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Principal Author: James Kern

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Name and address of submitting organization: MapTech, Inc.
3154 State Street
Blacksburg, VA 24060

ABSTRACT

High levels of Total Dissolved Solids (TDS) and specific conductivity have been identified as stressors to the aquatic community in many Total Maximum Daily Load (TMDL) studies where resource extraction impacts water quality. Although there is ongoing debate as to the level at which, and mechanism through which, TDS impacts aquatic life, State regulatory authorities and industry representatives are interested in determining the benefit of current and potential Best Management Practices (BMPs) with regard to TDS reduction. TDS is the sum of all dissolved constituents, including dissolved metals, sulfate, and chloride; all of which can be toxic to aquatic life at increased levels. TDS, conductivity and their constituents are pollutants of concern, not only in the coalfields, but potentially everywhere mineral extraction is conducted.

Although many standard and innovative BMPs show promise, little data exist on the quantitative effectiveness of these BMPs in reducing these pollutant loads. The primary goal of this project was to evaluate the effectiveness of Best Management Practices in controlling delivery of TDS and its constituent elements to receiving streams. To this end, two approaches were pursued, direct monitoring of TDS reductions due to specific BMPs and statistical analysis of water quality as impacted by various land uses with differing levels of BMP installation.

BMPs that show promise based on this study include: constructed wetlands, polymer treatment of hollow fills to decrease impacts from leaching, peat filters, and standard reclamation.

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1. INTRODUCTION

The primary goal of this project was to evaluate the effectiveness of Best Management Practices (BMPs) in controlling delivery of TDS and its constituent elements to receiving streams. To this end, two approaches were pursued, direct monitoring of TDS reductions due to specific BMPs and statistical analysis of water quality as impacted by various land uses with differing levels of BMP installation. Specific objectives to achieve this goal included the following:

1. Identify existing BMPs and sites appropriate for BMP installation.

2. Directly monitor the effects of selected BMPs on TDS.

3. Assemble a comprehensive database of land use activity and BMP utilization in one or more intensively monitored watersheds in Southwestern Virginia's Coalfield Region.

4. Develop statistical model(s) to evaluate the effectiveness of specific types of BMPs and/or combinations of BMPs for controlling TDS from mining and related activities.

1.1 Background

The Clean Water Act requires all states to monitor their waters, develop a list of impaired waters based on their State standards, and conduct Total Maximum Daily Load (TMDL) studies to determine the maximum amount of the pollutant in question that the stream can assimilate. Following the development of TMDLs, implementation of the TMDL is planned and executed. During Implementation Plan development, appropriate BMPs are identified and quantified to determine the cost and benefit of implementation. Using Virginia as an example for the region, in 1997, the Virginia General Assembly enacted the Water Quality Monitoring, Information, and Restoration Act, which direct Virginia's Department of Environmental Quality (VADEQ) to develop a plan to implement TMDLs. In 2000, VADEQ and Virginia's Department of Mines, Minerals, and Energy's (VADMME) Division of Mined Land Reclamation (DMLR) signed a Memorandum of Understanding (MOU) agreeing to cooperative effort in the TMDL process as it relates to mining. To date, TMDLs have been developed for nine impaired stream segments in Southwestern Virginia's coalfields (VADEQ, 2008). Four of these stream segments also have TMDL Implementation Plan studies completed or in progress. In six of these resource-extraction TMDLs – Russell Prater Creek, Callahan Creek, Dumps Creek, Knox Creek, Pawpaw Creek and Straight Creek – total dissolved solids (TDS) has been identified as a pollutant of concern and as a water quality endpoint for the TMDL. In a seventh resource-extraction TMDL, where acid mine drainage (AMD) impacts were significant – Black Creek – conductivity, which increases as a result of increasing TDS, was identified as one of the water quality endpoints. Throughout the Appalachian coalfield region, TDS has been identified as a pollutant of concern. TDS levels can be increased in runoff from active and abandoned mine land, as well as from outflows of AMD.

TDS is a measure of the actual concentration of all dissolved metals, minerals, and organic matter in water. In the Appalachian coalfields, the dissolved ions typically include: bicarbonate, sulfate, chloride, and dissolved metals. Although there is ongoing debate as to the level at which, and mechanism through which, TDS impacts aquatic life, recent literature (Society of Environmental Toxicology and Chemistry, 2004; Goodfellow et al., 2000; Kennedy, 2002; Pond, 2004) identifies TDS as a pollutant of concern with regard to the health of aquatic organisms. Aquatic organisms balance water and internal ions through a number of different mechanisms, including osmotic pressure across semi-permeable membranes. Therefore, high concentrations and significant fluctuations in TDS can place stress on the organisms. The resulting chronic stress affects processes such as growth and reproduction. Additionally, 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 umhos/cm then the concentration of dissolved ions can be high enough to cause stress to aquatic organism (Goodfellow et al., 2000). Because TDS is the sum of all dissolved constituents, individual constituents can reach toxic levels long before these reported thresholds for TDS/conductivity are reached.

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 pollutants of concern in these watersheds was elevated TDS (Pond, 2004). Elevated TDS concentrations impact pollution sensitive mayflies more than other species. Figure 1, extracted from this report, shows that “drastic reductions in mayflies occurred at sites with conductivities generally above 500 umhos/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.

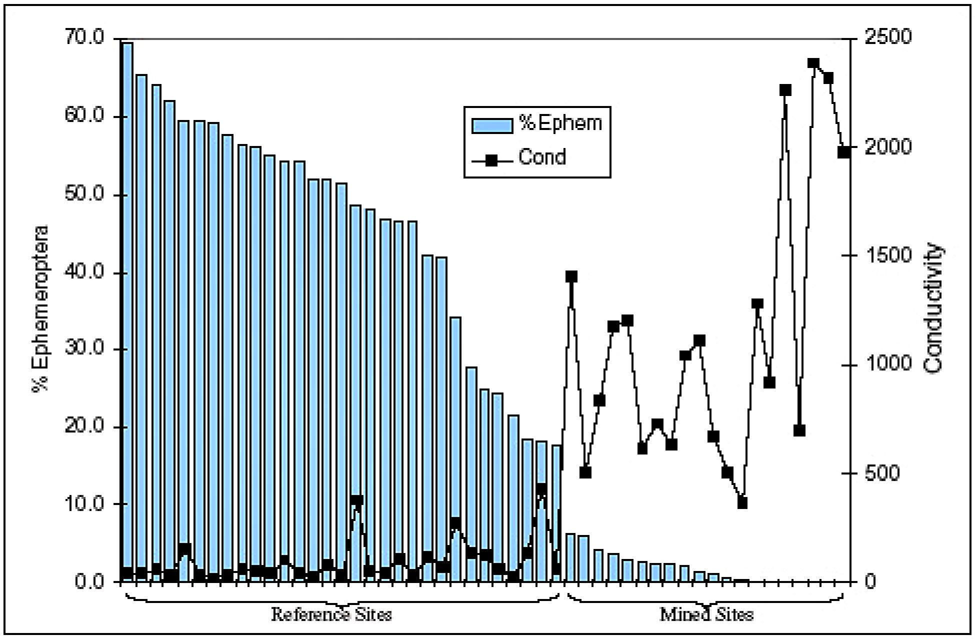

Figure 1. The relationship between % Ephemeroptera and conductivity from reference and mined sites (Pond, 2004).

TDS, conductivity and their constituents are at issue, not only in the coalfields, but potentially everywhere mineral extraction is conducted. Table 1 shows a comparison of monitored data collected from the streams studied by MapTech for resource extraction TMDLs and from streams in the same region where no impacts to aquatic life have been recorded. Supporting data for Table 1 are included in Appendix A (Tables A.1 and A.2). The mean, median, standard deviation, and 90th percentile values measured in the impacted streams are all approximately double those measured in the non-impacted streams. In general, TDS values are consistently higher and show greater fluctuation in streams impacted by resource extraction. At issue is the development of appropriate Best Management Practice (BMP) strategies to control TDS, and consequently its component constituents. Although many standard and innovative BMPs show promise, little data exist on the quantitative effectiveness of these BMPs in reducing these pollutant loads. The effect of TDS on aquatic life is a contentious issue due, in part, to concerns over the associated costs of controlling TDS. A better understanding of the effectiveness of these BMPs is necessary in order to determine the appropriate course of action and associated costs of remediating impacted streams.

Table 1. Comparison of TDS (mg/L) in streams impacted by resource extraction and non-impacted streams.

	Coalfield TMDL Streams	Non-impaired Streams
Mean	370	173
Median	322	170
Standard Deviation	233	69
90th Percentile	689	291

1.2 Preliminary Studies

As mentioned earlier, very little data exists with regard to the efficiencies of BMPs in controlling TDS. However, a cursory analysis indicates that standard reclamation practices do result in benefits, with regard to TDS levels. Figure 2 shows in-stream TDS levels over time in a headwater area where approximately 20% of the contributing watershed was disturbed and reclaimed in 1996. Supporting data for this figure are included in Appendix A (Table A.3). The data, while limited, clearly show impacts due to disturbance during the mining and reclamation period, as well as in the first two years following. However, improvement in stream conditions can be seen, starting in late 1998, approximately 2 years after regrading and revegetating the site. These data show promise for these reclamation practices in controlling TDS. Additionally, these data indicate the need for the statistical approach being pursued in this study.

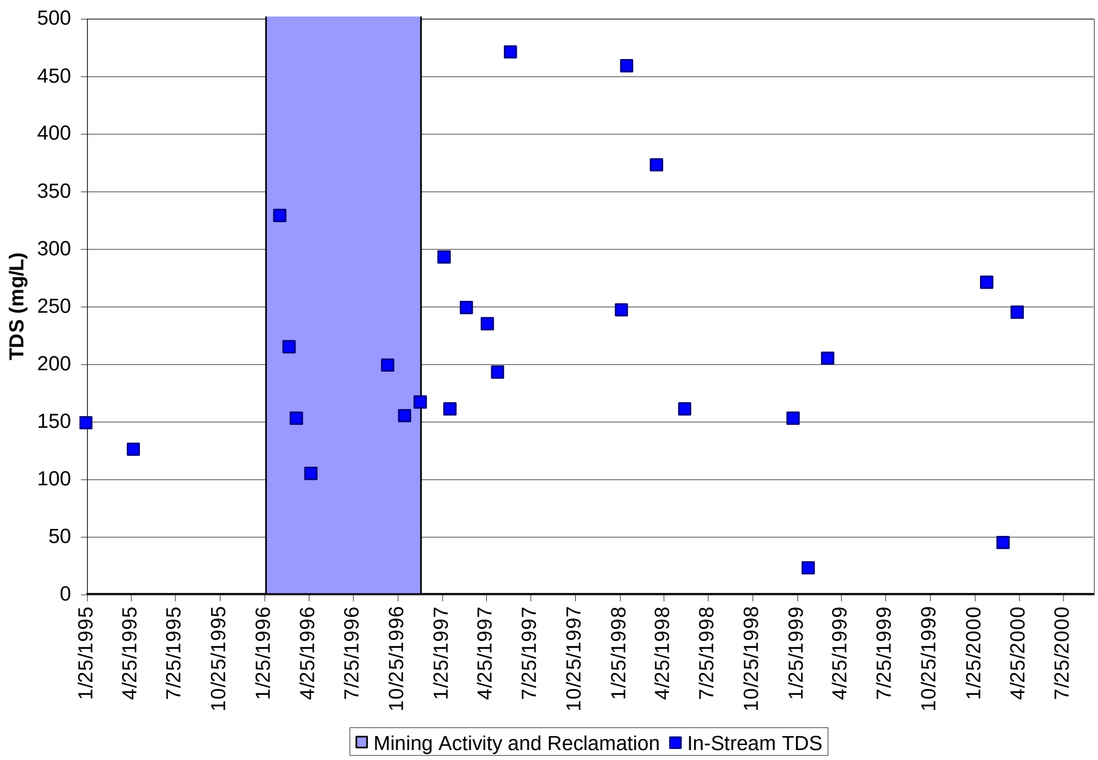

Figure 2. Response of in-stream TDS levels to mining activity and reclamation.

1.3 Experimental Procedures/Methodologies

VADMME has identified 12 BMPs that have served as cost-effective controls for other pollutants and may be useful in controlling TDS (Table 2). Being accepted BMPs for controlling other pollutants, the costs associated with them are well understood. However, there is little data available to quantify their efficiencies with regard to TDS. The intention of this study is to assess these BMPs and/or others to determine their effectiveness in controlling TDS. In addition to the BMPs listed in Table 2, truck wash facilities, water reuse, improvement of diversion ditches around hollow fills, alternative pH control systems designed to target less basic pH values, and treatment with apatite have been identified as potential TDS-controlling BMPs.

Table 2. Mined land BMPs identified by Virginia VADMME as having potential in controlling TDS.

Mined Land Best Management Practice (BMP)	*Description of BMP*
Revegetation	The establishment of a diverse and permanent vegetative cover on mined areas that is adequate to control surface water infiltration and erosion.
Regrading	The restoration of original contours on mined areas.
Infiltration Channels	Construction of a shallow, excavated trench backfilled with coarse gravel then covered with soil with grass planted on the surface. Stormwater runoff diverted into the trench gradually infiltrates into the surrounding soils from the bottom and sides of the trench.
Daylighting with Resource recovery	The exposure, by surface mining, of a deep-mined coal seam with the purpose of recovering the remaining coal and eliminating existing pollutional discharge.
Daylighting without Resource recovery	The exposure, by surface mining, of a deep-mined coal seam with the purpose of eliminating existing pollutional discharge.
Check Dams	Small permeable dams constructed of gravel or other material to retard flow in ditches and channels and provide sediment control.
Paving Roads	Paving haulroad surfaces within the mining operation.
Wetland Construction	The establishment of a wetland area as part of the mining and reclamation process.
Sediment Pond Construction	The construction and placement of ponds to collect drainage from disturbed areas and provide stormwater retention and sedimentation.
Silt Fence	Fabric fencing placed to reduce sedimentation from mined areas.
Stream Buffer	The restoration of a riparian area along a stream segment that includes plantings and structures designed to buffer the stream.
Diversion Ditches	The construction of ditches and the restoration of drainage patterns to direct water away from outslopes and areas where the potential for erosion and mineralization are high.

Some of the BMPs identified (*e.g.*, wetlands and ponds) lend themselves toward small monitoring study to determine TDS removal efficiencies, while others (*e.g.*, regrading and revegetation) do not. Because of this difference, two approaches were pursued to determine the efficiency of BMPs in controlling TDS, direct monitoring of TDS reductions due to specific BMPs and statistical analysis of water quality as impacted by various land uses with differing levels of BMP installation. These two approaches are described in Section 3 of this report. The specific BMPs analyzed were selected based on consultation with Virginia's Department of Mines, Minerals, and Energy (VADMME) personnel and industry representatives.

2. EXECUTIVE SUMMARY

High levels of Total Dissolved Solids (TDS) and specific conductivity have been identified as stressors to the aquatic community in many Total Maximum Daily Load (TMDL) studies where resource extraction impacts water quality. Although there is ongoing debate as to the level at which, and mechanism through which, TDS impacts aquatic life, State regulatory authorities and industry representatives are interested in determining the benefit of current and potential Best Management Practices (BMPs) with regard to TDS reduction. TDS is the sum of all dissolved constituents, including dissolved metals, sulfate, and chloride; all of which can be toxic to aquatic life at increased levels. TDS, conductivity and their constituents are pollutants of concern, not only in the coalfields, but potentially everywhere mineral extraction is conducted.

Although many standard and innovative BMPs show promise, little data exist on the quantitative effectiveness of these BMPs in reducing these pollutant loads. The primary goal of this project was to evaluate the effectiveness of Best Management Practices in controlling delivery of TDS and its constituent elements to receiving streams. To this end, two approaches were pursued, direct monitoring of TDS reductions due to specific BMPs and statistical analysis of water quality as impacted by various land uses with differing levels of BMP installation.

The primary goal of this study was to evaluate the effectiveness of Best Management Practices in controlling delivery of TDS and its constituent elements to receiving streams. To this end, two approaches were pursued, direct monitoring of TDS reductions due to specific BMPs and statistical analysis of water quality as impacted by various land uses with differing levels of BMP installation. Specific objectives to achieve this goal included the following:

- Identification of existing BMPs and sites appropriate for BMP installation.
- Directly monitoring the effects of selected BMPs on TDS.
- Assembling a comprehensive database of land use activity and BMP utilization in one or more intensively monitored watersheds in Southwestern Virginia's Coalfield Region.
- Developing statistical model(s) to evaluate the effectiveness of specific types of BMPs and/or combinations of BMPs for controlling TDS from mining and related activities.

The BMPs monitored directly included Apatite II, detention ponds, constructed wetlands, polymer treatment of fill material to decrease impacts from leaching, and peat filters. Several watersheds within the North Fork Powell River drainage basin were identified for the statistical analysis. BMPs that show promise based on this study include: constructed wetlands, polymer treatment of hollow fills to decrease impacts from leaching, peat filters, and standard reclamation.

The conclusions listed below indicate the relative strength of the BMPs assessed.

- ✓ It appears that the Apatite II treatment is not effective in reducing TDS levels.
- ✓ Detention ponds may slightly increase TDS levels, but more data is needed to verify the results.
- ✓ Constructed wetlands may decrease TDS levels (~7%), but more data is needed to verify the results.
- ✓ The polymer treatment may have potential in sealing hollow fills.
- ✓ The polymer treatment does reduce TDS production where it is applied and allowed to cure (~100%).
- ✓ The peat filter appears to be effective at reducing TDS (~18%).
- ✓ The statistical study indicated that hollow fills have a large potential impact on TDS concentrations, and that BMPs to reduce these impacts should be explored.
- ✓ The statistical study also indicated that reclamation of disturbed areas has an initial negative impact on TDS concentrations, but provides a 67% reduction in the TDS load from those areas over a 2 to 3 year period, as compared to a 36% improvement due solely to completion of mining.

Implications for future research include:

- ✓ Constructed wetlands and traditional reclamation efforts should continue to be assessed to refine the efficiency estimates developed in this study.
- ✓ The use of a peat filter should be further explored to determine efficiencies under varied conditions.
- ✓ BMPs for reducing TDS loads from hollow fills should be explored, including assessment of the polymer treatment at a plot or field scale.

3. EXPERIMENTAL DESIGN

As discussed in Section 2 of this report, some of the BMPs identified for analysis lend themselves toward small monitoring study to determine TDS removal efficiencies, while others do not. Because of this difference, two approaches were pursued to determine the efficiency of BMPs in controlling TDS, direct monitoring of TDS reductions due to specific BMPs and statistical analysis of water quality as impacted by various land uses with differing levels of BMP installation.

3.1 Monitoring Study

Objective 1: Identify existing BMPs and/or sites appropriate for BMP installation.

A description of this project was presented to industry representatives at the Virginia Department of Mines, Minerals, and Energy (VADMME); Division of Mined Land Reclamation (DMLR) Total Maximum Daily Load (TMDL) Workshop, held on September 28, 2006 at Virginia Highlands Community College, Learning Resources Center, Abingdon, Virginia. The goal of this presentation was to solicit participation from industry representatives in the BMP monitoring program. Consequently, a meeting was held with industry representatives at the Virginia Department of Environmental Quality (DEQ) offices in Abingdon, VA, on October 17, 2006 to discuss potential BMPs, and possibilities for participation. While there was significant interest in the goals of the project, interest in participation was limited. In terms of BMPs, the greatest interest was shown in application of the Apatite II.

Apatite is a phosphate mineral group that can be used to precipitate metals from contaminated waters. Apatite II is made from processed fish bones, the nominal composition of Apatite II is $Ca_{10-x}Na_x(PO_4)_{6-x}(CO_3)_x(OH)_2$, where $x < 1$. Product literature indicated that it works through four general non-mutually-exclusive processes, depending upon the aqueous chemistry of the system. These four processes include: heterogeneous nucleation (supplying a small amount of PO_4 to solution to exceed the solubility limits of most metal apatites), buffering low pH (raises pH to 6.5 - 7 causing precipitation of many metal phases), adsorption (uncompensated PO4 and OH-groups on the surface induce metal sorption), and biological stimulation (P and bioavailable organics can stimulate microbial community activity in many chemical systems, e.g., high SO_4 or NO_3). Indications, based on the literature, were that Apatite II reduced concentrations of all metals as well as SO_4. Given the reductions to these dissolved constituents, it was anticipated that treatment with the product would reduce TDS levels to some degree.

Apart from Apatite II, there was general interest in any BMP that could economically reduce TDS levels. There is very little information as to the impact of standard BMPs (*i.e.*, constructed wetlands and ponds) on TDS concentrations, so there was interest in measuring these impacts. Three ponds and two constructed wetlands were identified and monitored. Additionally, two treatments were assessed a bench-top scale. The first involved treatment of fill material with a polymer (PolyPavement™). PolyPavement™ is sold as a "soil solidifier", intended for producing "paved" surfaces using in-situ materials.

It has also been used for control of soil erosion. PolyPavement™ was assessed for its potential in reducing rainwater percolation through and/or contact with fill materials. Drainage from fill areas have shown among the highest TDS values that have been measured from mining activities (*e.g.*, >2,000 mg/l). This is most likely due to the reduced particle size of the material, which leaves more surface area available to weathering. The treatment mechanism would be to produce a cap that would serve to reduce flow through the fill or to encapsulate enough of the material to gain the reductions that are needed. This approach to producing a cap would be inexpensive, and neither labor nor energy intensive as compared to other capping methods (*i.e.*, traditional pavements). The second treatment explored the use of a peat filter to reduce TDS. Peat filters have been used to reduce TDS in the aquaculture industry. This treatment does decrease pH, but this side affect may be acceptable in non-acid drainage situations.

For the field portion of the monitoring study (*i.e.*, assessment of Apatite II, ponds, and wetlands), DMLR assisted with identifying local cooperators. Three ponds were identified, each treating different water quality conditions (deep mine discharge, runoff from an active surface mine area that was in cessation, and runoff/drainage from a large valley fill). Together, these three ponds provided a good cross-section of typical water quality conditions produced on mines in the region. Additionally, two constructed wetlands that operate in series to treat AMD were identified for monitoring.

Objective 2: Directly monitor the effects of selected BMPs on TDS.

All of the BMPs were assessed using an upstream/downstream monitoring approach. In each case the difference between influent and effluent (upstream/downstream) was measured. Both field and laboratory measurements were made in order to assess BMP effectiveness. Continuous, in-situ, measurements of flow depth (stage) and conductivity, using *In-Situ Aqua TROLL 200* sensors, were supplemented by laboratory analysis of grab samples for conductivity, Total Suspended Solids (TSS), and Total Dissolved Solids (TDS). The laboratory analyses were conducted in MapTech's Environmental Diagnostics Laboratory, using the analytical methods shown in Table 3. In addition, DMLR provided more comprehensive analysis of 5 grab samples, including: alkalinity (Alk), chloride (Cl), conductivity (Cond), pH, Total Phosphorus (TP), sulfate (SO4), TDS, Total Manganese (TMn), Total Potassium (TK), and Total Sodium (TNa).

Table 3. Methods and approximate detection limits for parameters measured in the laboratory.

Parameter	Approximate Detection Limit(s)	Method
Conductivity	Lower = 10 uS/cm Upper = 10,000 uS/cm	Standard Methods 20th ed. 2510
TDS	Lower = 10mg/L	Standard Methods 20th ed. 2540 C
TSS (Gravimetric)	Lower = 10mg/L	Standard Methods 20th ed. 2540 D

The correlation between measured TDS and conductivity will be assessed to determine the validity of using conductivity as a surrogate for TDS to compare relative values before and after treatment. The data were treated as paired data and tested for significant differences between treatment means. Where appropriate, efficiencies were then calculated based on reductions to treatment means and medians, as well as peak values.

3.1.1 Apatite II Treatment Units

A 1-ton supersack of Apatite II was located and purchased with funds provided by DMLR. In total, three Apatite II units were constructed and deployed, as illustrated in Figure 3 (Pond 1: a deep-mine discharge, Pond 2: draining an active surface mine site, and Pond 3: draining a large fill area). Access to these sites was provided by the Red River Coal Company, Norton, VA.

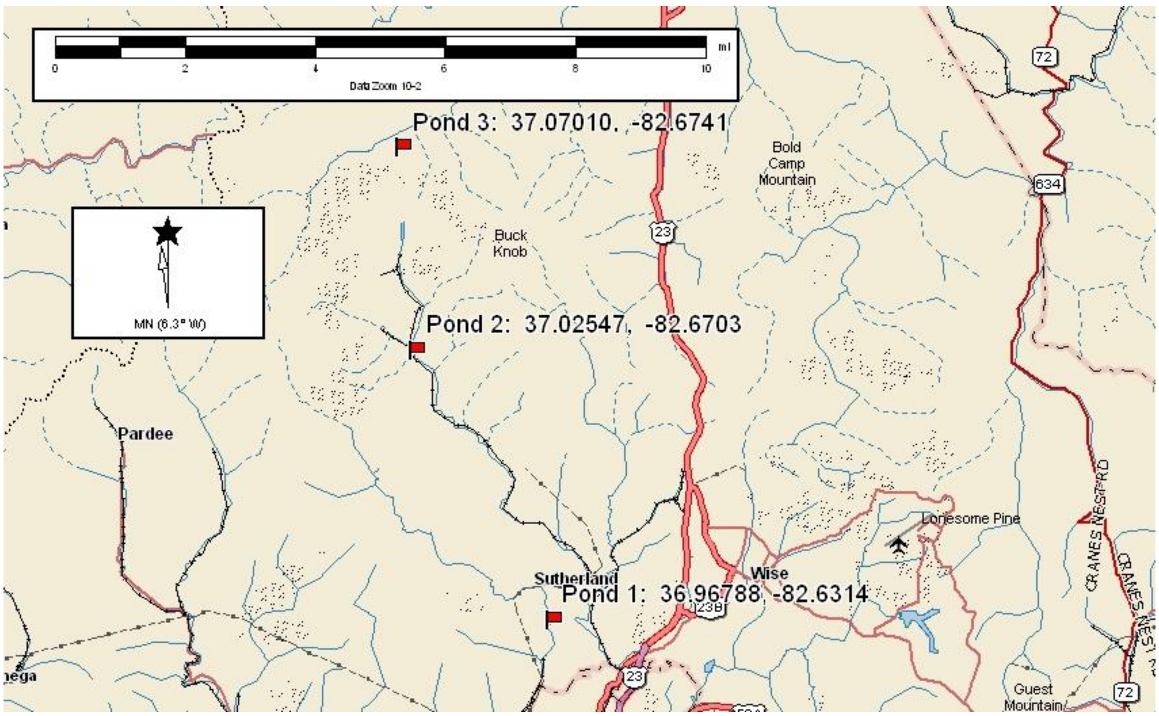

Figure 3. Location of Apatite II treatment units.

The treatment apparatus was designed to ensure a constant pressure head difference between the inlet and outlet of the system, and consequently a constant flow rate through the treatment (Figures 4 and 5). The system was comprised of two 55-gallon drums connected by a flexible hose. The first drum provided a reservoir for influent water, while the second drum contained the Apatite II treatment. The elevation difference of the two drums was measured. Pressure, temperature and conductivity were continuously monitored in each drum. Pressure was used to calculate the depth of water in each drum, and the resulting pressure difference in the system. A gate valve controlled the flow rate through the treatment and was adjusted to achieve a 2 gallon per hour flow rate.

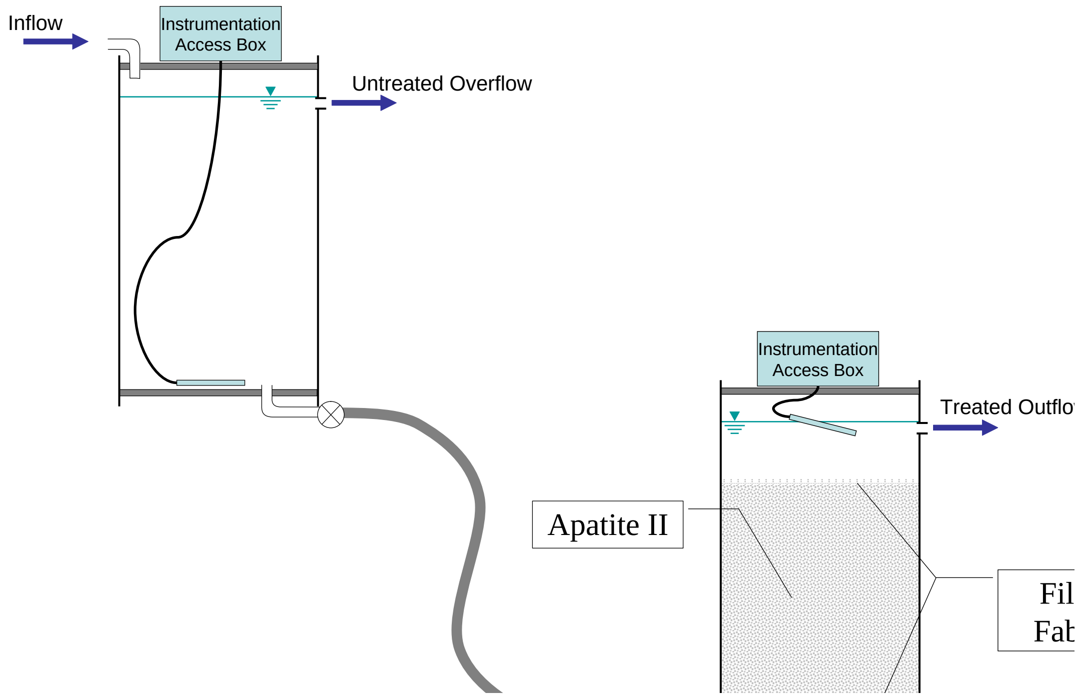

Figure 4. Schematic depiction of Apatite II treatment apparatus.

Figure 5 shows two of the systems in place. Shortly after installation, a site visit was conducted with Jack Fellbinger of OSM and Joey O'Quinn of VADMME to inspect/demonstrate the site installations. Some problems were identified and corrected at the Apatite II units. Problems included expansion/swelling of the Apatite II (50% to 100%), which resulted in substantially decreased flow through the system, disruption of input flow at some sites, and wildlife disturbance (bear) at one site. Input flow disruptions were corrected during the visit. A second visit was required to remove enough of the Apatite II to restore the intended flow through the system, and repair damage caused by the bear incident.

Figure 5. Installation of Apatite II treatment apparatus.

3.1.2 Pond and Wetland Monitoring

The *In-Situ* monitors were used to monitor upstream and downstream of three ponds and two constructed wetlands (Figure 6). The location and description of each site is presented in Figure 7 and Table 4. The three ponds were the same ponds used to provide input to the Apatite II treatment units (Figure 3). The wetlands were located on Black Creek in Wise County, VA.

Figure 6. Installation of in-stream monitoring device.

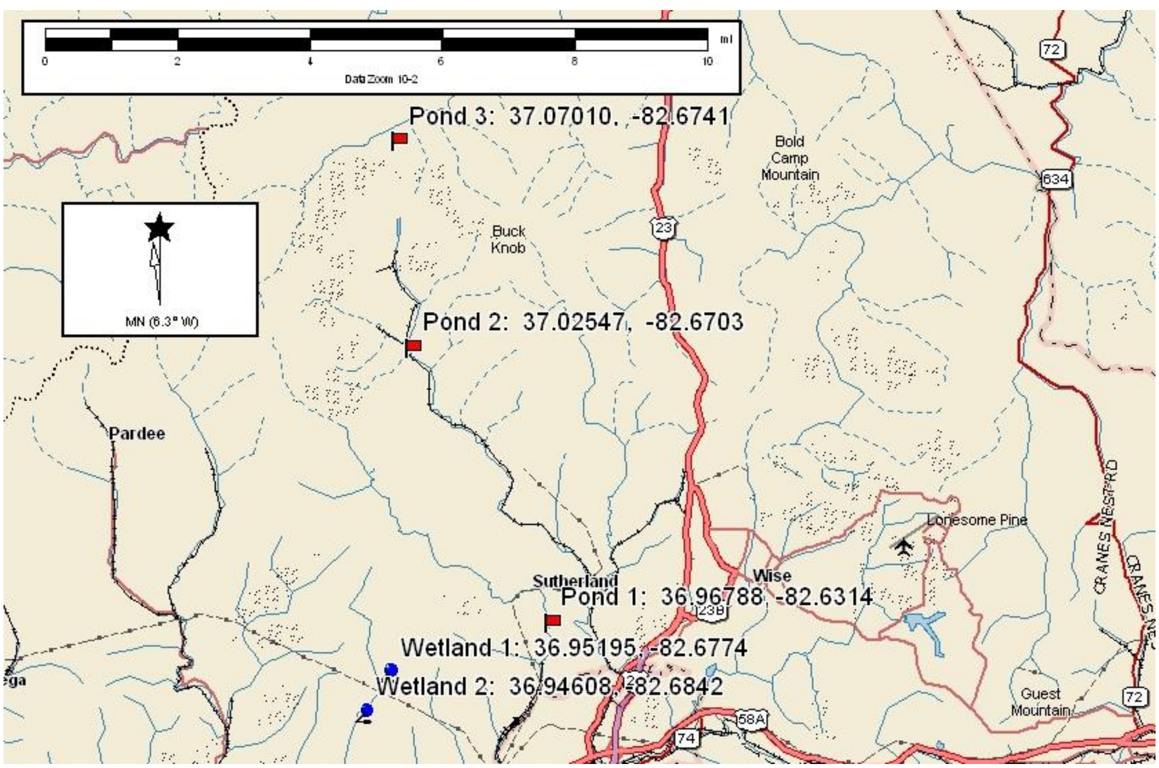

Figure 7. Location of structural BMPs (ponds and constructed wetlands) monitored for this project.

Table 4. Description of structural BMPs (ponds and constructed wetlands) monitored for this project.

BMP	Description	Latitude	Longitude
Pond 1	Detention pond, treating limited runoff and deep-mine discharge.	36.96788	-82.6314
Pond 2	Detention pond, treating runoff from active surface mining (in cessation during study).	37.02547	-82.6703
Pond 3	Detention pond, treating drainage from a large fill area.	37.07010	-82.6741
Wetland 1	First in a series of two constructed wetlands, treating AMD and runoff from surface mining.	36.95195	-82.6774
Wetland 2	Second in a series of two constructed wetlands, treating AMD and runoff from surface mining.	36.94608	-82.6842

3.1.3 Bench-Top Studies

Two additional BMPs were assessed at a bench-top scale. The first involved treatment of fill material with a polymer (*i.e.*, PolyPavement ™). The treatment mechanism would be to produce a cap that would serve to reduce flow through the fill or to encapsulate enough of the material to gain the reductions that are needed. The second treatment will explore the use of a peat filter to reduce TDS. Peat filters have bean used to reduce TDS in the aquaculture industry. This treatment does decrease pH, but this side affect may be acceptable in non-acid drainage situations.
Twelve leaching columns were constructed to assess the potential for the polymer treatment (Figures 8 and 9). The columns were constructed of 8” PVC pipe, with a bottom drain and a side access point near the bottom of the column for collecting samples. Six of the columns were instrumented with the *In-Situ* monitors at the side access point to continually measure conductivity. Twelve columns allowed for four replicates of three treatments (*i.e.*, Control, Treatment 1 – surface application, and Treatment 2 – distributed application). Two types of fill material were collected for the experiment (Figure 10). The parent material of one is primarily sandstone, while the parent material of the other is primarily shale. These samples were collected from fill areas through cooperation from a local mining company. Each of the three treatments was applied to two replicates of each fill material.

A synthetic acid rain (SAR) mix was produced for the leaching experiment following the method outlined in EPA Method 1312 - SYNTHETIC PRECIPITATION LEACHING PROCEDURE, with the exception that the target pH (4.5) was set to match this geographical region. The SAR was added to each leaching column and saturated hydraulic conductivity was measured. Electrical conductivity was continuously monitored in two replicates of each treatment, and three grab samples were collected from each cylinder (*i.e.*, “first flush”, 1hr, and 10 days). These samples were analyzed for conductivity and TDS concentrations.

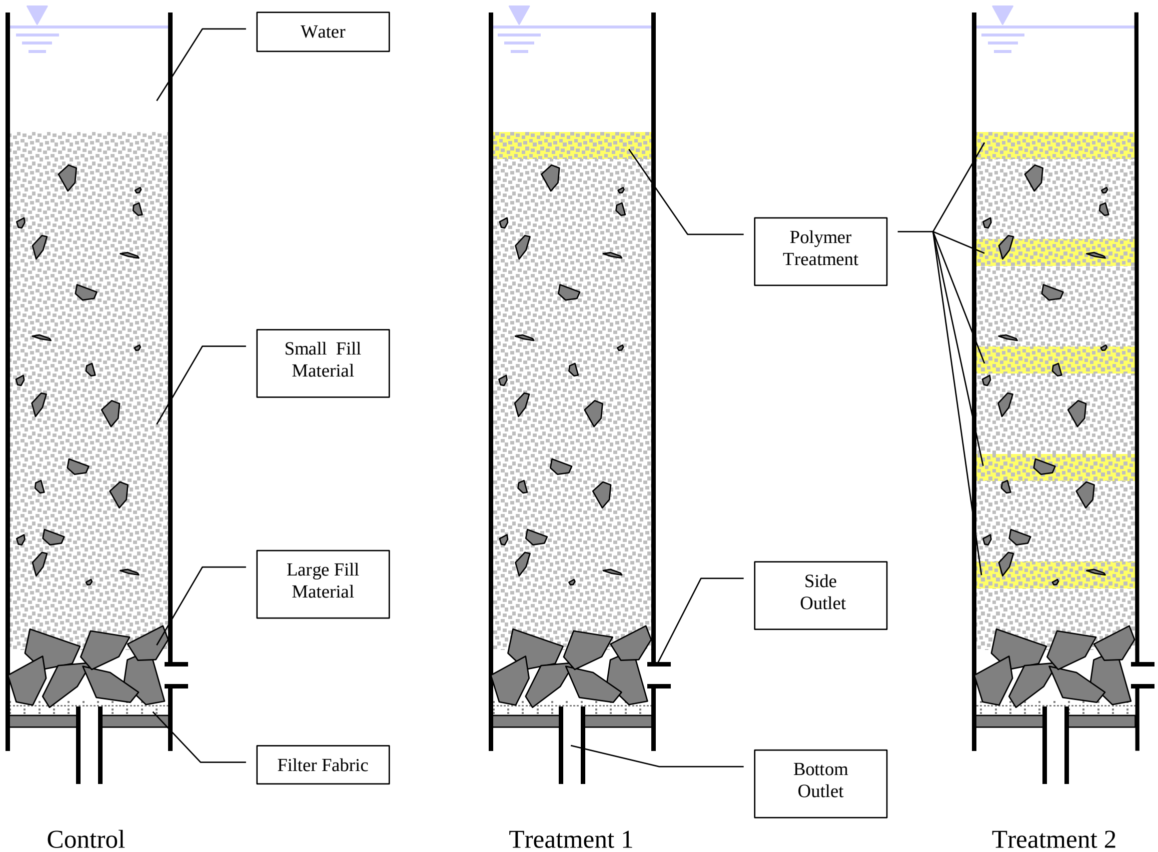

Figure 8. Schematic depiction of polymer treatment experiment.

Figure 9. Leaching columns for polymer treatment experiment.

Figure 10. Fill material for polymer treatment experiment.

Leachate from the polymer treatment experiment was then used in the peat filter experiment. Unpublished data indicates that a 90% reduction in TDS is achievable with a contact time of 30 minutes. Another leaching column was constructed, using 4" PVC and filled with peat to filter the leachate (Figure 11). Approximately 300 in^3 of peat was used in the filter and saturated with leachate (~120 in^3). Grab samples were collected to assess the leachate being treated and the first flush through the filter. Next, a steady state flow was established to achieve a 1-hr contact time and the conductivity probe was used to continuously monitor conductivity at the outlet. In order to assess the effect of contact time, the outlet was closed for 21 hours, while conductivity continued to be measured.

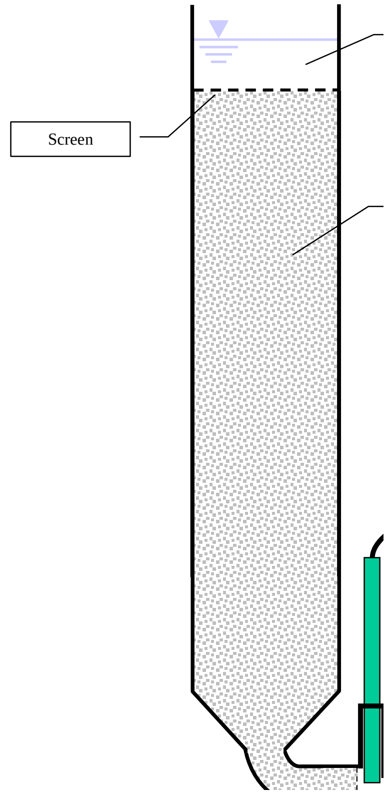

Figure 11. Schematic depiction of the peat filter experiment.

3.2 Statistical Study

For those BMPs that are not readily monitored or that require time for establishment of the BMP (*e.g.*, establishment of vegetative cover) before water-quality results are expected, a statistical analysis was conducted to relate levels of BMP installation to water quality conditions. Watersheds were identified with monitored water quality data and varying activity in space and time. For each monitored location in a specific time, water quality (*i.e.*, TDS) and contributing features were summarized. These records were used to develop a regression that predicts TDS as a function of watershed characteristics.

Objective 3: Assemble a comprehensive database of land use activity and BMP utilization in one or more intensively monitored watersheds in Southwestern Virginia's Coalfield Region.

Through consultations with VADMME representatives the North Fork Powell River watershed was identified as having a significant amount of in-stream monitored data, and watersheds with varying degrees of mining activity. GIS layers and associated databases for land use, elevation, hydrography, Abandoned Mine Land (AML), hollow fill areas, and mine permits were obtained. Seventy-three watersheds were delineated, one for each identified monitoring station, and overlaid on these GIS layers (Figure 12). Information on the timing of specific activities related to permits was obtained from ledger reports. The amount of land disturbance, re-grading, and re-vegetation was reported annually for each permit. However, the specific location of activities, within the permit area, could not be determined. So, in order to get a more accurate relationship between activities and the resulting water quality, six watersheds were identified that contained whole or nearly whole permit areas.

Table 5 gives a list of parameters considered in the regression analysis. Other parameters that were investigated, but rejected, due to a lack of variation in the watersheds analyzed, included non-mining land use, geology, and post-mining land use (unmanaged forestry). Precipitation recorded at the National Weather Service Station at Pennington Gap, Virginia, was used in this analysis. Both daily precipitation and total 30-day rainfall were used. As noted above, the land disturbance and reclamation information was gathered from anniversary reports and was therefore limited in that the time and location of activities was only generally known (*i.e.*, activities occurred on a known amount of land, within a twelve-month period, and inside of the permit boundaries). Since permit areas were not always entirely contained within the watersheds delineated, the areas reported in the anniversary reports were adjusted based on the amount of the permit area that fell within the watershed of interest. In addition to considering the amount of land disturbed and reclaimed in any given year, cumulative disturbance and reclamation was considered. Additionally, the amount of area impacted prior to a one to five-year lag period of the water sample collection was also considered. For these, land-based, parameters the decimal fraction of the impacted watershed was used in the analysis, in order to normalize the effects.

The location and volumetric capacity of hollow fills were known, however, the size of the fills at any given time was not known. As with the land-based parameters, a one to five-year lag in impacts was considered, and the total capacity in each watershed was divided by the watershed area in order to normalize the effects. The area of AML features and re-mining efforts were not available. So, in order to account for the potential impacts, the number of features per acre of watershed was considered in the analysis. Similarly, in order to account for deep mine discharges, the number of discharges per acre of watershed was considered in the analysis.

Although this is a relatively small set of watersheds (6), the goal of this study was not to compare watersheds as the experimental unit, but watersheds over time, or watershed condition. Since the least refined temporal measurement (*i.e.*, land disturbance and reclamation, based on the anniversary reports) was available on a one-year time step, the effective experimental unit was watershed-years. There were a total of 53 watershed-years represented in the dataset that included 568 observations of TDS for these watershed-years.

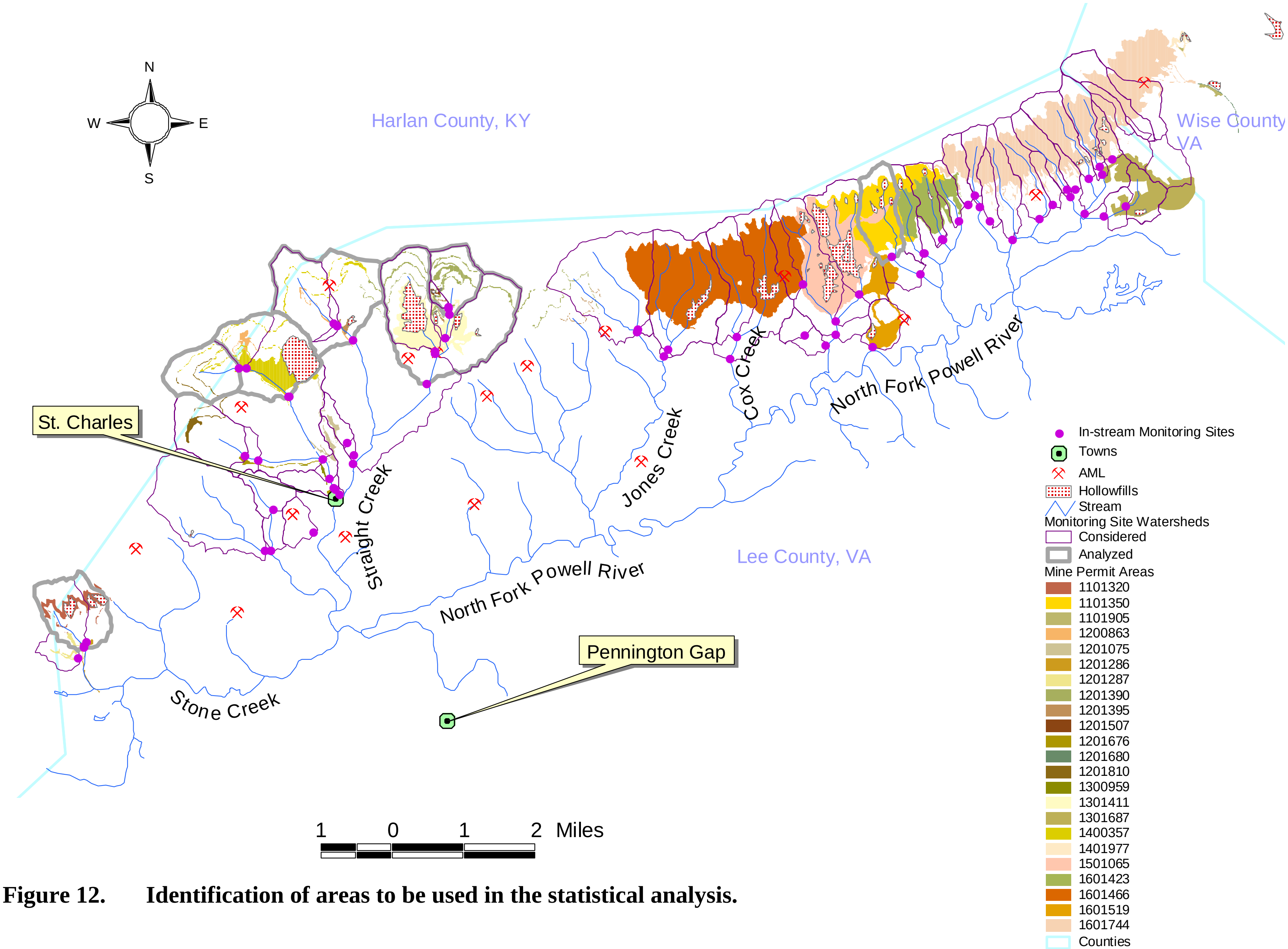

Figure 12. Identification of areas to be used in the statistical analysis.

Table 5. Parameters investigated in regression analysis.

Parameter	Description
Precipitation	Daily precipitation.
30-day_Prec	Total precipitation over the previous 30 days.
Disturbed Area	Decimal fraction of watershed area disturbed during the year sampled, based on anniversary reports, and proportional to the amount of permitted area in the watershed.
DA-Lag1	"Disturbed Area" in the previous year.
DA-Lag2	"Disturbed Area" in the year preceding the sample year by 2.
DA-Lag3	"Disturbed Area" in the year preceding the sample year by 3.
DA-Lag4	"Disturbed Area" in the year preceding the sample year by 4.
DA-Lag5	"Disturbed Area" in the year preceding the sample year by 5.
Cumulative-DA	Decimal fraction of the cumulative disturbance in the watershed through the year sampled, based on anniversary reports, and proportional to the amount of permitted area in the watershed.
CDA-Lag1	"Cumulative-DA" in the previous year.
CDA-Lag2	"Cumulative-DA" in the year preceding the sample year by 2.
CDA-Lag3	"Cumulative-DA" in the year preceding the sample year by 3.
CDA-Lag4	"Cumulative-DA" in the year preceding the sample year by 4.
CDA-Lag5	"Cumulative-DA" in the year preceding the sample year by 5.
Reclaimed Area	Decimal fraction of watershed area regraded and revegetated during the year sampled, based on anniversary reports, and proportional to the amount of permitted area in the watershed.
RA-Lag1	"Reclaimed Area" in the previous year.
RA-Lag2	"Reclaimed Area" in the year preceding the sample year by 2.
RA-Lag3	"Reclaimed Area" in the year preceding the sample year by 3.
RA-Lag4	"Reclaimed Area" in the year preceding the sample year by 4.
RA-Lag5	"Reclaimed Area" in the year preceding the sample year by 5.
Cumulative-RA	Decimal fraction of the cumulative reclamation (regrading and revegetation) in the watershed through the year sampled, based on anniversary reports, and proportional to the amount of permitted area in the watershed.
CRA-Lag1	"Cumulative-RA" in the previous year.
CRA-Lag2	"Cumulative-RA" in the year preceding the sample year by 2.
CRA-Lag3	"Cumulative-RA" in the year preceding the sample year by 3.
CRA-Lag4	"Cumulative-RA" in the year preceding the sample year by 4.
CRA-Lag5	"Cumulative-RA" in the year preceding the sample year by 5.
Fill Volume	Ratio of available hollow fill volume to the total acreage in the watershed.
FV-Lag1	"Fill Volume" available in the previous year.
FV-Lag2	"Fill Volume" available in the year preceding the sample year by 2.
FV-Lag3	"Fill Volume" available in the year preceding the sample year by 3.
FV-Lag4	"Fill Volume" available in the year preceding the sample year by 4.
FV-Lag5	"Fill Volume" available in the year preceding the sample year by 5.
AML	Number of known AML features per acre of watershed.
Deep-Mine	Number of deep mine discharges per acre of watershed.
Remining	Number of known AML features within permitted areas per acre of watershed.

Objective 4: Develop statistical model(s) to evaluate the effectiveness of specific types of BMPs and/or combinations of BMPs for controlling TDS from mining and related activities.

A multiple regression model was developed to predict TDS concentrations as a function of the parameters described above. In order to identify significant parameters, a mixed stepwise regression was performed with an alpha = 0.1 for inclusion and removal of parameters. The resulting parameter estimates are given in Table 6.

Table 6. Parameters identified through mixed stepwise regression analysis.

Parameter	Estimate	p-value
Intercept	364	-
Precipitation	-99	0.0003
30-day_Prec	-12	0.0019
Disturbed Area	547	<0.0001
DA-Lag1	565	<0.0001
DA-Lag2	177	0.0653
Reclaimed Area	382	0.0005
RA-Lag1	930	<0.0001
RA-Lag2	452	<0.0001
RA-Lag3	-561	0.0047
Fill Volume	-28,240	0.0001
FV-Lag5	30,973	<0.0001

4. RESULTS AND DISCUSSION

Results of the analyses are presented here in 5 sections; the first four (4.1 - 4.4) address the results of the monitoring study while the last section discusses the results of the statistical study.

4.1 Apatite II Treatment Units

In total, three Apatite II units were deployed. Site 1 treated water from a deep-mine discharge. Site 2 treated water from the outlet of a pond draining an active surface mine site. Site 3 treated water from the outlet of a pond draining a large fill area. The results of continuous monitoring of specific conductivity are shown in Figures 13 through 15. In general, the apatite increased conductivity (27%, 41%, and 3% at Sites 1, 2, and 3, respectively). The amount of increase was most affected by the residence time; a higher residence time resulted in higher conductivity. This is evident in lower increase (3%) at Site 3, where a higher gradient allowed for a higher flow rate, and there were no apparent problems with flow. In contrast, Site 2 had the lowest flow rate and there were interruptions in flow due to occasional low water or freezing. The water quality analyses provided by VADMME (Table 7) showed small decreases in the concentration of some constituents (*i.e.*, sulfate and magnesium), where contact time was short (Site 3). However, these reductions were offset by increased concentrations of other dissolved constituents. Where the residence time was higher, increases were seen across all measured constituents (*i.e.*, alkalinity, chloride, phosphorus, sulfate, magnesium, potassium, and sodium). These results are born out by other Apatite II treatment studies (Conca and Wright, 2006 and Wright et al., 2004), which were identified after the experiment was conducted and showed pH, alkalinity and TDS values increased due to treatment with Apatite II. Overall, it appears that the Apatite II treatment is not effective in reducing TDS levels.

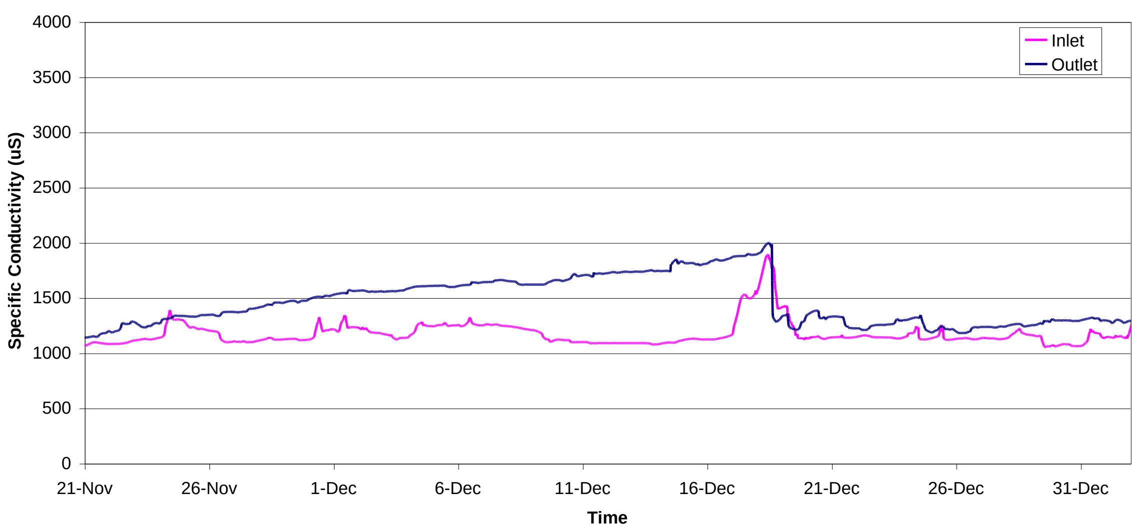

Figure 13. Specific conductivity monitored at the inlet and outlet of the Apatite II treatment unit at Site 1.

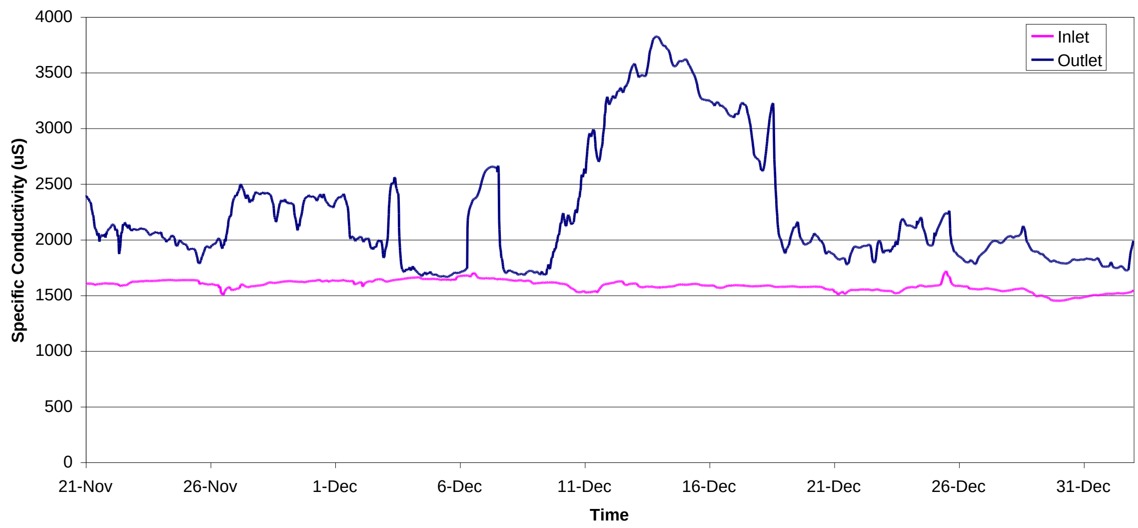

Figure 14. Specific conductivity monitored at the inlet and outlet of the Apatite II treatment unit at Site 2.

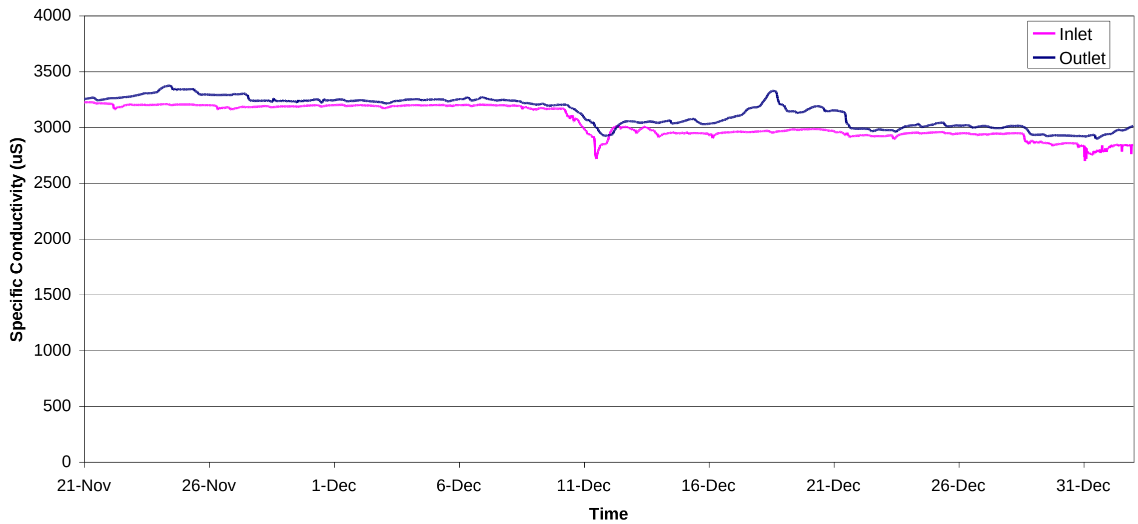

Figure 15. Specific conductivity monitored at the inlet and outlet of the Apatite II treatment unit at Site 3.

Table 7. Water quality results provided by VADMME for samples collected at the Apatite II treatment units.

Parameter	Units	Site 1 Inflow (above pond)	Site 1 Inflow (below pond)	Site 1 Outflow	Site 3 Inflow	Site 3 Outflow
Alkalinity, HC03	mg/l	238	246	1,742	118	118
Chloride	mg/l	4.96	6.18	292	5.76	5.51
Conductivity	uS/cm	1,032	1,099	6,230	2,218	2,275
pH	STD	7.90	8.00	7.00	7.80	7.50
Phosphorus, Total	mg/l	0.015	0.026	55.7	0.024	0.196
Sulfate	mg/l	249	297	340	1,968	1,871
TDS	mg/l	690	646	2,282	3,078	3,176
Magnesium, Total	mg/l	30.5	30.7	39.6	53.9	52.2
Potassium, Total	mg/l	8.10	7.96	277	16.2	17.0
Sodium, Total	mg/l	177	170	348	71.4	73.7

4.2 Pond and Wetland Monitoring

Three ponds and two sections of wetlands were monitored (Figure 7 and Table 4). Pond 1 treated water from a deep-mine discharge. Pond 2 treated water draining from an active surface mine site. Pond 3 treated water draining from a large fill area. The two constructed wetlands are located on Black Creek in Wise County, VA, operate in series and treat an area with AMD and active mining impacts. Figures 16 through 19 show the results of monitoring. A paired T-test was used to determine if conductivity measured at the outlet (downstream) of each structure was significantly different from conductivity measured at the structure's inlet (upstream). In each case, the difference was statistically significant (Table 8). For the ponds, the differences were marginal (*i.e.*, < 7% average change), but there tended to be an increase, this may have been due to evaporation from the pond. The average increase in specific conductivity for Wetland 1 was considerable (344 uS/cm). Further investigation revealed the potential for continued AMD discharges in this section of the wetlands. The downstream wetland (Wetland 2) did show a decrease in specific conductivity (~ 7%).

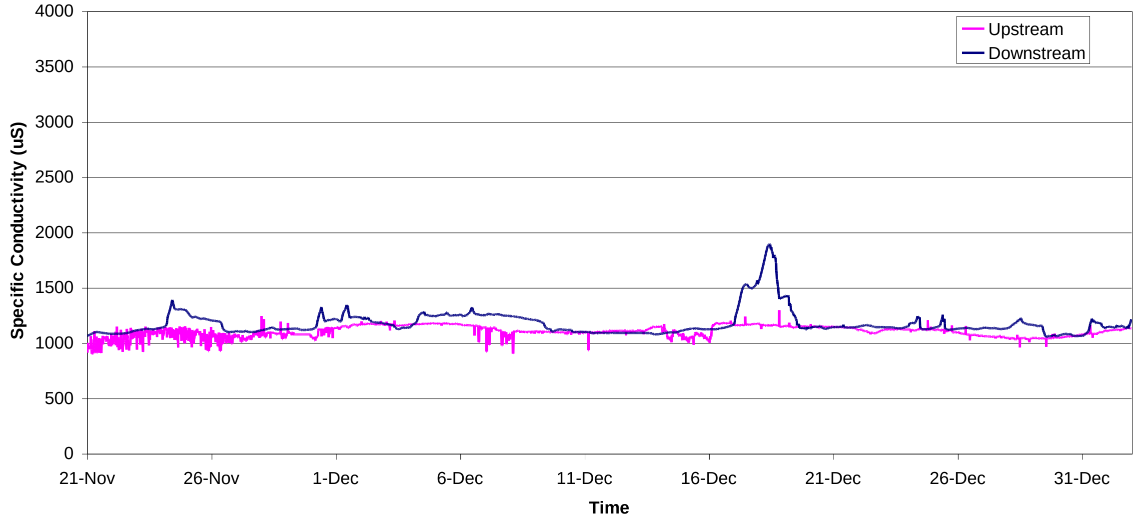

Figure 16. Specific conductivity measured upstream and downstream from a pond controlling discharge from a deep mine.

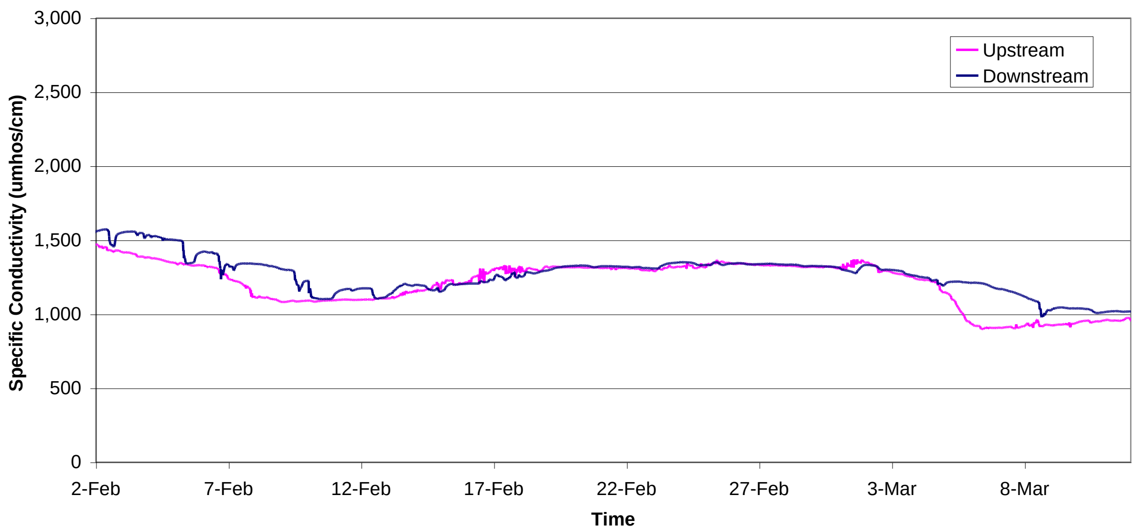

Figure 17. Specific conductivity measured upstream and downstream from a pond controlling runoff from an active surface mine area.

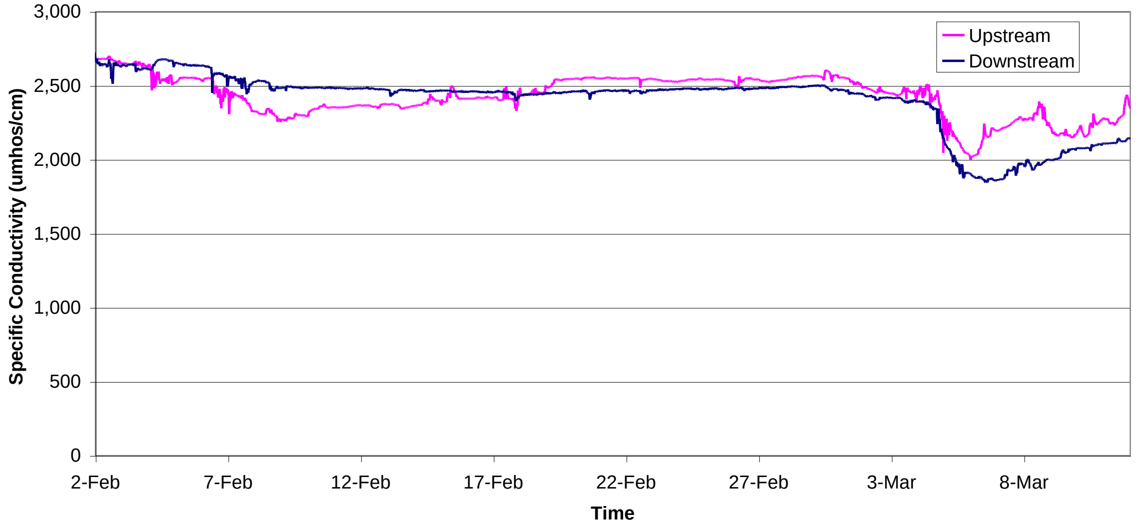

Figure 18. Specific conductivity measured upstream and downstream from a pond controlling runoff from hollow fill area.

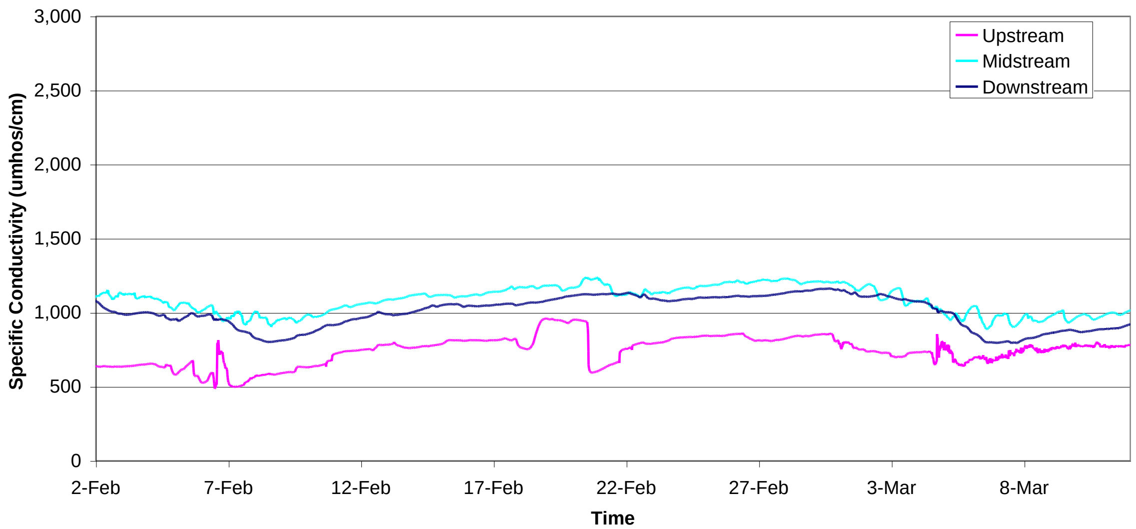

Figure 19. Specific conductivity measured at three locations in a series of wetlands controlling runoff from an area with acid mine drainage.

Table 8. Changes in specific conductivity for structural BMPs (ponds and constructed wetlands) monitored for this project.

BMP	Type of Impact	Average Inlet Conductivity	Average Difference (Outlet-Inlet)	P-value
Pond 1	Increase in specific conductivity.	1,102	73	<0.0001
Pond 2	Increase in specific conductivity.	1,209	58	<0.0001
Pond 3	Decrease in specific conductivity.	2,430	-28	<0.0001
Wetland 1	Increase in specific conductivity.	742	344	<0.0001
Wetland 2	Decrease in specific conductivity.	1,086	-81	<0.0001

4.3 Polymer Treatment

Two analyses were conducted to assess the polymer treatments. First, saturated hydraulic conductivity was measured (Table 9). Diminished saturated hydraulic conductivity would indicate the ability of the treatment to help prevent water from leaching through fill areas. The lowest saturated hydraulic conductivity (3 in/hr) was measured in one of the "Top" treatments. This shows promise for the potential of the treatment in reducing infiltration and consequent leaching through fill areas. However, the results varied widely, and no statistically significant differences were found. It was noted during the experiment that, as the polymer treatment cured, the crust layer formed at the surface tended to pull away from the edge of the cylinder. This may have resulted in short-circuiting along the cylinder sidewall. After the experiment was completed, the top crust layers were examined and appeared porous, probably due to the coarseness of the fill material. Altering the polymer application method/amount could potentially reduce the porosity and provide a more effective barrier.

Table 9. Saturated hydraulic conductivity (in/hr).

Fill Material	**Treatment**		
	Control	**Layer**	**Top**
Shale1	10	141	1,800
Shale2	22	900	123
Sandstone1	162	46	1,260
Sandstone2	39	413	3

The second analysis examined the relative conductivity and TDS levels of the leachate from the different treatments. Results of this analysis are shown in Table 9 and Figure 20. Table 10 shows the average TDS value by treatment for the three grab samples collected. Analysis of Variance (ANOVA) indicated no statistically significant differences between treatments ($p = 0.39$). However, Figure 20 suggests that the timing of the grab samples did not reflect the typical condition during the experiment. A paired analysis using the continuous data conductivity data collected indicates a significant difference between treatments (Table 11), with the "Top" treatment showing significantly lower TDS levels and the "Layered" Treatment showing significantly higher TDS levels.

One possible explanation for these differences is related to the curing process for the polymer product. Instructions for the product indicate that while the chemical emulsifier (surfactant) is present, PolyPavement has low resistance to water invasion. After the emulsifier is degraded (curing process) PolyPavement resists water. The curing process is a photo-degradation of the emulsifier. In bright sunlight, the surface cures in a day or so. However, the subsurface requires approximately 30 days to fully cure. The treatments were given 30 days to cure, however, when the leaching columns were examined after the experiment, a solidified layer was only found on the surface, suggesting that the subsurface layers never fully cured. This could have been responsible for the increase in TDS seen in the "Layered" treatment.

The TDS reduction produced by the "Top" treatment was approximately 9%. The volume of fill material treated was approximately 8%, suggesting a near 100% containment of TDS in the treated volume.

Table 10. Treatment average TDS.

Treatment	Total Dissolved Solids (mg/L)		
	First-Flush	1-hr	10-hr
Control	155	146	312
Polymer applied to top	116	140	495
Polymer applied in layers	126	176	387

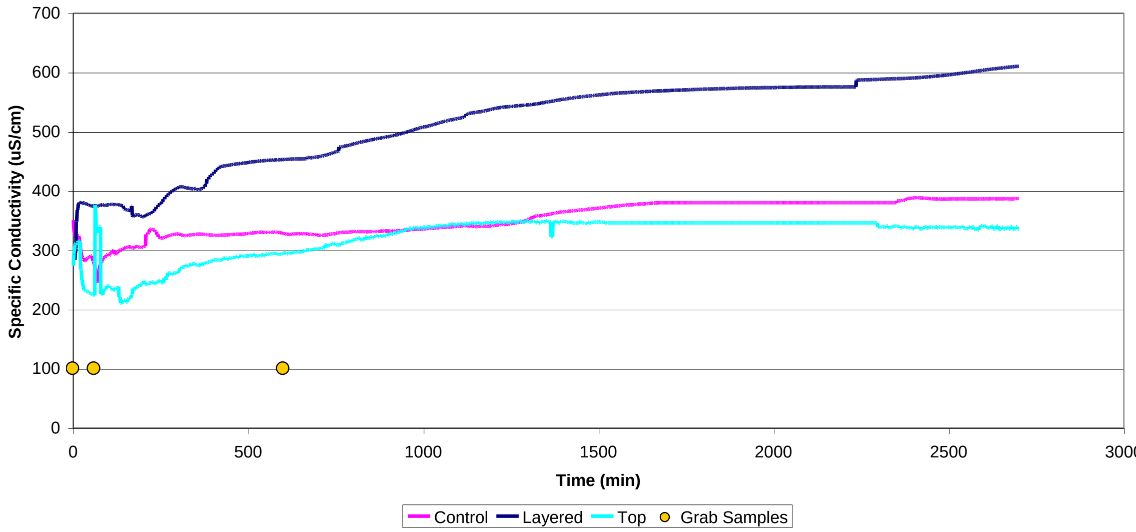

Figure 20. Treatment average specific conductivity continuously measured at outlet of leaching columns, and timing of grab samples.

Table 11. Changes in specific conductivity for polymer treatments, as compared to the control treatment.

Treatment	Impact	Average Conductivity	Average Difference (Treatment-Control)	P-value
Polymer applied to top.	Decrease	322	-32	<0.0001
Polymer applied in layers.	Increase	519	165	<0.0001

4.4 Peat Filter

While the peat filter did not produce the 90% reduction suggested by the literature review, it did produce an average 18% reduction with very little variation (Figure 21). During the continuous flow experiment, conductivity decreased, but when flow was stopped, conductivity began to slowly increase, suggesting that a longer contact time would not be beneficial.

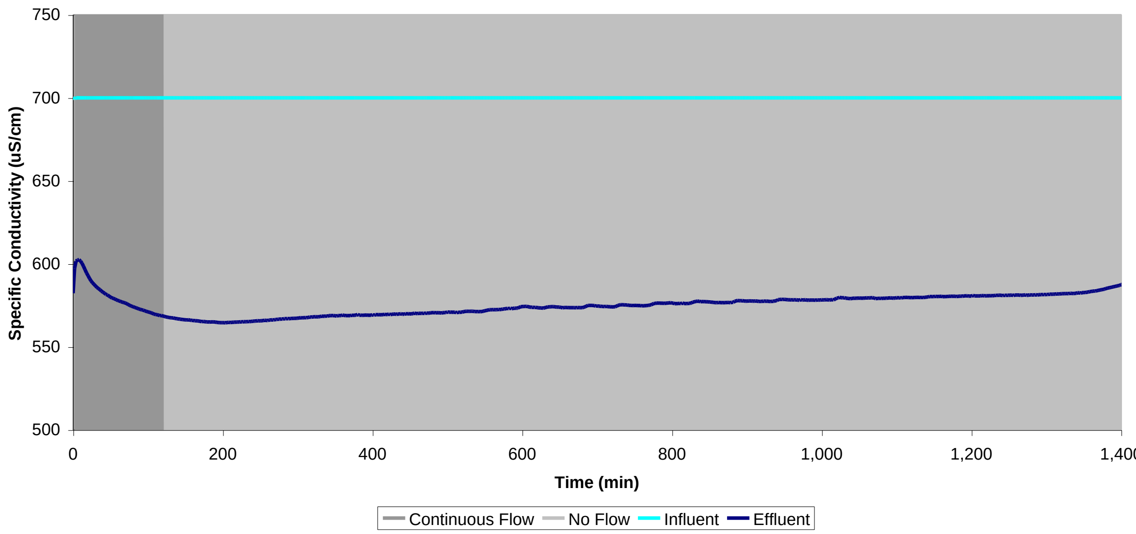

Figure 21. Specific conductivity of influent to and effluent from a peat filter.

4.5 Statistical Study

A regression model developed using JMP 5.0.1 (SAS Institute Inc.) through mixed stepwise regression analysis (Table 12). The model had a coefficient of determination (R^2) of 0.42, indicating that 42% of the variation in TDS concentrations could be explained by the parameters identified. Given that the goal was to examine the relationship between reclamation efforts and TDS concentrations, rather than to develop a model for predicting TDS, this is acceptable. Given the coarse nature of the data used, this R^2 is encouraging. The only inconsistency in the model was the inclusion of both the *Fill Volume* and the 5-year lagged fill volume (*FV-Lag5*). These parameter estimates were -28,240 and 30,773, respectively. This likely reflects the fact that only the capacity of the hollow fills, and not the amount of fill in them, was available. Over time, as the hollow fill capacity is used, TDS impacts develop. However, the inclusion of both parameters is likely a product of colinearity between the two factors. Consequently, the *Fill Volume* parameter was removed from the model, reducing the R^2 to 0.39.

A great deal can be learned by examining the parameter estimates. First, the explanatory variables (*Precipitation* and *30-day_Prec*) have an inverse relationship with TDS concentrations. This is consistent with reports indicating that TDS increases with decreasing stream flow. If the annual precipitation for the area of 47 inches is assumed, and used to calculate average values for *Precipitation* and *30-day_Prec* (0.13 and 3.9, respectively), then, in the absence of any other activity, the expected TDS concentration would be 299 mg/L, which is reasonable, if a bit high, for undisturbed headwater streams in this area.

Of the land-use activities impacting TDS levels, the 5-year lagged fill volume (*FV-Lag5*) has the greatest potential impact, with a parameter estimate of 2,816. Although this does not directly indicate a BMP efficiency, it does indicate the need to identify BMPs to control TDS from hollow fills. The remaining parameters deal with the amount of land disturbed and reclaimed. It is apparent that there is a lag in the impacts of reclamation. Also, it appears that the act of reclamation itself may initially cause an increase in TDS concentrations. This makes sense, since the re-grading process is land-disturbing and often requires fill areas, which may have impacts similar to the hollow fills. Based on the regression equation developed, it appears that over a period of 2 to 3 years after mining is complete, ongoing reclamation provides a 67% improvement over disturbed conditions, as compared to 36% improvement over that same period of time just due to completion of mining.

Table 12. Parameters identified through mixed stepwise regression analysis.

Parameter	Initial		Adjusted	
	Estimate	p-value	Estimate	p-value
Intercept	364	-	359	-
Precipitation	-99	0.0003	-100	0.0004
30-day_Prec	-12	0.0019	-12	0.0023
Disturbed Area	547	<0.0001	494	<0.0001
DA-Lag1	565	<0.0001	489	<0.0001
DA-Lag2	177	0.0653	212	0.0286
Reclaimed Area	382	0.0005	393	0.0004
RA-Lag1	930	<0.0001	899	<0.0001
RA-Lag2	452	<0.0001	472	<0.0001
RA-Lag3	-561	0.0047	-465	0.0193
Fill Volume	-28,240	0.0001	-	-
FV-Lag5	30,973	<0.0001	2,816	<0.0001

5. CONCLUSIONS

This study was designed to look at a large number of BMPs that have the potential to reduce TDS loads, and provide direction for future work in this area. The conclusions listed below indicate the relative strength of the BMPs assessed.

- ✓ It appears that the Apatite II treatment is not effective in reducing TDS levels.
- ✓ Detention ponds may slightly increase TDS levels, but more data is needed to verify the results.
- ✓ Constructed wetlands may decrease TDS levels (~7%), but more data is needed to verify the results.
- ✓ The polymer treatment may have potential in sealing hollow fills.
- ✓ The polymer treatment does reduce TDS production where it is applied and allowed to cure (~100%).
- ✓ The peat filter appears to be effective at reducing TDS (~18%).
- ✓ The statistical study indicated that hollow fills have a large potential impact on TDS concentrations, and that BMPs to reduce these impacts should be explored.
- ✓ The statistical study also indicated that reclamation of disturbed areas has an initial negative impact on TDS concentrations, but provides a 67% reduction in the TDS load from those areas over a 2 to 3 year period, as compared to a 36% improvement due solely to completion of mining.

Implications for future research include:

- ✓ Constructed wetlands and traditional reclamation efforts should continue to be assessed to refine the efficiency estimates developed in this study.
- ✓ The use of a peat filter should be further explored to determine efficiencies under varied conditions.
- ✓ BMPs for reducing TDS loads from hollow fills should be explored, including assessment of the polymer treatment at a plot or field scale.

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APPENDIX A: SUPPLEMENTAL DATA

Table A.1. TDS (mg/L) measured in streams impacted by resource extraction and non-impacted streams. (Part 1 of 5)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
Knox Creek	6020042	01/25/96	96	Knox Creek	6020042	07/23/99	338
Knox Creek	6020042	02/27/96	178	Knox Creek	6020042	08/30/99	444
Knox Creek	6020042	03/15/96	120	Knox Creek	6020042	09/17/99	528
Knox Creek	6020042	04/16/96	200	Knox Creek	6020042	10/27/99	456
Knox Creek	6020042	05/29/96	162	Knox Creek	6020042	11/29/99	238
Knox Creek	6020042	06/17/96	502	Knox Creek	6020042	12/16/99	158
Knox Creek	6020042	07/25/96	504	Knox Creek	6020042	01/24/00	236
Knox Creek	6020042	08/23/96	340	Knox Creek	6020042	02/21/00	118
Knox Creek	6020042	09/09/96	126	Knox Creek	6020042	03/13/00	122
Knox Creek	6020042	10/28/96	414	Knox Creek	6020042	04/27/00	106
Knox Creek	6020042	11/21/96	212	Knox Creek	6020042	05/25/00	396
Knox Creek	6020042	12/10/96	168	Knox Creek	6020042	06/21/00	456
Knox Creek	6020042	01/29/97	34	Knox Creek	6020042	07/10/00	286
Knox Creek	6020042	02/24/97	198	Knox Creek	6020042	08/07/00	252
Knox Creek	6020042	03/15/97	190	Knox Creek	6020042	09/08/00	426
Knox Creek	6020042	05/13/97	196	Knox Creek	6020042	10/06/00	546
Knox Creek	6020042	06/20/97	230	Knox Creek	6020042	11/03/00	644
Knox Creek	6020042	07/17/97	342	Knox Creek	6020042	12/04/00	544
Knox Creek	6020042	08/26/97	461	Knox Creek	6020042	01/04/01	468
Knox Creek	6020042	09/09/97	526	Knox Creek	6020042	02/05/01	306
Knox Creek	6020042	10/24/97	738	Knox Creek	6020042	03/07/01	118
Knox Creek	6020042	11/19/97	572	Knox Creek	6020042	04/13/01	200
Knox Creek	6020042	12/18/97	460	Knox Creek	6020042	05/04/01	314
Knox Creek	6020042	01/30/98	100	Knox Creek	6020042	06/18/01	326
Knox Creek	6020042	02/26/98	166	Knox Creek	6020042	07/02/01	186
Knox Creek	6020042	03/25/98	126	Knox Creek	6020042	08/15/01	390
Knox Creek	6020042	04/23/98	194	Knox Creek	6020042	09/11/01	572
Knox Creek	6020042	05/22/98	384	Knox Creek	6020042	10/22/01	540
Knox Creek	6020042	06/24/98	272	Knox Creek	6020042	11/12/01	524
Knox Creek	6020042	07/15/98	334	Knox Creek	6020042	12/26/01	364
Knox Creek	6020042	08/25/98	484	Knox Creek	6020042	01/31/02	264
Knox Creek	6020042	09/28/98	434	Knox Creek	6020042	02/25/02	264
Knox Creek	6020042	10/21/98	570	Knox Creek	6020042	03/13/02	240
Knox Creek	6020042	11/11/98	502	Knox Creek	6020042	04/10/02	162
Knox Creek	6020042	12/10/98	208	Knox Creek	6020042	05/31/02	390
Knox Creek	6020042	01/26/99	190	Knox Creek	6020042	06/18/02	318
Knox Creek	6020042	02/24/99	188	Knox Creek	6020042	07/22/02	304
Knox Creek	6020042	03/18/99	118	Knox Creek	6020042	08/22/02	558
Knox Creek	6020042	04/21/99	154	Knox Creek	6020042	09/19/02	624
Knox Creek	6020042	05/26/99	324	Knox Creek	6020042	10/30/02	226
Knox Creek	6020042	06/25/99	592	Knox Creek	6020042	11/27/02	194

Table A.1. TDS (mg/L) measured in streams impacted by resource extraction and non-impacted streams. (Part 2 of 5)

Stream	Station_ID	Date	TDS (mg/L)
Knox Creek	6020042	12/17/02	176
Knox Creek	6020042	01/09/03	136
Knox Creek	6020042	02/27/03	164
Knox Creek	6020042	03/27/03	312
Knox Creek	6020042	04/28/03	242
Knox Creek	6020042	05/28/03	216
Knox Creek	6020042	06/12/03	252
Knox Creek	6020042	07/17/03	340
Knox Creek	6020042	08/25/03	246
Knox Creek	6020042	09/26/03	388
Knox Creek	6020042	10/16/03	300
Knox Creek	6020042	11/21/03	148
Knox Creek	6020042	12/10/03	152
Knox Creek	6020042	01/22/04	108
Knox Creek	6020042	02/18/04	292
Knox Creek	6020042	03/17/04	116
Knox Creek	6020042	04/30/04	192
Knox Creek	6020042	05/20/04	320
Knox Creek	6020042	06/23/04	278
Knox Creek	6020042	07/22/04	552
Knox Creek	6020042	08/18/04	404
Knox Creek	6020042	09/07/04	410
Knox Creek	6020042	10/06/04	236
Knox Creek	6020042	11/02/04	190
Knox Creek	6020042	12/07/04	136
Straight Creek	6BSRA001.11	07/01/90	434
Straight Creek	6BSRA001.11	08/01/90	400
Straight Creek	6BSRA001.11	11/01/90	488
Straight Creek	6BSRA001.11	12/01/90	271.2
Straight Creek	6BSRA001.11	01/01/91	194
Straight Creek	6BSRA001.11	03/01/91	208
Straight Creek	6BSRA001.11	04/01/91	269
Straight Creek	6BSRA001.11	05/01/91	336
Straight Creek	6BSRA001.11	06/01/91	472
Straight Creek	6BSRA001.11	07/01/91	448
Straight Creek	6BSRA001.11	09/01/91	407
Straight Creek	6BSRA001.11	10/01/91	489
Straight Creek	6BSRA001.11	07/01/92	194
Straight Creek	6BSRA001.11	10/01/92	613
Straight Creek	6BSRA001.11	01/01/93	351.5
Straight Creek	6BSRA001.11	04/01/93	246
Straight Creek	6BSRA001.11	07/01/93	561
Straight Creek	6BSRA001.11	10/01/93	879
Straight Creek	6BSRA001.11	01/01/94	369
Straight Creek	6BSRA001.11	04/01/94	251
Straight Creek	6BSRA001.11	10/01/94	722
Straight Creek	6BSRA001.11	01/01/95	266
Straight Creek	6BSRA001.11	04/01/95	499
Straight Creek	6BSRA001.11	07/01/95	603
Straight Creek	6BSRA001.11	10/01/95	808
Straight Creek	6BSRA001.11	01/01/96	179
Straight Creek	6BSRA001.11	04/01/96	340.5
Straight Creek	6BSRA001.11	08/01/96	494
Straight Creek	6BSRA001.11	10/01/96	519
Straight Creek	6BSRA001.11	01/01/97	288
Straight Creek	6BSRA001.11	04/01/97	371
Straight Creek	6BSRA001.11	07/01/97	929
Straight Creek	6BSRA001.11	10/01/97	1019
Straight Creek	6BSRA001.11	01/01/98	426
Straight Creek	6BSRA001.11	04/01/98	434.5
Straight Creek	6BSRA001.11	07/01/98	808
Straight Creek	6BSRA001.11	09/01/98	1003
Straight Creek	6BSRA001.11	11/01/98	737.5
Straight Creek	6BSRA001.11	01/01/99	316
Straight Creek	6BSRA001.11	03/01/99	268.5
Straight Creek	6BSRA001.11	05/01/99	322.5
Straight Creek	6BSRA001.11	07/01/99	648
Straight Creek	6BSRA001.11	09/01/99	895
Straight Creek	6BSRA001.11	11/01/99	731
Straight Creek	6BSRA001.11	01/01/00	374
Straight Creek	6BSRA001.11	03/01/00	258.5
Straight Creek	6BSRA001.11	05/01/00	552
Straight Creek	6BSRA001.11	07/01/00	728
Straight Creek	6BSRA001.11	09/01/00	664.5
Straight Creek	6BSRA001.11	11/01/00	666
Straight Creek	6BSRA001.11	03/01/01	410
Straight Creek	6BSRA001.11	07/01/03	575
Straight Creek	6BSRA001.11	08/01/03	708
Straight Creek	6BSRA001.11	09/01/03	1030
Straight Creek	6BSRA001.11	10/01/03	1320
Straight Creek	6BSRA001.11	11/01/03	651
Straight Creek	6BSRA001.11	12/01/03	396

Table A.1. TDS (mg/L) measured in streams impacted by resource extraction and non-impacted streams. (Part 3 of 5)

Stream	Station_ID	Date	TDS (mg/L)
Straight Creek	6BSRA001.11	01/01/04	450
Straight Creek	6BSRA001.11	02/01/04	604
Straight Creek	6BSRA001.11	03/01/04	504
Callahan Creek	0002604	03/01/98	163
Callahan Creek	0002604	04/01/98	457
Callahan Creek	0002604	05/01/98	248
Callahan Creek	0002604	06/01/98	107
Callahan Creek	0002604	07/01/98	443
Callahan Creek	0002604	08/01/98	425
Callahan Creek	0002604	09/01/98	697
Callahan Creek	0002604	10/01/98	710
Callahan Creek	0002604	11/01/98	680
Callahan Creek	0002604	01/01/99	168
Callahan Creek	0002604	02/01/99	182
Callahan Creek	0002604	03/01/99	101
Callahan Creek	0002604	04/01/99	166
Callahan Creek	0002604	05/01/99	207
Callahan Creek	0002604	06/01/99	420
Callahan Creek	0002604	02/01/00	165
Callahan Creek	0002604	03/01/00	222
Callahan Creek	0002604	04/01/00	98
Callahan Creek	0002604	05/01/00	326
Callahan Creek	0002604	07/01/00	299
Callahan Creek	0002604	02/01/01	191
Callahan Creek	0002604	03/01/01	142
Callahan Creek	0002604	04/01/01	276
Callahan Creek	0002604	05/01/01	818
Callahan Creek	0002604	06/01/01	393
Callahan Creek	0002604	07/01/01	458
Callahan Creek	0002604	08/01/01	391
Callahan Creek	0002604	12/01/01	126
Callahan Creek	0002604	01/01/02	157
Callahan Creek	0002604	02/01/02	214
Callahan Creek	0002604	03/01/02	223
Callahan Creek	0002604	04/01/02	122
Callahan Creek	0002604	05/01/02	209
Callahan Creek	0002604	06/01/02	248
Callahan Creek	0002604	07/01/02	206
Callahan Creek	0002604	08/01/02	413
Callahan Creek	0002604	09/01/02	348
Callahan Creek	0002604	10/01/02	230
Callahan Creek	0002604	11/01/02	105
Callahan Creek	0002604	12/01/02	140
Callahan Creek	0002604	01/01/03	205
Callahan Creek	0002604	02/01/03	195
Callahan Creek	0002604	03/01/03	224
Callahan Creek	0002604	04/01/03	190
Callahan Creek	0002604	05/01/03	271
Callahan Creek	0002604	06/01/03	203
Callahan Creek	0002604	07/01/03	408
Callahan Creek	0002604	08/01/03	531
Callahan Creek	0002604	09/01/03	268
Callahan Creek	0002604	10/01/03	251
Callahan Creek	0002604	11/01/03	152
Callahan Creek	0002604	12/01/03	297
Russell Prater Creek	5020263	10/01/95	510
Russell Prater Creek	5020263	11/01/95	488
Russell Prater Creek	5020263	12/01/95	386
Russell Prater Creek	5020263	04/01/96	336
Russell Prater Creek	5020263	05/01/96	309.5
Russell Prater Creek	5020263	07/01/96	596
Russell Prater Creek	5020263	08/01/96	711
Russell Prater Creek	5020263	09/01/96	505
Russell Prater Creek	5020263	11/01/96	352.5
Russell Prater Creek	5020263	12/01/96	340
Russell Prater Creek	5020263	02/01/97	211
Russell Prater Creek	5020263	03/01/97	258
Russell Prater Creek	5020263	04/01/97	358
Russell Prater Creek	5020263	05/01/97	357
Russell Prater Creek	5020263	06/01/97	342
Russell Prater Creek	5020263	07/01/97	490
Russell Prater Creek	5020263	08/01/97	542
Russell Prater Creek	5020263	09/01/97	1452
Russell Prater Creek	5020263	10/01/97	1075
Russell Prater Creek	5020263	11/01/97	674
Russell Prater Creek	5020263	12/01/97	460
Russell Prater Creek	5020263	01/01/98	289
Russell Prater Creek	5020263	02/01/98	188
Russell Prater Creek	5020263	03/01/98	271
Russell Prater Creek	5020263	04/01/98	288
Russell Prater Creek	5020263	05/01/98	354
Russell Prater Creek	5020263	06/01/98	421

Table A.1. TDS (mg/L) measured in streams impacted by resource extraction and non-impacted streams. (Part 4 of 5)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
Russell Prater Creek	5020263	07/01/98	562	PawPaw Creek	6020159	03/30/95	252
Russell Prater Creek	5020263	08/01/98	718	PawPaw Creek	6020159	04/26/95	174
Russell Prater Creek	5020263	09/01/98	1350	PawPaw Creek	6020159	05/23/95	624
Russell Prater Creek	5020263	10/01/98	892	PawPaw Creek	6020159	06/08/95	392
Russell Prater Creek	5020263	11/01/98	725	PawPaw Creek	6020159	07/20/95	528
Russell Prater Creek	5020263	12/01/98	445	PawPaw Creek	6020159	08/30/95	708
Russell Prater Creek	5020263	01/01/99	301	PawPaw Creek	6020159	09/27/95	380
Russell Prater Creek	5020263	02/01/99	324	PawPaw Creek	6020159	10/24/95	558
Russell Prater Creek	5020263	03/01/99	222	PawPaw Creek	6020159	11/06/95	308
Russell Prater Creek	5020263	04/01/99	254	PawPaw Creek	6020159	12/05/95	334
Russell Prater Creek	5020263	05/01/99	377	PawPaw Creek	6020159	01/30/96	184
Russell Prater Creek	5020263	06/01/99	479	PawPaw Creek	6020159	02/20/96	266
Russell Prater Creek	5020263	07/01/99	698	PawPaw Creek	6020159	03/20/96	130
Russell Prater Creek	5020263	08/01/99	778	PawPaw Creek	6020159	04/18/96	125
Russell Prater Creek	5020263	09/01/99	941	PawPaw Creek	6020159	05/02/96	125
Russell Prater Creek	5020263	10/01/99	705.5	PawPaw Creek	6020159	06/06/96	277
Russell Prater Creek	5020263	11/01/99	525.5	PawPaw Creek	6020159	07/13/96	310
Russell Prater Creek	5020263	12/01/99	517.5	PawPaw Creek	6020159	08/12/96	138
Russell Prater Creek	5020263	01/01/00	354	PawPaw Creek	6020159	09/10/96	340
Russell Prater Creek	5020263	02/01/00	194	PawPaw Creek	6020159	10/14/96	328
Russell Prater Creek	5020263	03/01/00	584	PawPaw Creek	6020159	11/08/96	150
Russell Prater Creek	5020263	04/01/00	206	PawPaw Creek	6020159	12/05/96	125
Russell Prater Creek	5020263	05/01/00	638	PawPaw Creek	6020159	01/16/97	120
Russell Prater Creek	5020263	06/01/00	689	PawPaw Creek	6020159	03/14/97	167
Russell Prater Creek	5020263	10/01/00	688	PawPaw Creek	6020159	01/14/98	191
Russell Prater Creek	5020263	11/01/00	882	PawPaw Creek	6020159	03/10/98	121
Russell Prater Creek	5020263	12/01/00	937	PawPaw Creek	6020159	09/28/98	323
Russell Prater Creek	5020263	04/01/01	255	PawPaw Creek	6020159	10/15/98	322
Russell Prater Creek	5020263	05/01/01	564	PawPaw Creek	6020159	11/05/98	363
Russell Prater Creek	5020263	06/01/01	190	PawPaw Creek	6020159	12/08/98	120
Russell Prater Creek	5020263	07/01/01	484	PawPaw Creek	6020159	01/11/99	99
Russell Prater Creek	5020263	08/01/01	552	PawPaw Creek	6020159	02/04/99	140
Russell Prater Creek	5020263	09/01/01	695	PawPaw Creek	6020159	03/11/99	86
Russell Prater Creek	5020263	10/01/01	897	PawPaw Creek	6020159	03/25/99	204
Russell Prater Creek	5020263	11/01/01	849	PawPaw Creek	6020159	04/26/99	254
Russell Prater Creek	5020263	12/01/01	526	PawPaw Creek	6020159	05/13/99	251
Russell Prater Creek	5020263	01/01/02	454	PawPaw Creek	6020159	06/08/99	304
Russell Prater Creek	5020263	02/01/02	385	PawPaw Creek	6020159	07/14/99	397
Russell Prater Creek	5020263	03/01/02	466	PawPaw Creek	6020159	08/16/99	279
PawPaw Creek	6020159	01/18/95	72	PawPaw Creek	6020159	09/08/99	325
PawPaw Creek	6020159	02/28/95	194	PawPaw Creek	6020159	10/08/99	418

Table A.1. TDS (mg/L) measured in streams impacted by resource extraction and non-impacted streams. (Part 5 of 5)

Stream	Station_ID	Date	TDS (mg/L)
PawPaw Creek	6020159	11/05/99	398
PawPaw Creek	6020159	12/07/99	289
PawPaw Creek	6020159	01/10/00	72
PawPaw Creek	6020159	02/01/00	74
PawPaw Creek	6020159	04/24/00	83
PawPaw Creek	6020159	07/26/00	84
PawPaw Creek	6020159	08/10/00	57
PawPaw Creek	6020159	07/02/01	42
PawPaw Creek	6020159	04/12/02	86
PawPaw Creek	6020159	05/07/02	106
PawPaw Creek	6020159	09/01/02	1304
PawPaw Creek	6020159	11/14/02	160
PawPaw Creek	6020159	12/06/02	96
PawPaw Creek	6020159	12/20/02	120
PawPaw Creek	6020159	04/07/03	118
PawPaw Creek	6020159	05/07/03	291
PawPaw Creek	6020159	06/06/03	343
PawPaw Creek	6020159	08/08/03	72
PawPaw Creek	6020159	09/15/03	357
PawPaw Creek	6020159	11/24/03	214
PawPaw Creek	6020159	12/08/03	152
PawPaw Creek	6020159	01/06/04	162
PawPaw Creek	6020159	02/13/04	230
PawPaw Creek	6020159	03/10/04	222
PawPaw Creek	6020159	04/09/04	244
PawPaw Creek	6020159	05/14/04	316
PawPaw Creek	6020159	06/09/04	292
PawPaw Creek	6020159	07/06/04	424
PawPaw Creek	6020159	08/11/04	394
PawPaw Creek	6020159	09/07/04	548
PawPaw Creek	6020159	10/06/04	414
PawPaw Creek	6020159	11/09/04	212
PawPaw Creek	6020159	12/15/04	208

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 1 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
N.F. Pound River	6APNK001.26	10/24/01	80	Dismal Creek	6ADIS001.24	08/30/94	328
N.F. Pound River	6APNK001.26	09/20/01	89	Dismal Creek	6ADIS001.24	11/28/94	334
N.F. Pound River	6APNK001.26	08/09/01	62	Dismal Creek	6ADIS001.24	02/22/95	226
N.F. Pound River	6APNK001.26	06/21/01	45	Dismal Creek	6ADIS001.24	05/23/95	204
N.F. Pound River	6APNK001.26	05/23/01	52	Dismal Creek	6ADIS001.24	08/14/95	365
N.F. Pound River	6APNK001.26	04/24/01	46	Dismal Creek	6ADIS001.24	11/21/95	260
Left Fork Lick Creek	6ALLF002.19	04/09/03	49	Dismal Creek	6ADIS001.24	02/13/96	166
Fox Creek	6AFOX001.69	05/05/04	121	Dismal Creek	6ADIS001.24	05/08/96	143
Johnson Branch	6BJNN001.35	03/24/03	119	Dismal Creek	6ADIS001.24	08/13/96	194
Adiar Run	9-ADR000.13	09/26/00	142	Dismal Creek	6ADIS001.24	11/20/96	201
Adiar Run	9-ADR000.13	05/08/01	104	Dismal Creek	6ADIS001.24	05/13/97	207
Adiar Run	9-ADR000.13	07/13/99	162	Dismal Creek	6ADIS001.24	08/13/97	407
Adiar Run	9-ADR000.13	11/20/00	185	Dismal Creek	6ADIS001.24	11/18/97	334
Little Walker Creek	9-LWK000.77	06/06/01	39	Dismal Creek	6ADIS001.24	02/10/98	141
Adiar Run	9-ADR000.13	07/25/00	116	Dismal Creek	6ADIS001.24	05/13/98	196
Adiar Run	9-ADR000.13	05/03/00	88	Dismal Creek	6ADIS001.24	08/25/98	312
Adiar Run	9-ADR000.13	03/07/00	95	Dismal Creek	6ADIS001.24	10/05/98	376
Adiar Run	9-ADR000.13	01/11/00	125	Dismal Creek	6ADIS001.24	12/14/98	175
Adiar Run	9-ADR000.13	11/09/99	195	Dismal Creek	6ADIS001.24	02/09/99	217
Adiar Run	9-ADR000.13	09/15/99	202	Dismal Creek	6ADIS001.24	04/29/99	92
Adiar Run	9-ADR000.13	03/15/01	99	Dismal Creek	6ADIS001.24	06/09/99	363
Little Walker Creek	9-LWK000.77	05/03/00	34	Dismal Creek	6ADIS001.24	08/04/99	307
Little Walker Creek	9-LWK000.77	07/13/99	49	Dismal Creek	6ADIS001.24	12/13/99	226
Little Walker Creek	9-LWK000.77	09/15/99	82	Dismal Creek	6ADIS001.24	02/10/00	158
Little Walker Creek	9-LWK000.77	11/09/99	88	Dismal Creek	6ADIS001.24	04/19/00	174
Little Walker Creek	9-LWK000.77	03/07/00	36	Dismal Creek	6ADIS001.24	06/12/00	344
Little Walker Creek	9-LWK000.77	08/29/00	53	Dismal Creek	6ADIS001.24	08/24/00	297
Little Walker Creek	9-LWK000.77	10/11/00	74	Dismal Creek	6ADIS001.24	10/05/00	366
Little Walker Creek	9-LWK000.77	12/20/00	35	Dismal Creek	6ADIS001.24	12/06/00	370
Little Walker Creek	9-LWK000.77	02/21/01	36	Dismal Creek	6ADIS001.24	02/01/01	305
Little Walker Creek	9-LWK000.77	04/16/01	46	Dismal Creek	6ADIS013.73	04/30/03	198
Adiar Run	9-ADR000.13	04/29/02	81	McClure River	6AMCR000.20	04/30/96	197
Little Walker Creek	9-LWK000.77	01/11/00	45	McClure River	6AMCR000.20	06/25/96	329
Little Stony Creek	6BLSR004.78	05/10/04	20	McClure River	6AMCR000.20	08/13/96	148
Dismal Creek	6ADIS001.24	08/04/92	304	McClure River	6AMCR000.20	10/21/96	333
Dismal Creek	6ADIS001.24	11/18/92	426	McClure River	6AMCR000.20	12/09/96	126
Dismal Creek	6ADIS001.24	02/18/93	143	McClure River	6AMCR000.20	02/05/97	176
Dismal Creek	6ADIS001.24	05/20/93	237	McClure River	6AMCR000.20	04/21/97	263
Dismal Creek	6ADIS001.24	08/11/93	527	McClure River	6AMCR000.20	06/10/97	214
Dismal Creek	6ADIS001.24	11/04/93	308	McClure River	6AMCR000.20	08/13/97	340
Dismal Creek	6ADIS001.24	05/25/94	274	McClure River	6AMCR000.20	12/16/97	249

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 2 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
McClure River	6AMCR000.20	02/10/98	161	Big Cedar Creek	6BBCD004.18	07/13/98	223
McClure River	6AMCR000.20	04/27/98	252	Big Cedar Creek	6BBCD004.18	09/28/98	217
McClure River	6AMCR000.20	06/01/98	229	Big Cedar Creek	6BBCD004.18	11/23/98	235
McClure River	6AMCR000.20	09/14/98	416	Big Cedar Creek	6BBCD004.18	01/11/99	191
McClure River	6AMCR000.20	11/02/98	427	Big Cedar Creek	6BBCD004.18	03/17/99	185
McClure River	6AMCR000.20	01/13/99	156	Big Cedar Creek	6BBCD004.18	05/26/99	223
McClure River	6AMCR000.20	03/29/99	249	Big Cedar Creek	6BBCD004.18	07/14/99	240
McClure River	6AMCR000.20	05/10/99	232	Big Cedar Creek	6BBCD004.18	09/29/99	215
McClure River	6AMCR000.20	07/06/99	303	Big Cedar Creek	6BBCD004.18	11/15/99	239
McClure River	6AMCR000.20	09/07/99	400	Big Cedar Creek	6BBCD004.18	01/13/00	198
McClure River	6AMCR000.20	01/06/00	331	Big Cedar Creek	6BBCD004.18	03/14/00	215
McClure River	6AMCR000.20	03/27/00	214	Big Cedar Creek	6BBCD004.18	05/09/00	198
McClure River	6AMCR000.20	05/10/00	342	Big Cedar Creek	6BBCD004.18	07/12/00	204
McClure River	6AMCR000.20	07/17/00	241	Big Cedar Creek	6BBCD004.18	09/18/00	211
McClure River	6AMCR000.20	09/25/00	648	Big Cedar Creek	6BBCD004.18	11/20/00	224
McClure River	6AMCR000.20	01/09/01	529	Big Cedar Creek	6BBCD004.18	01/23/01	222
McClure River	6AMCR000.20	03/01/01	209	Big Cedar Creek	6BBCD004.18	03/08/01	197
Big Cedar Creek	6BBCD004.18	05/17/94	178	Clinch River	6BCLN206.70	03/21/95	160
Big Cedar Creek	6BBCD004.18	07/12/94	199	Clinch River	6BCLN206.70	04/19/95	184
Big Cedar Creek	6BBCD004.18	09/28/94	220	Clinch River	6BCLN206.70	05/17/95	136
Big Cedar Creek	6BBCD004.18	11/30/94	215	Clinch River	6BCLN206.70	06/07/95	155
Big Cedar Creek	6BBCD004.18	01/26/95	195	Clinch River	6BCLN206.70	07/17/95	191
Big Cedar Creek	6BBCD004.18	03/06/95	203	Clinch River	6BCLN206.70	08/16/95	250
Big Cedar Creek	6BBCD004.18	05/24/95	192	Clinch River	6BCLN206.70	09/06/95	242
Big Cedar Creek	6BBCD004.18	07/25/95	205	Clinch River	6BCLN206.70	10/02/95	247
Big Cedar Creek	6BBCD004.18	10/17/95	237	Clinch River	6BCLN206.70	11/20/95	196
Big Cedar Creek	6BBCD004.18	11/14/95	192	Clinch River	6BCLN206.70	12/14/95	175
Big Cedar Creek	6BBCD004.18	02/26/96	186	Clinch River	6BCLN206.70	01/18/96	143
Big Cedar Creek	6BBCD004.18	03/25/96	185	Clinch River	6BCLN206.70	02/22/96	150
Big Cedar Creek	6BBCD004.18	05/21/96	189	Clinch River	6BCLN206.70	03/26/96	158
Big Cedar Creek	6BBCD004.18	07/29/96	199	Clinch River	6BCLN206.70	04/17/96	166
Big Cedar Creek	6BBCD004.18	09/09/96	226	Clinch River	6BCLN206.70	05/20/96	146
Big Cedar Creek	6BBCD004.18	11/12/96	206	Clinch River	6BCLN206.70	06/10/96	175
Big Cedar Creek	6BBCD004.18	01/22/97	189	Clinch River	6BCLN206.70	07/15/96	207
Big Cedar Creek	6BBCD004.18	03/24/97	181	Clinch River	6BCLN206.70	08/05/96	193
Big Cedar Creek	6BBCD004.18	05/28/97	193	Clinch River	6BCLN206.70	09/24/96	192
Big Cedar Creek	6BBCD004.18	07/16/97	216	Clinch River	6BCLN206.70	10/23/96	199
Big Cedar Creek	6BBCD004.18	09/17/97	207	Clinch River	6BCLN206.70	11/19/96	186
Big Cedar Creek	6BBCD004.18	11/20/97	236	Clinch River	6BCLN206.70	12/17/96	162
Big Cedar Creek	6BBCD004.18	03/03/98	174	Clinch River	6BCLN206.70	01/14/97	183
Big Cedar Creek	6BBCD004.18	05/27/98	208	Clinch River	6BCLN206.70	02/24/97	183

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 3 of 12)

Stream	Station_ID	Date	TDS (mg/L)
Clinch River	6BCLN206.70	03/11/97	174
Clinch River	6BCLN206.70	04/14/97	164
Clinch River	6BCLN206.70	05/06/97	138
Clinch River	6BCLN206.70	06/11/97	182
Clinch River	6BCLN206.70	07/30/97	257
Clinch River	6BCLN206.70	08/26/97	247
Clinch River	6BCLN206.70	09/15/97	309
Clinch River	6BCLN206.70	10/22/97	273
Clinch River	6BCLN206.70	11/19/97	280
Clinch River	6BCLN206.70	12/03/97	256
Clinch River	6BCLN206.70	01/07/98	217
Clinch River	6BCLN206.70	02/23/98	151
Clinch River	6BCLN206.70	03/12/98	159
Clinch River	6BCLN206.70	04/28/98	190
Clinch River	6BCLN206.70	05/28/98	167
Clinch River	6BCLN206.70	06/22/98	199
Clinch River	6BCLN206.70	07/28/98	224
Clinch River	6BCLN206.70	08/12/98	246
Clinch River	6BCLN206.70	09/22/98	245
Clinch River	6BCLN206.70	10/26/98	270
Clinch River	6BCLN206.70	11/23/98	290
Clinch River	6BCLN206.70	12/16/98	204
Clinch River	6BCLN206.70	01/12/99	171
Clinch River	6BCLN206.70	02/03/99	192
Clinch River	6BCLN206.70	03/18/99	159
Clinch River	6BCLN206.70	04/06/99	182
Clinch River	6BCLN206.70	05/05/99	159
Clinch River	6BCLN206.70	06/08/99	186
Clinch River	6BCLN206.70	07/13/99	204
Clinch River	6BCLN206.70	08/24/99	219
Clinch River	6BCLN206.70	09/28/99	253
Clinch River	6BCLN206.70	10/21/99	235
Clinch River	6BCLN206.70	11/17/99	243
Clinch River	6BCLN206.70	12/07/99	229
Clinch River	6BCLN206.70	01/24/00	206
Clinch River	6BCLN206.70	02/09/00	223
Clinch River	6BCLN206.70	03/22/00	160
Clinch River	6BCLN206.70	04/25/00	160
Clinch River	6BCLN206.70	05/22/00	203
Clinch River	6BCLN206.70	06/26/00	241
Clinch River	6BCLN206.70	07/26/00	223
Clinch River	6BCLN206.70	09/21/00	236
Clinch River	6BCLN206.70	10/24/00	257
Clinch River	6BCLN206.70	11/27/00	258
Clinch River	6BCLN206.70	12/11/00	297
Clinch River	6BCLN206.70	02/26/01	161
Clinch River	6BCLN206.70	03/12/01	175
Clinch River	6BCLN206.70	07/15/03	172
Clinch River	6BCLN206.70	09/10/03	208
Clinch River	6BCLN206.70	11/06/03	207
Clinch River	6BCLN206.70	01/06/04	153
Clinch River	6BCLN206.70	03/09/04	160
Clinch River	6BCLN237.09	02/10/92	151
Clinch River	6BCLN237.09	07/22/92	272
Clinch River	6BCLN237.09	08/12/92	243
Clinch River	6BCLN237.09	09/17/92	218
Clinch River	6BCLN237.09	10/29/92	268
Clinch River	6BCLN237.09	12/07/92	202
Clinch River	6BCLN237.09	03/03/93	220
Clinch River	6BCLN237.09	04/21/93	177
Clinch River	6BCLN237.09	05/13/93	241
Clinch River	6BCLN237.09	06/23/93	237
Clinch River	6BCLN237.09	07/07/93	209
Clinch River	6BCLN237.09	08/26/93	223
Clinch River	6BCLN237.09	09/13/93	250
Clinch River	6BCLN237.09	10/20/93	239
Clinch River	6BCLN237.09	11/30/93	178
Clinch River	6BCLN237.09	12/20/93	168
Clinch River	6BCLN237.09	01/12/94	153
Clinch River	6BCLN237.09	02/23/94	195
Clinch River	6BCLN237.09	03/21/94	172
Clinch River	6BCLN237.09	04/21/94	156
Clinch River	6BCLN237.09	05/17/94	171
Clinch River	6BCLN237.09	06/28/94	222
Clinch River	6BCLN237.09	07/12/94	239
Clinch River	6BCLN237.09	08/24/94	175
Clinch River	6BCLN237.09	09/19/94	231
Clinch River	6BCLN237.09	10/04/94	244
Clinch River	6BCLN237.09	11/30/94	187
Clinch River	6BCLN237.09	12/15/94	162
Clinch River	6BCLN237.09	01/26/95	170
Clinch River	6BCLN237.09	02/14/95	185

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 4 of 12)

Stream	Station_ID	Date	TDS (mg/L)
Clinch River	6BCLN237.09	03/06/95	154
Clinch River	6BCLN237.09	04/12/95	178
Clinch River	6BCLN237.09	05/24/95	148
Clinch River	6BCLN237.09	06/13/95	169
Clinch River	6BCLN237.09	07/25/95	212
Clinch River	6BCLN237.09	08/29/95	258
Clinch River	6BCLN237.09	09/13/95	312
Clinch River	6BCLN237.09	10/17/95	277
Clinch River	6BCLN237.09	11/14/95	166
Clinch River	6BCLN237.09	12/05/95	166
Clinch River	6BCLN237.09	02/26/96	160
Clinch River	6BCLN237.09	03/25/96	155
Clinch River	6BCLN237.09	04/10/96	167
Clinch River	6BCLN237.09	05/21/96	158
Clinch River	6BCLN237.09	06/06/96	183
Clinch River	6BCLN237.09	07/29/96	255
Clinch River	6BCLN237.09	08/14/96	168
Clinch River	6BCLN237.09	09/09/96	206
Clinch River	6BCLN237.09	10/29/96	234
Clinch River	6BCLN237.09	11/12/96	172
Clinch River	6BCLN237.09	12/03/96	151
Clinch River	6BCLN237.09	01/22/97	161
Clinch River	6BCLN237.09	02/25/97	167
Clinch River	6BCLN237.09	03/24/97	147
Clinch River	6BCLN237.09	04/28/97	138
Clinch River	6BCLN237.09	05/28/97	125
Clinch River	6BCLN237.09	07/16/97	243
Clinch River	6BCLN237.09	08/20/97	268
Clinch River	6BCLN237.09	09/17/97	252
Clinch River	6BCLN237.09	10/14/97	295
Clinch River	6BCLN237.09	11/20/97	321
Clinch River	6BCLN237.09	12/10/97	237
Clinch River	6BCLN237.09	02/17/98	153
Clinch River	6BCLN237.09	03/03/98	162
Clinch River	6BCLN237.09	04/09/98	111
Clinch River	6BCLN237.09	05/27/98	159
Clinch River	6BCLN237.09	06/09/98	177
Clinch River	6BCLN237.09	07/13/98	215
Clinch River	6BCLN237.09	08/10/98	255
Clinch River	6BCLN237.09	09/28/98	273
Clinch River	6BCLN237.09	10/27/98	318
Clinch River	6BCLN237.09	11/23/98	327
Clinch River	6BCLN237.09	01/11/99	163
Clinch River	6BCLN237.09	02/24/99	142
Clinch River	6BCLN237.09	03/17/99	148
Clinch River	6BCLN237.09	04/14/99	141
Clinch River	6BCLN237.09	05/26/99	165
Clinch River	6BCLN237.09	06/23/99	215
Clinch River	6BCLN237.09	07/14/99	217
Clinch River	6BCLN237.09	08/11/99	238
Clinch River	6BCLN237.09	09/29/99	278
Clinch River	6BCLN237.09	10/20/99	270
Clinch River	6BCLN237.09	11/15/99	291
Clinch River	6BCLN237.09	12/14/99	205
Clinch River	6BCLN237.09	01/13/00	164
Clinch River	6BCLN237.09	02/28/00	141
Clinch River	6BCLN237.09	03/14/00	149
Clinch River	6BCLN237.09	04/18/00	159
Clinch River	6BCLN237.09	05/09/00	153
Clinch River	6BCLN237.09	06/06/00	155
Clinch River	6BCLN237.09	07/12/00	210
Clinch River	6BCLN237.09	08/01/00	210
Clinch River	6BCLN237.09	09/18/00	247
Clinch River	6BCLN237.09	10/11/00	276
Clinch River	6BCLN237.09	11/20/00	276
Clinch River	6BCLN237.09	12/05/00	338
Clinch River	6BCLN237.09	01/23/01	176
Clinch River	6BCLN237.09	02/08/01	186
Clinch River	6BCLN237.09	02/08/01	187
Clinch River	6BCLN237.09	03/08/01	153
Clinch River	6BCLN271.50	02/10/92	180
Clinch River	6BCLN271.50	07/22/92	213
Clinch River	6BCLN271.50	08/12/92	18.5
Clinch River	6BCLN271.50	09/17/92	181
Clinch River	6BCLN271.50	10/29/92	209
Clinch River	6BCLN271.50	12/07/92	180
Clinch River	6BCLN271.50	03/03/93	206
Clinch River	6BCLN271.50	04/21/93	158
Clinch River	6BCLN271.50	05/13/93	221
Clinch River	6BCLN271.50	06/23/93	169
Clinch River	6BCLN271.50	07/07/93	161
Clinch River	6BCLN271.50	08/26/93	167

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 5 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
Clinch River	6BCLN271.50	09/13/93	175	Clinch River	6BCLN271.50	03/24/97	149
Clinch River	6BCLN271.50	10/20/93	187	Clinch River	6BCLN271.50	04/28/97	149
Clinch River	6BCLN271.50	11/30/93	175	Clinch River	6BCLN271.50	05/28/97	164
Clinch River	6BCLN271.50	12/20/93	167	Clinch River	6BCLN271.50	06/16/97	214
Clinch River	6BCLN271.50	01/12/94	160	Clinch River	6BCLN271.50	07/16/97	201
Clinch River	6BCLN271.50	02/23/94	199	Clinch River	6BCLN271.50	08/20/97	215
Clinch River	6BCLN271.50	03/21/94	167	Clinch River	6BCLN271.50	09/17/97	184
Clinch River	6BCLN271.50	04/21/94	139	Clinch River	6BCLN271.50	10/14/97	197
Clinch River	6BCLN271.50	05/17/94	142	Clinch River	6BCLN271.50	11/20/97	314
Clinch River	6BCLN271.50	06/28/94	183	Clinch River	6BCLN271.50	12/10/97	225
Clinch River	6BCLN271.50	07/12/94	176	Clinch River	6BCLN271.50	02/17/98	157
Clinch River	6BCLN271.50	08/24/94	206	Clinch River	6BCLN271.50	03/03/98	155
Clinch River	6BCLN271.50	09/19/94	171	Clinch River	6BCLN271.50	04/09/98	142
Clinch River	6BCLN271.50	10/04/94	178	Clinch River	6BCLN271.50	05/27/98	153
Clinch River	6BCLN271.50	11/30/94	195	Clinch River	6BCLN271.50	06/09/98	194
Clinch River	6BCLN271.50	12/15/94	176	Clinch River	6BCLN271.50	07/13/98	191
Clinch River	6BCLN271.50	01/26/95	171	Clinch River	6BCLN271.50	08/10/98	190
Clinch River	6BCLN271.50	02/14/95	117	Clinch River	6BCLN271.50	09/28/98	220
Clinch River	6BCLN271.50	03/06/95	165	Clinch River	6BCLN271.50	10/27/98	234
Clinch River	6BCLN271.50	04/12/95	153	Clinch River	6BCLN271.50	11/23/98	240
Clinch River	6BCLN271.50	05/24/95	149	Clinch River	6BCLN271.50	01/11/99	180
Clinch River	6BCLN271.50	06/13/95	164	Clinch River	6BCLN271.50	02/24/99	162
Clinch River	6BCLN271.50	07/25/95	164	Clinch River	6BCLN271.50	03/17/99	158
Clinch River	6BCLN271.50	08/29/95	186	Clinch River	6BCLN271.50	04/14/99	155
Clinch River	6BCLN271.50	09/13/95	189	Clinch River	6BCLN271.50	05/26/99	184
Clinch River	6BCLN271.50	10/17/95	199	Clinch River	6BCLN271.50	06/23/99	170
Clinch River	6BCLN271.50	11/14/95	175	Clinch River	6BCLN271.50	07/14/99	202
Clinch River	6BCLN271.50	12/05/95	175	Clinch River	6BCLN271.50	08/11/99	208
Clinch River	6BCLN271.50	02/26/96	159	Clinch River	6BCLN271.50	09/29/99	176
Clinch River	6BCLN271.50	03/25/96	160	Clinch River	6BCLN271.50	10/20/99	213
Clinch River	6BCLN271.50	04/10/96	158	Clinch River	6BCLN271.50	11/15/99	219
Clinch River	6BCLN271.50	05/21/96	183	Clinch River	6BCLN271.50	12/14/99	203
Clinch River	6BCLN271.50	06/06/96	178	Clinch River	6BCLN271.50	01/13/00	168
Clinch River	6BCLN271.50	07/29/96	213	Clinch River	6BCLN271.50	02/28/00	201
Clinch River	6BCLN271.50	08/14/96	181	Clinch River	6BCLN271.50	03/14/00	166
Clinch River	6BCLN271.50	09/09/96	207	Clinch River	6BCLN271.50	04/18/00	152
Clinch River	6BCLN271.50	10/29/96	209	Clinch River	6BCLN271.50	05/09/00	162
Clinch River	6BCLN271.50	11/12/96	173	Clinch River	6BCLN271.50	07/12/00	200
Clinch River	6BCLN271.50	12/03/96	133	Clinch River	6BCLN271.50	08/01/00	186
Clinch River	6BCLN271.50	01/22/97	167	Clinch River	6BCLN271.50	09/18/00	188
Clinch River	6BCLN271.50	02/25/97	168	Clinch River	6BCLN271.50	10/11/00	219

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 6 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
Clinch River	6BCLN271.50	11/20/00	237	Clinch River	6BCLN315.11	07/14/99	239
Clinch River	6BCLN271.50	12/05/00	236	Clinch River	6BCLN315.11	08/11/99	247
Clinch River	6BCLN271.50	01/23/01	194	Clinch River	6BCLN315.11	09/29/99	273
Clinch River	6BCLN271.50	02/08/01	197	Clinch River	6BCLN315.11	10/20/99	258
Clinch River	6BCLN271.50	03/08/01	155	Clinch River	6BCLN315.11	11/15/99	243
Clinch River	6BCLN271.50	08/07/03	192	Clinch River	6BCLN315.11	12/14/99	199
Clinch River	6BCLN271.50	10/27/03	210	Clinch River	6BCLN315.11	01/13/00	191
Clinch River	6BCLN271.50	12/04/03	193	Clinch River	6BCLN315.11	02/28/00	209
Clinch River	6BCLN271.50	02/03/04	198	Clinch River	6BCLN315.11	03/14/00	166
Clinch River	6BCLN271.50	04/19/04	175	Clinch River	6BCLN315.11	04/18/00	151
Clinch River	6BCLN315.11	12/09/92	161	Clinch River	6BCLN315.11	05/09/00	177
Clinch River	6BCLN315.11	03/17/93	171	Clinch River	6BCLN315.11	06/06/00	271
Clinch River	6BCLN315.11	06/09/93	307	Clinch River	6BCLN315.11	07/12/00	201
Clinch River	6BCLN315.11	09/23/93	196	Clinch River	6BCLN315.11	08/01/00	224
Clinch River	6BCLN315.11	12/20/93	157	Clinch River	6BCLN315.11	09/18/00	270
Clinch River	6BCLN315.11	06/28/94	192	Clinch River	6BCLN315.11	10/11/00	323
Clinch River	6BCLN315.11	09/22/94	193	Clinch River	6BCLN315.11	11/20/00	296
Clinch River	6BCLN315.11	12/06/94	171	Clinch River	6BCLN315.11	12/05/00	310
Clinch River	6BCLN315.11	03/29/95	158	Clinch River	6BCLN315.11	01/23/01	205
Clinch River	6BCLN315.11	06/13/95	171	Clinch River	6BCLN315.11	02/08/01	221
Clinch River	6BCLN315.11	09/13/95	266	Clinch River	6BCLN315.11	03/08/01	162
Clinch River	6BCLN315.11	12/05/95	179	Clinch River	6BCLN321.13	08/04/03	214
Clinch River	6BCLN315.11	06/06/96	216	Clinch River	6BCLN321.13	10/23/03	193
Clinch River	6BCLN315.11	09/09/96	251	Clinch River	6BCLN321.13	12/30/03	188
Clinch River	6BCLN315.11	12/03/96	145	Clinch River	6BCLN321.13	02/25/04	181
Clinch River	6BCLN315.11	03/24/97	168	Clinch River	6BCLN321.13	04/27/04	145
Clinch River	6BCLN315.11	06/16/97	226	Clinch River	6BCLN339.53	05/26/92	229
Clinch River	6BCLN315.11	09/17/97	235	Clinch River	6BCLN339.53	09/02/92	196
Clinch River	6BCLN315.11	12/10/97	273	Clinch River	6BCLN339.53	11/05/92	202
Clinch River	6BCLN315.11	03/03/98	153	Clinch River	6BCLN339.53	01/07/93	182
Clinch River	6BCLN315.11	06/09/98	198	Clinch River	6BCLN339.53	03/23/93	167
Clinch River	6BCLN315.11	08/10/98	224	Clinch River	6BCLN339.53	03/25/93	140
Clinch River	6BCLN315.11	09/28/98	336	Clinch River	6BCLN339.53	07/01/93	175
Clinch River	6BCLN315.11	10/27/98	354	Clinch River	6BCLN339.53	09/08/93	197
Clinch River	6BCLN315.11	11/23/98	329	Clinch River	6BCLN339.53	11/29/93	218
Clinch River	6BCLN315.11	01/11/99	188	Clinch River	6BCLN339.53	02/15/94	157
Clinch River	6BCLN315.11	02/24/99	183	Clinch River	6BCLN339.53	05/26/94	158
Clinch River	6BCLN315.11	03/17/99	146	Clinch River	6BCLN339.53	07/28/94	201
Clinch River	6BCLN315.11	04/14/99	156	Clinch River	6BCLN339.53	09/22/94	195
Clinch River	6BCLN315.11	05/26/99	193	Clinch River	6BCLN339.53	11/14/94	182
Clinch River	6BCLN315.11	06/23/99	215	Clinch River	6BCLN339.53	02/23/95	172

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 7 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
Clinch River	6BCLN339.53	03/29/95	167	Clinch River	6BCLN339.53	07/12/00	212
Clinch River	6BCLN339.53	05/24/95	159	Clinch River	6BCLN339.53	08/01/00	179
Clinch River	6BCLN339.53	07/25/95	159	Clinch River	6BCLN339.53	09/18/00	182
Clinch River	6BCLN339.53	09/13/95	169	Clinch River	6BCLN339.53	10/11/00	206
Clinch River	6BCLN339.53	11/14/95	190	Clinch River	6BCLN339.53	11/20/00	208
Clinch River	6BCLN339.53	02/26/96	167	Clinch River	6BCLN339.53	12/05/00	181
Clinch River	6BCLN339.53	05/21/96	175	Clinch River	6BCLN339.53	01/23/01	174
Clinch River	6BCLN339.53	07/29/96	184	Clinch River	6BCLN339.53	02/08/01	189
Clinch River	6BCLN339.53	09/09/96	206	Clinch River	6BCLN339.53	03/08/01	194
Clinch River	6BCLN339.53	11/12/96	187	Copper Creek	6BCOP002.00	09/21/92	178
Clinch River	6BCLN339.53	01/22/97	182	Copper Creek	6BCOP002.00	11/16/92	190
Clinch River	6BCLN339.53	03/24/97	172	Copper Creek	6BCOP002.00	01/20/93	184
Clinch River	6BCLN339.53	05/28/97	172	Copper Creek	6BCOP002.00	03/29/93	188
Clinch River	6BCLN339.53	07/16/97	184	Copper Creek	6BCOP002.00	05/10/93	166
Clinch River	6BCLN339.53	09/17/97	200	Copper Creek	6BCOP002.00	07/06/93	173
Clinch River	6BCLN339.53	11/20/97	236	Copper Creek	6BCOP002.00	09/21/93	179
Clinch River	6BCLN339.53	03/03/98	145	Copper Creek	6BCOP002.00	11/23/93	187
Clinch River	6BCLN339.53	05/27/98	168	Copper Creek	6BCOP002.00	01/26/94	187
Clinch River	6BCLN339.53	07/13/98	195	Copper Creek	6BCOP002.00	04/19/94	151
Clinch River	6BCLN339.53	08/10/98	187	Copper Creek	6BCOP002.00	06/23/94	165
Clinch River	6BCLN339.53	09/28/98	199	Copper Creek	6BCOP002.00	09/20/94	176
Clinch River	6BCLN339.53	10/27/98	196	Copper Creek	6BCOP002.00	11/17/94	179
Clinch River	6BCLN339.53	11/23/98	200	Copper Creek	6BCOP002.00	01/11/95	205
Clinch River	6BCLN339.53	01/11/99	185	Copper Creek	6BCOP002.00	03/21/95	164
Clinch River	6BCLN339.53	02/24/99	171	Copper Creek	6BCOP002.00	05/17/95	193
Clinch River	6BCLN339.53	03/17/99	176	Copper Creek	6BCOP002.00	07/17/95	170
Clinch River	6BCLN339.53	04/14/99	155	Copper Creek	6BCOP002.00	09/06/95	187
Clinch River	6BCLN339.53	05/26/99	170	Copper Creek	6BCOP002.00	11/20/95	199
Clinch River	6BCLN339.53	06/23/99	157	Copper Creek	6BCOP002.00	01/18/96	180
Clinch River	6BCLN339.53	07/14/99	197	Copper Creek	6BCOP002.00	03/26/96	163
Clinch River	6BCLN339.53	08/11/99	205	Copper Creek	6BCOP002.00	05/20/96	168
Clinch River	6BCLN339.53	09/29/99	193	Copper Creek	6BCOP002.00	07/15/96	170
Clinch River	6BCLN339.53	10/20/99	200	Copper Creek	6BCOP002.00	09/24/96	180
Clinch River	6BCLN339.53	11/15/99	208	Copper Creek	6BCOP002.00	11/19/96	186
Clinch River	6BCLN339.53	12/14/99	231	Copper Creek	6BCOP002.00	01/14/97	184
Clinch River	6BCLN339.53	01/13/00	193	Copper Creek	6BCOP002.00	03/11/97	168
Clinch River	6BCLN339.53	02/28/00	213	Copper Creek	6BCOP002.00	05/06/97	170
Clinch River	6BCLN339.53	03/14/00	170	Copper Creek	6BCOP002.00	07/30/97	214
Clinch River	6BCLN339.53	04/18/00	160	Copper Creek	6BCOP002.00	09/15/97	177
Clinch River	6BCLN339.53	05/09/00	172	Copper Creek	6BCOP002.00	11/19/97	187
Clinch River	6BCLN339.53	06/06/00	196	Copper Creek	6BCOP002.00	01/07/98	184

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 8 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
Copper Creek	6BCOP002.00	03/12/98	181	S.F. Powell River	6BPLL006.38	05/22/00	62
Copper Creek	6BCOP002.00	05/28/98	176	S.F. Powell River	6BPLL006.38	07/25/00	53
Copper Creek	6BCOP002.00	07/28/98	185	S.F. Powell River	6BPLL006.38	11/27/00	74
Copper Creek	6BCOP002.00	08/12/98	76	S.F. Powell River	6BPLL006.38	03/12/01	32
Copper Creek	6BCOP002.00	10/26/98	185	Byers Branch	6CBYS000.23	10/25/00	309
Copper Creek	6BCOP002.00	12/16/98	196	Byers Branch	6CBYS000.23	11/06/00	310
Copper Creek	6BCOP002.00	02/03/99	176	Byers Branch	6CBYS000.23	12/05/00	310
Copper Creek	6BCOP002.00	04/06/99	169	Byers Branch	6CBYS000.23	01/04/01	313
Copper Creek	6BCOP002.00	06/08/99	206	Byers Branch	6CBYS000.23	01/23/01	339
Copper Creek	6BCOP002.00	08/24/99	166	Byers Branch	6CBYS000.23	02/08/01	316
Copper Creek	6BCOP002.00	10/21/99	185	Byers Branch	6CBYS000.23	02/21/01	323
Copper Creek	6BCOP002.00	12/07/99	196	Byers Branch	6CBYS000.23	03/07/01	317
Copper Creek	6BCOP002.00	02/09/00	212	Byers Branch	6CBYS000.23	03/20/01	307
Copper Creek	6BCOP002.00	04/25/00	178	Byers Branch	6CBYS000.23	04/12/01	294
Copper Creek	6BCOP002.00	06/26/00	185	Byers Branch	6CBYS000.23	04/12/01	294
Copper Creek	6BCOP002.00	10/24/00	198	Byers Branch	6CBYS000.23	04/26/01	306
Copper Creek	6BCOP002.00	12/11/00	179	Byers Branch	6CBYS000.23	05/15/01	316
Copper Creek	6BCOP002.00	02/26/01	189	Byers Branch	6CBYS000.23	06/12/01	318
S.F. Powell River	6BPLL006.38	06/10/96	44	Byers Branch	6CBYS000.23	06/26/01	290
S.F. Powell River	6BPLL006.38	08/05/96	43	M.F. Holston River	6CMFH045.72	08/05/92	172
S.F. Powell River	6BPLL006.38	10/23/96	59	M.F. Holston River	6CMFH045.72	10/19/92	158
S.F. Powell River	6BPLL006.38	12/17/96	36	M.F. Holston River	6CMFH045.72	12/15/92	130
S.F. Powell River	6BPLL006.38	02/24/97	42	M.F. Holston River	6CMFH045.72	02/08/93	138
S.F. Powell River	6BPLL006.38	04/14/97	42	M.F. Holston River	6CMFH045.72	04/19/93	86
S.F. Powell River	6BPLL006.38	06/11/97	45	M.F. Holston River	6CMFH045.72	06/29/93	164
S.F. Powell River	6BPLL006.38	08/26/97	65	M.F. Holston River	6CMFH045.72	08/19/93	155
S.F. Powell River	6BPLL006.38	10/22/97	84	M.F. Holston River	6CMFH045.72	10/28/93	163
S.F. Powell River	6BPLL006.38	12/03/97	64	M.F. Holston River	6CMFH045.72	12/27/93	161
S.F. Powell River	6BPLL006.38	02/23/98	31	M.F. Holston River	6CMFH045.72	02/08/94	106
S.F. Powell River	6BPLL006.38	04/28/98	43	M.F. Holston River	6CMFH045.72	04/25/94	120
S.F. Powell River	6BPLL006.38	06/22/98	52	M.F. Holston River	6CMFH045.72	06/22/94	137
S.F. Powell River	6BPLL006.38	09/22/98	50	M.F. Holston River	6CMFH045.72	08/15/94	163
S.F. Powell River	6BPLL006.38	11/23/98	66	M.F. Holston River	6CMFH045.72	10/20/94	178
S.F. Powell River	6BPLL006.38	01/12/99	41	M.F. Holston River	6CMFH045.72	12/08/94	102
S.F. Powell River	6BPLL006.38	03/18/99	27	M.F. Holston River	6CMFH045.72	03/15/95	94
S.F. Powell River	6BPLL006.38	05/05/99	35	M.F. Holston River	6CMFH045.72	04/26/95	123
S.F. Powell River	6BPLL006.38	07/13/99	72	M.F. Holston River	6CMFH045.72	08/15/95	152
S.F. Powell River	6BPLL006.38	09/28/99	86	M.F. Holston River	6CMFH045.72	10/11/95	167
S.F. Powell River	6BPLL006.38	11/17/99	89	M.F. Holston River	6CMFH045.72	12/12/95	143
S.F. Powell River	6BPLL006.38	01/24/00	57	M.F. Holston River	6CMFH045.72	02/14/96	101
S.F. Powell River	6BPLL006.38	03/22/00	35	M.F. Holston River	6CMFH045.72	04/25/96	112

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 9 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
M.F. Holston River	6CMFH045.72	06/17/96	161	M.F. Holston River	6CMFH045.72	02/21/01	105
M.F. Holston River	6CMFH045.72	08/20/96	168	M.F. Holston River	6CMFH045.72	03/07/01	104
M.F. Holston River	6CMFH045.72	10/08/96	170	M.F. Holston River	6CMFH053.36	08/05/92	164
M.F. Holston River	6CMFH045.72	12/04/96	97	M.F. Holston River	6CMFH053.36	10/19/92	156
M.F. Holston River	6CMFH045.72	02/26/97	122	M.F. Holston River	6CMFH053.36	12/15/92	142
M.F. Holston River	6CMFH045.72	04/07/97	121	M.F. Holston River	6CMFH053.36	02/08/93	146
M.F. Holston River	6CMFH045.72	06/24/97	156	M.F. Holston River	6CMFH053.36	04/19/93	91
M.F. Holston River	6CMFH045.72	08/11/97	174	M.F. Holston River	6CMFH053.36	06/29/93	147
M.F. Holston River	6CMFH045.72	10/07/97	165	M.F. Holston River	6CMFH053.36	08/19/93	138
M.F. Holston River	6CMFH045.72	12/02/97	155	M.F. Holston River	6CMFH053.36	10/28/93	157
M.F. Holston River	6CMFH045.72	02/12/98	101	M.F. Holston River	6CMFH053.36	12/27/93	154
M.F. Holston River	6CMFH045.72	04/02/98	150	M.F. Holston River	6CMFH053.36	02/08/94	129
M.F. Holston River	6CMFH045.72	06/10/98	114	M.F. Holston River	6CMFH053.36	04/25/94	123
M.F. Holston River	6CMFH045.72	08/20/98	172	M.F. Holston River	6CMFH053.36	06/22/94	132
M.F. Holston River	6CMFH045.72	09/09/98	159	M.F. Holston River	6CMFH053.36	09/13/94	148
M.F. Holston River	6CMFH045.72	10/13/98	161	M.F. Holston River	6CMFH053.36	10/20/94	162
M.F. Holston River	6CMFH045.72	11/05/98	173	M.F. Holston River	6CMFH053.36	12/08/94	147
M.F. Holston River	6CMFH045.72	12/08/98	161	M.F. Holston River	6CMFH053.36	02/21/95	129
M.F. Holston River	6CMFH045.72	01/14/99	154	M.F. Holston River	6CMFH053.36	04/26/95	139
M.F. Holston River	6CMFH045.72	02/25/99	114	M.F. Holston River	6CMFH053.36	08/15/95	132
M.F. Holston River	6CMFH045.72	03/15/99	124	M.F. Holston River	6CMFH053.36	10/11/95	144
M.F. Holston River	6CMFH045.72	04/26/99	133	M.F. Holston River	6CMFH053.36	12/12/95	128
M.F. Holston River	6CMFH045.72	05/24/99	139	M.F. Holston River	6CMFH053.36	02/14/96	103
M.F. Holston River	6CMFH045.72	06/21/99	172	M.F. Holston River	6CMFH053.36	04/25/96	133
M.F. Holston River	6CMFH045.72	07/07/99	170	M.F. Holston River	6CMFH053.36	06/17/96	168
M.F. Holston River	6CMFH045.72	08/17/99	201	M.F. Holston River	6CMFH053.36	08/20/96	162
M.F. Holston River	6CMFH045.72	09/08/99	205	M.F. Holston River	6CMFH053.36	10/08/96	165
M.F. Holston River	6CMFH045.72	10/06/99	183	M.F. Holston River	6CMFH053.36	12/04/96	115
M.F. Holston River	6CMFH045.72	12/06/99	171	M.F. Holston River	6CMFH053.36	02/26/97	133
M.F. Holston River	6CMFH045.72	01/05/00	157	M.F. Holston River	6CMFH053.36	04/07/97	143
M.F. Holston River	6CMFH045.72	02/14/00	96	M.F. Holston River	6CMFH053.36	06/24/97	156
M.F. Holston River	6CMFH045.72	03/07/00	146	M.F. Holston River	6CMFH053.36	08/11/97	167
M.F. Holston River	6CMFH045.72	04/03/00	132	M.F. Holston River	6CMFH053.36	10/07/97	146
M.F. Holston River	6CMFH045.72	05/08/00	133	M.F. Holston River	6CMFH053.36	12/02/97	168
M.F. Holston River	6CMFH045.72	06/05/00	105	M.F. Holston River	6CMFH053.36	02/12/98	122
M.F. Holston River	6CMFH045.72	07/06/00	99	M.F. Holston River	6CMFH053.36	04/02/98	158
M.F. Holston River	6CMFH045.72	08/15/00	170	M.F. Holston River	6CMFH053.36	06/10/98	134
M.F. Holston River	6CMFH045.72	09/13/00	188	M.F. Holston River	6CMFH053.36	08/20/98	154
M.F. Holston River	6CMFH045.72	11/06/00	178	M.F. Holston River	6CMFH053.36	09/09/98	132
M.F. Holston River	6CMFH045.72	12/05/00	155	M.F. Holston River	6CMFH053.36	10/13/98	144
M.F. Holston River	6CMFH045.72	01/04/01	138	M.F. Holston River	6CMFH053.36	11/05/98	168

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 10 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
M.F. Holston River	6CMFH053.36	12/08/98	144	N.F. Holston River	6CNFH085.20	04/08/04	96
M.F. Holston River	6CMFH053.36	01/14/99	175	N.F. Holston River	6CNFH089.25	08/05/92	144
M.F. Holston River	6CMFH053.36	02/25/99	123	N.F. Holston River	6CNFH089.25	09/23/92	159
M.F. Holston River	6CMFH053.36	03/15/99	174	N.F. Holston River	6CNFH089.25	11/05/92	118
M.F. Holston River	6CMFH053.36	04/26/99	144	N.F. Holston River	6CNFH089.25	12/15/92	107
M.F. Holston River	6CMFH053.36	05/24/99	154	N.F. Holston River	6CNFH089.25	01/06/93	91
M.F. Holston River	6CMFH053.36	06/21/99	152	N.F. Holston River	6CNFH089.25	02/08/93	125
M.F. Holston River	6CMFH053.36	07/07/99	145	N.F. Holston River	6CNFH089.25	03/24/93	69
M.F. Holston River	6CMFH053.36	08/17/99	165	N.F. Holston River	6CNFH089.25	04/19/93	78
M.F. Holston River	6CMFH053.36	09/08/99	184	N.F. Holston River	6CNFH089.25	05/04/93	105
M.F. Holston River	6CMFH053.36	10/06/99	164	N.F. Holston River	6CNFH089.25	06/29/93	167
M.F. Holston River	6CMFH053.36	12/06/99	170	N.F. Holston River	6CNFH089.25	07/28/93	178
M.F. Holston River	6CMFH053.36	01/05/00	156	N.F. Holston River	6CNFH089.25	08/19/93	156
M.F. Holston River	6CMFH053.36	02/14/00	108	N.F. Holston River	6CNFH089.25	09/22/93	159
M.F. Holston River	6CMFH053.36	03/07/00	140	N.F. Holston River	6CNFH089.25	10/28/93	187
M.F. Holston River	6CMFH053.36	04/03/00	145	N.F. Holston River	6CNFH089.25	11/17/93	156
M.F. Holston River	6CMFH053.36	05/08/00	138	N.F. Holston River	6CNFH089.25	12/27/93	116
M.F. Holston River	6CMFH053.36	06/05/00	158	N.F. Holston River	6CNFH089.25	01/12/94	85
M.F. Holston River	6CMFH053.36	07/06/00	149	N.F. Holston River	6CNFH089.25	02/08/94	92
M.F. Holston River	6CMFH053.36	08/15/00	163	N.F. Holston River	6CNFH089.25	03/14/94	79
M.F. Holston River	6CMFH053.36	09/13/00	161	N.F. Holston River	6CNFH089.25	04/25/94	104
M.F. Holston River	6CMFH053.36	10/25/00	145	N.F. Holston River	6CNFH089.25	05/11/94	76
M.F. Holston River	6CMFH053.36	11/06/00	157	N.F. Holston River	6CNFH089.25	06/22/94	122
M.F. Holston River	6CMFH053.36	12/05/00	147	N.F. Holston River	6CNFH089.25	07/27/94	139
M.F. Holston River	6CMFH053.36	01/04/01	148	N.F. Holston River	6CNFH089.25	08/15/94	157
M.F. Holston River	6CMFH053.36	02/21/01	138	N.F. Holston River	6CNFH089.25	09/13/94	143
M.F. Holston River	6CMFH053.36	03/07/01	149	N.F. Holston River	6CNFH089.25	10/20/94	174
N.F. Holston River	6CNFH085.20	03/28/90	101	N.F. Holston River	6CNFH089.25	11/09/94	132
N.F. Holston River	6CNFH085.20	04/24/90	80	N.F. Holston River	6CNFH089.25	12/15/94	76
N.F. Holston River	6CNFH085.20	12/03/90	118	N.F. Holston River	6CNFH089.25	01/30/95	78
N.F. Holston River	6CNFH085.20	01/07/91	111	N.F. Holston River	6CNFH089.25	02/16/95	68
N.F. Holston River	6CNFH085.20	02/13/91	115	N.F. Holston River	6CNFH089.25	03/27/95	126
N.F. Holston River	6CNFH085.20	04/03/91	100	N.F. Holston River	6CNFH089.25	05/09/95	77
N.F. Holston River	6CNFH085.20	05/06/91	113	N.F. Holston River	6CNFH089.25	07/20/95	136
N.F. Holston River	6CNFH085.20	06/04/91	111	N.F. Holston River	6CNFH089.25	08/15/95	160
N.F. Holston River	6CNFH085.20	09/03/91	174	N.F. Holston River	6CNFH089.25	09/21/95	158
N.F. Holston River	6CNFH085.20	10/15/91	186	N.F. Holston River	6CNFH089.25	10/10/95	153
N.F. Holston River	6CNFH085.20	08/18/03	102	N.F. Holston River	6CNFH089.25	11/06/95	133
N.F. Holston River	6CNFH085.20	10/09/03	151	N.F. Holston River	6CNFH089.25	12/27/95	108
N.F. Holston River	6CNFH085.20	12/18/03	100	N.F. Holston River	6CNFH089.25	03/18/96	75
N.F. Holston River	6CNFH085.20	02/23/04	100	N.F. Holston River	6CNFH089.25	04/22/96	88

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 11 of 12)

Stream	Station_ID	Date	TDS (mg/L)	Stream	Station_ID	Date	TDS (mg/L)
N.F. Holston River	6CNFH089.25	05/13/96	83	N.F. Holston River	6CNFH089.25	10/13/99	209
N.F. Holston River	6CNFH089.25	06/17/96	129	N.F. Holston River	6CNFH089.25	01/19/00	97
N.F. Holston River	6CNFH089.25	07/11/96	150	N.F. Holston River	6CNFH089.25	02/07/00	137
N.F. Holston River	6CNFH089.25	08/20/96	116	N.F. Holston River	6CNFH089.25	03/29/00	104
N.F. Holston River	6CNFH089.25	09/03/96	164	N.F. Holston River	6CNFH089.25	04/20/00	66
N.F. Holston River	6CNFH089.25	10/02/96	110	N.F. Holston River	6CNFH089.25	05/02/00	104
N.F. Holston River	6CNFH089.25	11/05/96	115	N.F. Holston River	6CNFH089.25	06/27/00	128
N.F. Holston River	6CNFH089.25	12/11/96	90	N.F. Holston River	6CNFH089.25	07/26/00	113
N.F. Holston River	6CNFH089.25	01/27/97	78	N.F. Holston River	6CNFH089.25	08/10/00	119
N.F. Holston River	6CNFH089.25	02/19/97	114	N.F. Holston River	6CNFH089.25	09/11/00	158
N.F. Holston River	6CNFH089.25	03/04/97	78	N.F. Holston River	6CNFH089.25	10/18/00	174
N.F. Holston River	6CNFH089.25	04/30/97	87	N.F. Holston River	6CNFH089.25	11/28/00	155
N.F. Holston River	6CNFH089.25	05/20/97	126	N.F. Holston River	6CNFH089.25	12/20/00	110
N.F. Holston River	6CNFH089.25	06/23/97	135	N.F. Holston River	6CNFH089.25	01/16/01	105
N.F. Holston River	6CNFH089.25	07/17/97	179	N.F. Holston River	6CNFH089.25	02/13/01	105
N.F. Holston River	6CNFH089.25	08/07/97	167	N.F. Holston River	6CNFH089.25	03/13/01	81
N.F. Holston River	6CNFH089.25	09/03/97	180	Possum Creek	6CPSM017.73	04/29/04	164
N.F. Holston River	6CNFH089.25	10/15/97	203	S.F. Holston River	6CSFH098.10	05/11/04	95
N.F. Holston River	6CNFH089.25	11/24/97	160	Stony Fork	9-SFK002.81	04/28/04	46
N.F. Holston River	6CNFH089.25	12/08/97	144	Wolf Creek	9-WFC000.20	01/25/00	146
N.F. Holston River	6CNFH089.25	01/26/98	94	Wolf Creek	9-WFC000.20	05/03/00	90
N.F. Holston River	6CNFH089.25	02/18/98	56	Wolf Creek	9-WFC000.20	07/25/00	117
N.F. Holston River	6CNFH089.25	03/18/98	86	Wolf Creek	9-WFC000.20	09/26/00	130
N.F. Holston River	6CNFH089.25	04/01/98	117	Wolf Creek	9-WFC000.20	11/20/00	133
N.F. Holston River	6CNFH089.25	05/12/98	87	Wolf Creek	9-WFC000.20	01/30/01	104
N.F. Holston River	6CNFH089.25	06/02/98	114	Wolf Creek	9-WFC000.20	03/15/01	87
N.F. Holston River	6CNFH089.25	07/02/98	146	Wolf Creek	9-WFC000.20	05/08/01	101
N.F. Holston River	6CNFH089.25	08/03/98	186	Wolf Creek	9-WFC000.20	06/26/01	127
N.F. Holston River	6CNFH089.25	09/23/98	189	Wolf Creek	9-WFC016.45	08/19/92	102
N.F. Holston River	6CNFH089.25	10/14/98	173	Wolf Creek	9-WFC016.45	10/08/92	89
N.F. Holston River	6CNFH089.25	11/03/98	198	Wolf Creek	9-WFC016.45	12/03/92	85
N.F. Holston River	6CNFH089.25	12/02/98	179	Wolf Creek	9-WFC016.45	03/25/93	59
N.F. Holston River	6CNFH089.25	01/05/99	106	Wolf Creek	9-WFC016.45	06/10/93	107
N.F. Holston River	6CNFH089.25	02/04/99	108	Wolf Creek	9-WFC016.45	08/05/93	127
N.F. Holston River	6CNFH089.25	03/03/99	79	Wolf Creek	9-WFC016.45	10/25/93	126
N.F. Holston River	6CNFH089.25	04/05/99	108	Wolf Creek	9-WFC016.45	02/15/94	64
N.F. Holston River	6CNFH089.25	05/04/99	87	Wolf Creek	9-WFC016.45	04/20/94	70
N.F. Holston River	6CNFH089.25	06/14/99	176	Wolf Creek	9-WFC016.45	06/13/94	60
N.F. Holston River	6CNFH089.25	07/19/99	170	Wolf Creek	9-WFC016.45	08/17/94	130
N.F. Holston River	6CNFH089.25	08/19/99	179	Wolf Creek	9-WFC016.45	11/14/94	101
N.F. Holston River	6CNFH089.25	09/13/99	184	Wolf Creek	9-WFC016.45	12/06/94	83

Table A.2. TDS (mg/L) measured in streams that have no aquatic life impairment. (Part 12 of 12)

Stream	Station_ID	Date	TDS (mg/L)
Wolf Creek	9-WFC016.45	02/23/95	75
Wolf Creek	9-WFC016.45	04/24/95	92
Wolf Creek	9-WFC016.45	06/27/95	81
Wolf Creek	9-WFC016.45	09/19/95	137
Wolf Creek	9-WFC016.45	10/18/95	141
Wolf Creek	9-WFC016.45	12/20/95	53
Wolf Creek	9-WFC016.45	02/20/96	79
Wolf Creek	9-WFC016.45	06/19/96	105
Wolf Creek	9-WFC016.45	08/19/96	111
Wolf Creek	9-WFC016.45	10/09/96	103
Wolf Creek	9-WFC016.45	12/10/96	74
Wolf Creek	9-WFC016.45	02/11/97	83
Wolf Creek	9-WFC016.45	04/29/97	70
Wolf Creek	9-WFC016.45	06/04/97	62
Wolf Creek	9-WFC016.45	08/25/97	133
Wolf Creek	9-WFC016.45	10/29/97	149
Wolf Creek	9-WFC016.45	12/15/97	112
Wolf Creek	9-WFC016.45	04/15/98	58
Wolf Creek	9-WFC016.45	06/03/98	105
Wolf Creek	9-WFC016.45	09/17/98	142
Wolf Creek	9-WFC016.45	11/03/98	137
Wolf Creek	9-WFC016.45	01/20/99	93
Wolf Creek	9-WFC016.45	03/10/99	79
Wolf Creek	9-WFC016.45	05/03/99	64
Wolf Creek	9-WFC016.45	07/06/99	139
Wolf Creek	9-WFC016.45	09/20/99	135
Wolf Creek	9-WFC016.45	11/17/99	130
Wolf Creek	9-WFC016.45	01/25/00	135
Wolf Creek	9-WFC016.45	03/15/00	71
Wolf Creek	9-WFC016.45	05/15/00	103
Wolf Creek	9-WFC016.45	07/24/00	92
Wolf Creek	9-WFC016.45	09/27/00	81
Wolf Creek	9-WFC016.45	01/10/01	124
Wolf Creek	9-WFC016.45	03/12/01	74

Table A.3. TDS (mg/L) measured at pond outfall before, during, and after mining operations.

Permit	MPID	Outfall	Date	TDS (mg/L)	Activity
1101516	1583	CM-3	1/25/1995	148	Pre-Mining
1101516	1583	CM-3	5/29/1995	125	
1101516	1583	CM-3	2/28/1996	328	Active Mining and Reclamation
1101516	1583	CM-3	3/18/1996	214	
1101516	1583	CM-3	4/2/1996	152	
1101516	1583	CM-3	5/2/1996	104	
1101516	1583	CM-3	10/7/1996	198	
1101516	1583	CM-3	11/30/1996	154	
1101516	1583	CM-3	12/13/1996	166	
1101516	1583	CM-3	1/31/1997	292	Post-Mining
1101516	1583	CM-3	2/11/1997	160	
1101516	1583	CM-3	3/18/1997	248	
1101516	1583	CM-3	4/29/1997	234	
1101516	1583	CM-3	5/21/1997	192	
1101516	1583	CM-3	6/17/1997	470	
1101516	1583	CM-3	1/31/1998	246	
1101516	1583	CM-3	2/11/1998	458	
1101516	1583	CM-3	4/13/1998	372	
1101516	1583	CM-3	6/10/1998	160	
1101516	1583	CM-3	1/19/1999	152	
1101516	1583	CM-3	2/19/1999	22	
1101516	1583	CM-3	3/31/1999	204	
1101516	1583	CM-3	2/21/2000	270	
1101516	1583	CM-3	3/26/2000	44	
1101516	1583	CM-3	4/24/2000	244	