Benzo-a-pyrene	1,450		105.85	204.01
perylene		NA	26.39	37.49
Indeno Pyrene (1,2,3-cd)	NA		73.61	114.25
Dibenzo Anthracene (a,h)	NA		18.52	57.33
perylene benzo (ghi)	NA		74.05	199.78

* All data is reported in ppb (µg/kg).
[1] sum PAH (Polycyclic Aromatic Hydrocarbons or Polynuclear Aromatic Hydrocarbons-PNAs) denotes sum of all 21 PAH compounds reported

Table C.2 VADEQ special study PCB and Pesticide sediment data in Straight Creek.

Date	PEC	08/13/97 6BSRA001.34	06/18/02 6BSRA001.11
Total PCB[1]	676	0.52	6.56
Total Chlorodane[2]	17.6	0.24	4.11
Sum DDE[3]	31.3		0.25
Sum DDD[4]	28		
Sum DDT[5]	62.9		1.04
Total DDT[6]	572		1.30
Total BDE[7]	NA	0.41	22.24
Hexachlorobenzene	NA		0.28
Heptachlor	NA		0.07
Heptachlor epoxide	16		0.07
Pentachloroanisole	NA		0.13
gamma BHC	4.99		
Total BHC	4.99		
Octachlorodibenzodioxin	NA		0.09
cpd-1[8]	NA		1.09

[*] All values reported in ppb (ug/kg)

[1] PCB Total PCB denotes sum of polychlorinated biphenyl congeners

[2] Total Total Chlordane denotes sum of chlordane and breakdown products

[3] DDE sum DDE denotes sum of dichlorodiphenyl dichloroethylene isomers

[4] DDD sum DDD denotes sum of dichlorodiphenyl dichloroethane isomers

[5] DDT sum DDT denotes sum of dichlorodiphenyl trichloroethane isomers

[6] Total DDT denotes sum of isomers of DDE, DDD, and DDT

[7] BDE Total BDE denotes sum of polybrominated diphenyl ether congeners

[8] cpd-1 denotes compound 1; Dichloromethyldiphenylether