PROPOSED
TOTAL MAXIMUM DAILY LOAD (TMDL)

For

Low pH

In The

Great Smoky Mountains National Park

Located In The

Pigeon River Watershed (HUC 06010106)

Lower French Broad River Watershed (HUC 06010107)

Ft. Loudoun Lake Watershed (HUC 06010201)

Cocke and Sevier County, Tennessee

FINAL

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DEPARTMENT OF ENVIRONMENT & CONSERVATION

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LIST OF ABBREVIATIONS

CFR	Code of Federal regulations
CFS	Cubic Feet per Second
DEM	Digital Elevation Model
DWPC	Division of Water Pollution Control
EPA	Environmental Protection Agency
GIS	Geographic Information System
HUC	Hydrologic Unit Code
LA	Load Allocation
LDC	Load Duration Curve
LSPC	Loading Simulation Program in C^{++}
MGD	Million Gallons per Day
MOS	Margin of Safety
MRLC	Multi-Resolution Land Characteristic
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
RM	River Mile
TDEC	Tennessee Department of Environment & Conservation
TMDL	Total Maximum Daily Load
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
WCS	Watershed Characterization System
WLA	Waste Load Allocation

SUMMARY SHEET

Total Maximum Daily Load (TMDL) for Low pH in Great Smoky Mountains National Park

Impaired Waterbody Information

State: Tennessee
Counties: Cocke and Sevier
Watersheds: Pigeon River (HUC 06010106)
Lower French Broad River (HUC 06010107)
Ft. Loudoun Lake (HUC 06010201)
Constituents of Concern: Low pH

Impaired Waterbodies Addressed in This Document:

Waterbody ID	Waterbody	Miles Impaired
TN06010106004 – 0500	ROCK CREEK	2.80
TN06010106004 – 0610	INADU CREEK	2.66
TN06010106004 – 0810	OTTER CREEK	1.52
TN06010106004 – 0820	COPPERHEAD BRANCH	1.13
TN06010107007 – 0700	BUCK FORK	3.8
TN06010107007 – 0900	EAGLE ROCKS PRONG	6.4
TN06010107007 – 1120	SHUTTS PRONG	4.79
TN06010107007 – 1130	LOWES CREEK	2.22
TN06010107007 – 1140	CANNON CREEK	3.72
TN06010107010 – 1100	ROAD PRONG	4.6
TN06010201032 – 0510	GOSHEN PRONG	6.66
TN06010201032 – 0530	UNNAMED TRIB. TO FISH CAMP PRONG	1.34

Designated Uses:

The designated use classifications for waterbodies in the Great Smoky Mountains National Park include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

Water Quality Targets:

Derived from *State of Tennessee Water Quality Standards, Chapter 1200-4-3, General Water Quality Criteria, January, 2004*:

> The pH value shall lie within the range of 6.0 to 9.0 and shall not fluctuate more than 1.0 unit in this range over a period of 24 hours.

Acid Neutralizing Capacity (ANC) was used as a surrogate for pH. TDEC believes that meeting the target minimum ANC concentrations listed in the summary table will provide a pH within the criteria range of 6.0 – 9.0.

Note: In Tennessee, a waterbody is considered impaired whenever 10% or more of sample measurements do not meet the numeric water quality criteria. Therefore, for the purposes of this TMDL, a waterbody will be considered no longer impaired when at least 90% of sample measurements meet the numeric water quality criteria.

TMDL Scope:

Waterbodies identified on the Final 2008 303(d) list as impaired due to low pH.

Portions of Great Smoky Mountains National Park are located in North Carolina. This TMDL only addresses the portion of Great Smoky Mountains National Park located in Tennessee.

Analysis/Methodology:

The ANC TMDL for impaired waterbodies in the Great Smoky Mountains National Park was developed using a load duration curve methodology to assure compliance with the default target ANC of 50 μeq/L or a site-specific target ANC value (see Figure S-1 and Appendices C & D), which will provide a pH within the criteria range of 6.0 – 9.0. A duration curve is a cumulative frequency graph that represents the percentage of time during which the value of a given parameter is equaled or exceeded. Load duration curves are developed from flow duration curves and can illustrate existing water quality conditions (as represented by loads calculated from monitoring data), how these conditions compare to desired targets, and the region of the waterbody flow regime represented by these existing loads.

The TMDLs for ANC in the Great Smoky Mountains National Park are summarized in the following table.

Critical Conditions:

Water quality data collected over a period of 15 years for load duration curve analysis were used to assess the water quality standards representing a range of hydrologic and meteorological conditions.

Seasonal Variation:

The 15-year period used for LSPC model simulation period for development of load duration curve analysis included all seasons and a full range of flow and meteorological conditions.

Margin of Safety (MOS):

Implicit (conservative modeling assumptions) for each impaired subwatershed or drainage area.

Summary of ANC TMDLs, WLAs[a], & LAs expressed as daily loads for Impaired Waterbodies in the Great Smoky Mountains National Park

Impaired Waterbody Name	Impaired Waterbody ID	TMDL	LAs	Minimum Concentration[b]
		[meq/acre/day]	[meq/acre/day]	[μeq/L]
Rock Creek	TN06010106004 – 0500	99.0 x Q	99.0 x Q	35.158
Inadu Creek	TN06010106004 – 0610	33.7 x Q	33.7 x Q	10.376
Otter Creek	TN06010106004 – 0810	42.2 x Q	42.2 x Q	10.121
Copperhead Branch	TN06010106004 – 0820	318.5 x Q	318.5 x Q	25.304
Buck Fork	TN06010107007 – 0700	65.1 x Q	65.1 x Q	50
Eagle Rocks Prong	TN06010107007 – 0900	5.9 x Q	5.9 x Q	6.201
Shutts Prong	TN06010107007 – 1120	36.1 x Q	36.1 x Q	14.732
Lowes Creek	TN06010107007 – 1130	170.9 x Q	170.9 x Q	50
Cannon Creek	TN06010107007 – 1140	38.0 x Q	38.0 x Q	18.65
Road Prong	TN06010107010 – 1100	29.4 x Q	29.4 x Q	25.056
Goshen Prong	TN06010201032 – 0510	24.3 x Q	24.3 x Q	17.824
Unnamed Trib to Fish Camp Prong	TN06010201032 – 0530	218.3 x Q	218.3 x Q	19.581

Notes: Q = Mean Daily Flow (cfs).

a. There are currently no point sources in the Great Smoky Mountains National Park; therefore, there is no required load reduction for point sources (WLA). Any future point sources must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

b. The TMDL is also expressed in terms of minimum allowable water column concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

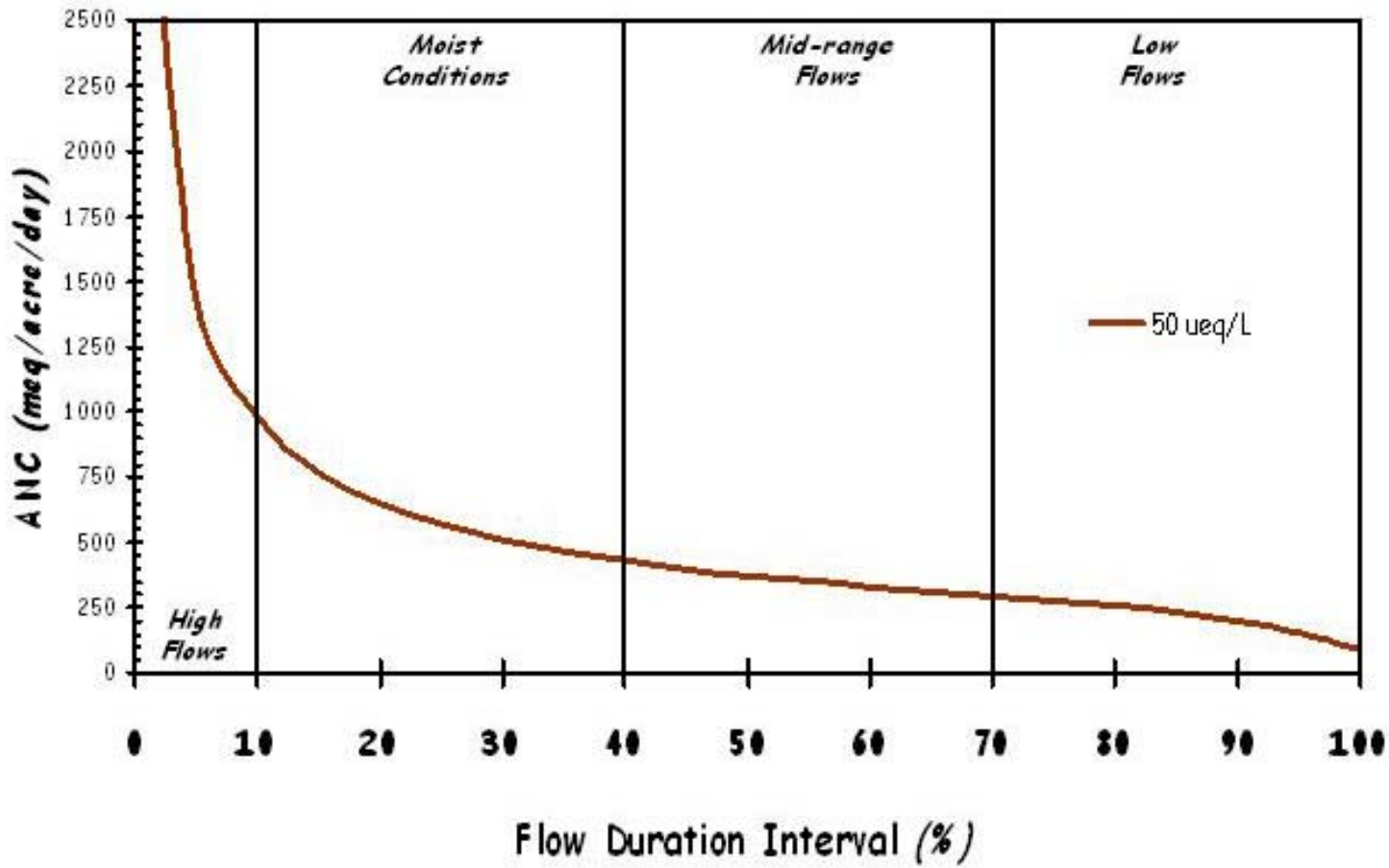

Figure S-1. Sample Target ANC Load Duration Curve (using default minimum ANC concentration)

LOW pH TOTAL MAXIMUM DAILY LOAD (TMDL)
GREAT SMOKY MOUNTAINS NATIONAL PARK

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act requires each state to list those waters within its boundaries for which technology based effluent limitations are not stringent enough to protect any water quality standard applicable to such waters. Listed waters are prioritized with respect to designated use classifications and the severity of pollution. In accordance with this prioritization, states are required to develop Total Maximum Daily Loads (TMDLs) for those water bodies that are not meeting designated uses. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991a).

2.0 WATERSHED DESCRIPTION

The Great Smoky Mountains (GSM) National Park is located in eastern Tennessee and western North Carolina (Figure 1). This document addresses only the portion of the watershed located in Tennessee. Portions of the GSM are located in three HUC8 watersheds: Pigeon River (HUC 06010106), Lower French Broad River (HUC 06010107), and Ft. Loudoun Lake (HUC 06010201). The Tennessee portion of the GSM falls within one Level III ecoregion (Blue Ridge Mountains) and contains four Level IV subecoregions (USEPA, 1997) as shown in Figure 2:

- **Southern Sedimentary Ridges (66e)** include some of the westernmost foothill areas of the Blue Ridge Mountains ecoregion, such as the Bean, Starr, Chilhowee, English, Stone, Bald, and Iron Mountain areas. Slopes are steep, and elevations are generally 1000-4500 feet. The rocks are primarily Cambrian-age sedimentary (shale, sandstone, siltstone, quartzite, conglomerate), although some lower stream reaches occur on limestone. Soils are predominantly friable loams and fine sandy loams with variable amounts of sandstone rock fragments, and support mostly mixed oak and oak-pine forests.
- **Limestone Valleys and Coves (66f)** are small but distinct lowland areas of the Blue Ridge, with elevations mostly between 1500 and 2500 feet. About 450 million years ago, older Blue Ridge rocks to the east were forced up and over younger rocks to the west. In places, the Precambrian rocks have eroded through to Cambrian or Ordovician-age limestones, as seen especially in isolated, deep cove areas that are surrounded by steep mountains. The main areas of limestone include the Mountain City lowland area and Shady Valley in the north; and Wear Cove, Tuckaleechee Cove, and Cades Cove of the Great Smoky Mountains in the south. Hay and pasture, with some tobacco patches on small farms, are typical land uses.
- **The Southern Metasedimentary Mountains (66g)** are steep, dissected, biologically-diverse mountains that include Clingmans Dome (6643 feet), the highest point in Tennessee. The Precambrian-age metamorphic and sedimentary geologic materials are generally older and more metamorphosed than the Southern Sedimentary Ridges

(66e) to the west and north. The Appalachian oak forests and, at higher elevations, the northern hardwoods forests include a variety of oaks and pines, as well as silverbell, hemlock, yellow poplar, basswood, buckeye, yellow birch, and beech. Spruce-fir forests, found generally above 5500 feet, have been affected greatly over the past twenty-five years by the balsam woolly aphid. The Copper Basin, in the southeast corner of Tennessee, was the site of copper mining and smelting from the 1850's to 1987, and once left more than fifty square miles of eroded earth.

- **The High Mountains (66i)** ecoregion includes several disjunct high-elevation areas generally above 4500 feet. The region has a more severe, boreal-like climate than surrounding regions, with wind and ice affecting vegetation, and it has frigid soils rather than mesic soils. Evergreen red spruce and Fraser fir forests are found at the higher elevations, and red oak forests and northern hardwood forests with beech, yellow birch, yellow buckeye, and sugar maple are common. The spruce-fir forests have been affected by the balsam wooly adelgid, a non-native insect that kills mature Fraser firs, and some forest growth declines are possibly linked to air pollutants. Heath balds dominated by evergreen rhododendron and mountain laurel, and grassy balds are found on some slopes and ridgetops. Northern flying squirrels, Blackburnian warblers, black-capped chickadees, and common ravens are seen in this region.

The Great Smoky Mountains National Park, located primarily in Cocke and Sevier Counties, Tennessee, has a drainage area of approximately 357 square miles (mi^2) in Tennessee. The total area of the GSM National Park, including the portions in Tennessee and North Carolina, is approximately 521,086 acres (814 mi^2). Watershed land use distribution is based on the Multi-Resolution Land Characteristic (MRLC) databases derived from Landsat Thematic Mapper digital images from the period 1990-1993. Although changes in the land use of the watersheds that include portions of the GSMNP have occurred since 1993 as a result of development, this is the most current land use data available. Land use for the Great Smoky Mountains National Park is summarized in Table 1 and Figure 3.

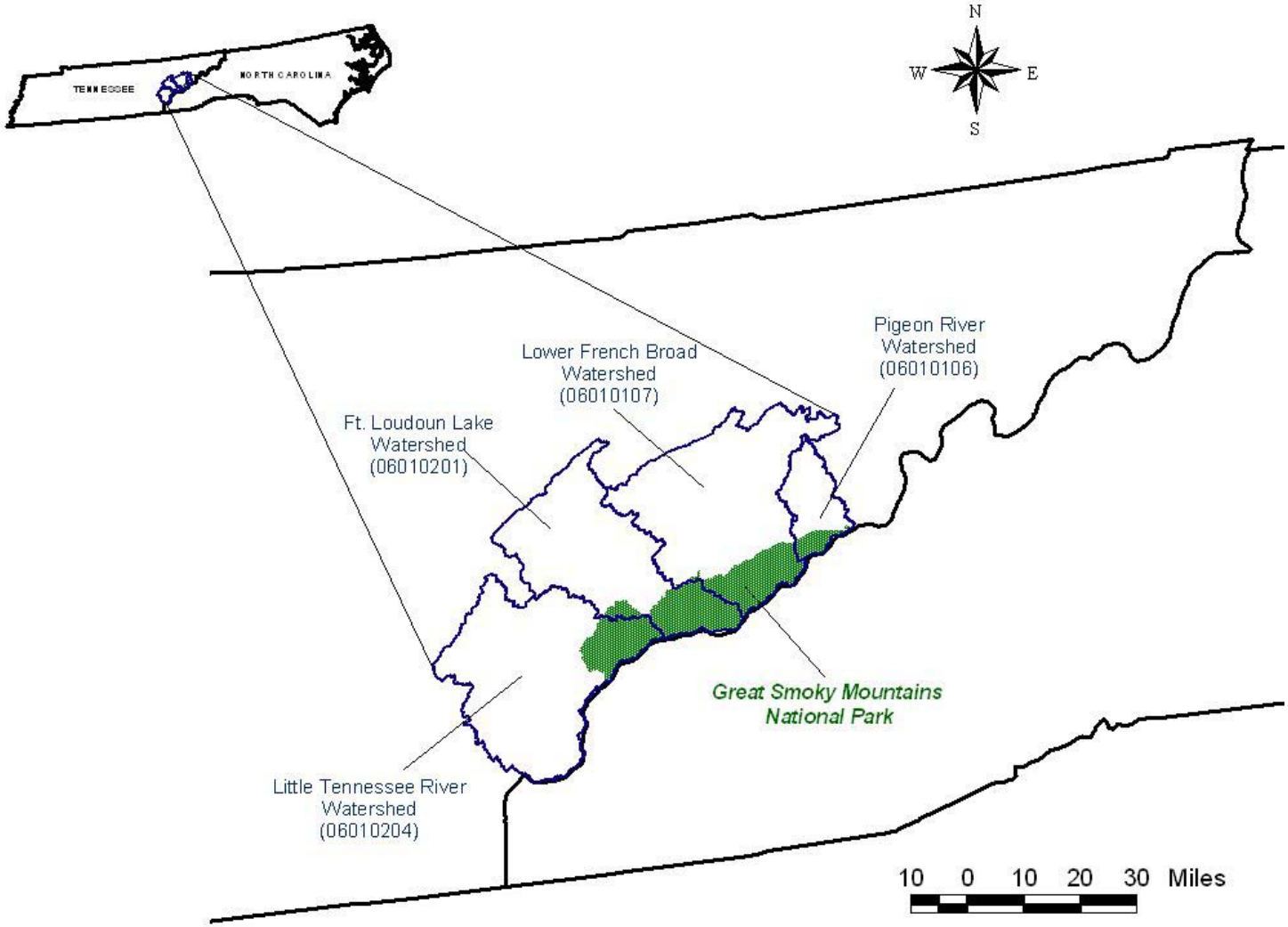

Figure 1 Location of Great Smoky Mountains National Park

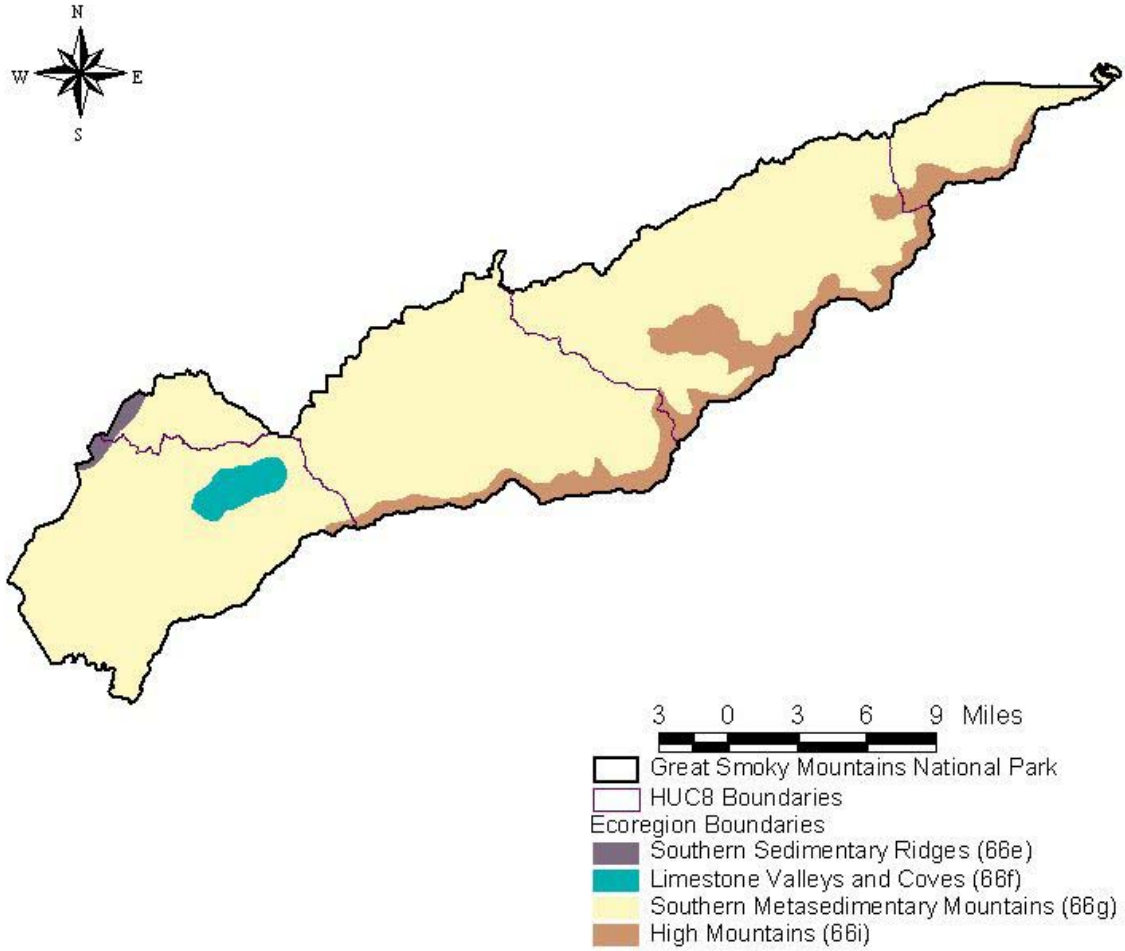

Figure 2 Great Smoky Mountains National Park Ecoregion Boundaries

Table 1 MRLC Land Use Distribution – Great Smoky Mountains National Park

	Great Smoky Mountains National Park (Tennessee only)	
Land Use	[acres]	[%]
Deciduous Forest	97,936.6	42.83
Emergent Herbaceous Wetlands	1.8	0.00
Evergreen Forest	82,184.8	35.94
High Intensity Commercial/Industrial/ Transportation	37.8	0.02
High Intensity Residential	1.3	0.00
Low Intensity Residential	22.9	0.01
Mixed Forest	46,195.6	20.20
Open Water	75.4	0.03
Other Grasses (Urban/recreational)	5.6	0.00
Pasture/Hay	1,707.1	0.75
Quarries/Strip Mines/Gravel Pits	4.0	0.00
Row Crops	29.4	0.01
Transitional	15.6	0.01
Woody Wetlands	457.7	0.20
Total	228,655.5	100.0

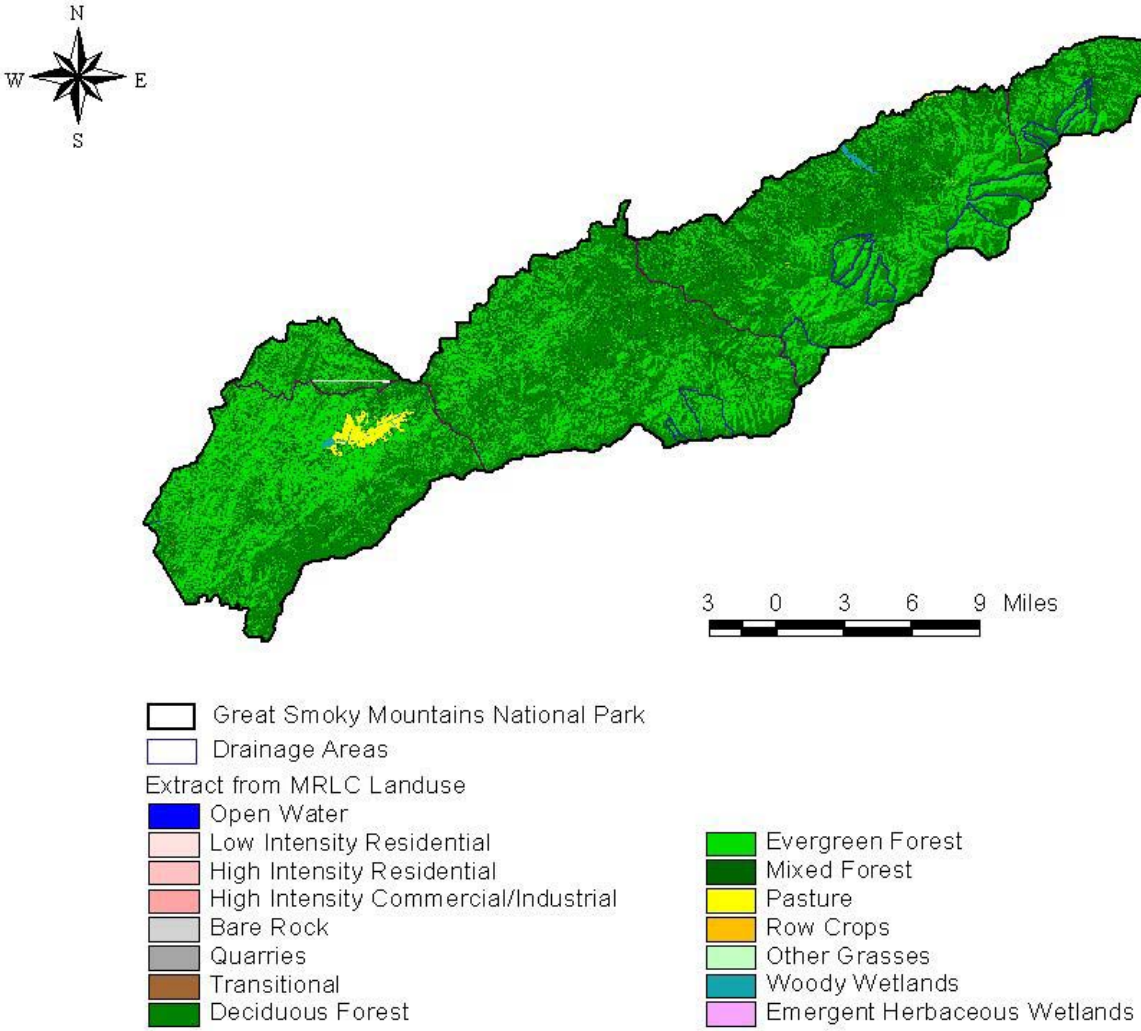

Figure 3 Great Smoky Mountains National Park Land Use Distribution

3.0 PROBLEM DEFINITION

The State of Tennessee's Final 2008 303(d) list (TDEC, 2008) was approved by the U.S. Environmental Protection Agency (EPA), Region IV, in June of 2008. The list identified several waterbodies in the Great Smoky Mountains National Park as not supporting designated use classifications due, in part, to low pH associated with atmospheric deposition. Information regarding acid deposition is contained in Appendix A. An excerpt from the 2008 303(d) list is presented in Table 2. Impaired segments in the Great Smoky Mountains National Park are shown in Figure 4.

Table 2 2008 303(d) List – Great Smoky Mountains National Park

Waterbody ID	Impacted Waterbody	County	Miles/Acres Impaired	Cause	Pollutant Source	Comments
Pigeon River Watershed (06010106)						
TN06010106 004 – 0500	Rock Creek	Cocke	2.80	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
TN06010106 004 – 0610	Inadu Creek	Cocke	2.66	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
TN06010106 004 – 0810	Otter Creek	Cocke	1.52	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.

Table 2 (cont'd) 2008 303(d) List – Great Smoky Mountains National Park

Waterbody ID	Impacted Waterbody	County	Miles/Acres Impaired	Cause	Pollutant Source	Comments
TN06010106 004 – 0820	Copperhead Branch	Cocke	1.13	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
Lower French Broad River Watershed (06010107)						
TN06010107 007 – 0700	Buck Fork	Sevier	3.8	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Acidity source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on TMDL.
TN06010107 007 – 0900	Eagle Rocks Prong	Sevier	6.4	Low pH	Atmospheric Deposition - Acidity	High elevation stream in Great Smoky Mountains National Park. Documented loss of native trout populations. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
TN06010107 007 – 1120	Shutts Prong	Sevier	4.79	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Acidity source is likely a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric TMDL.
TN06010107 007 – 1130	Lowes Creek	Sevier	2.22	Low pH	Atmospheric Deposition - Acidity	High elevation stream in Great Smoky Mountains National Park. Documented loss of native trout populations. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.

Table 2 (cont'd) 2008 303(d) List – Great Smoky Mountains National Park

Waterbody ID	Impacted Waterbody	County	Miles/Acres Impaired	Cause	Pollutant Source	Comments
TN06010107 007 – 1140	Cannon Creek	Sevier	3.72	Low pH	Atmospheric Deposition - Acidity	High elevation stream in Great Smoky Mountains National Park. Documented loss of native trout populations. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
TN06010107 010 – 1100	Road Prong	Sevier	4.6	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
Ft.Loudounr Lake Watershed (06010201)						
TN06010201 032 – 0510	Goshen Prong	Sevier	6.66	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.
TN06010201 032 – 0530	Unnamed Trib to Fish Camp Prong	Sevier	1.34	Low pH	Undetermined Source	High elevation stream in Great Smoky Mountains National Park. Low pH source may be a combination of natural conditions (anakeesta) and atmospheric deposition. Stream is Category 5. (One or more uses impaired.) EPA should take the lead on atmospheric deposition TMDL.

The designated use classifications for waterbodies in the Great Smoky Mountains National Park include fish and aquatic life, irrigation, livestock watering & wildlife, and recreation.

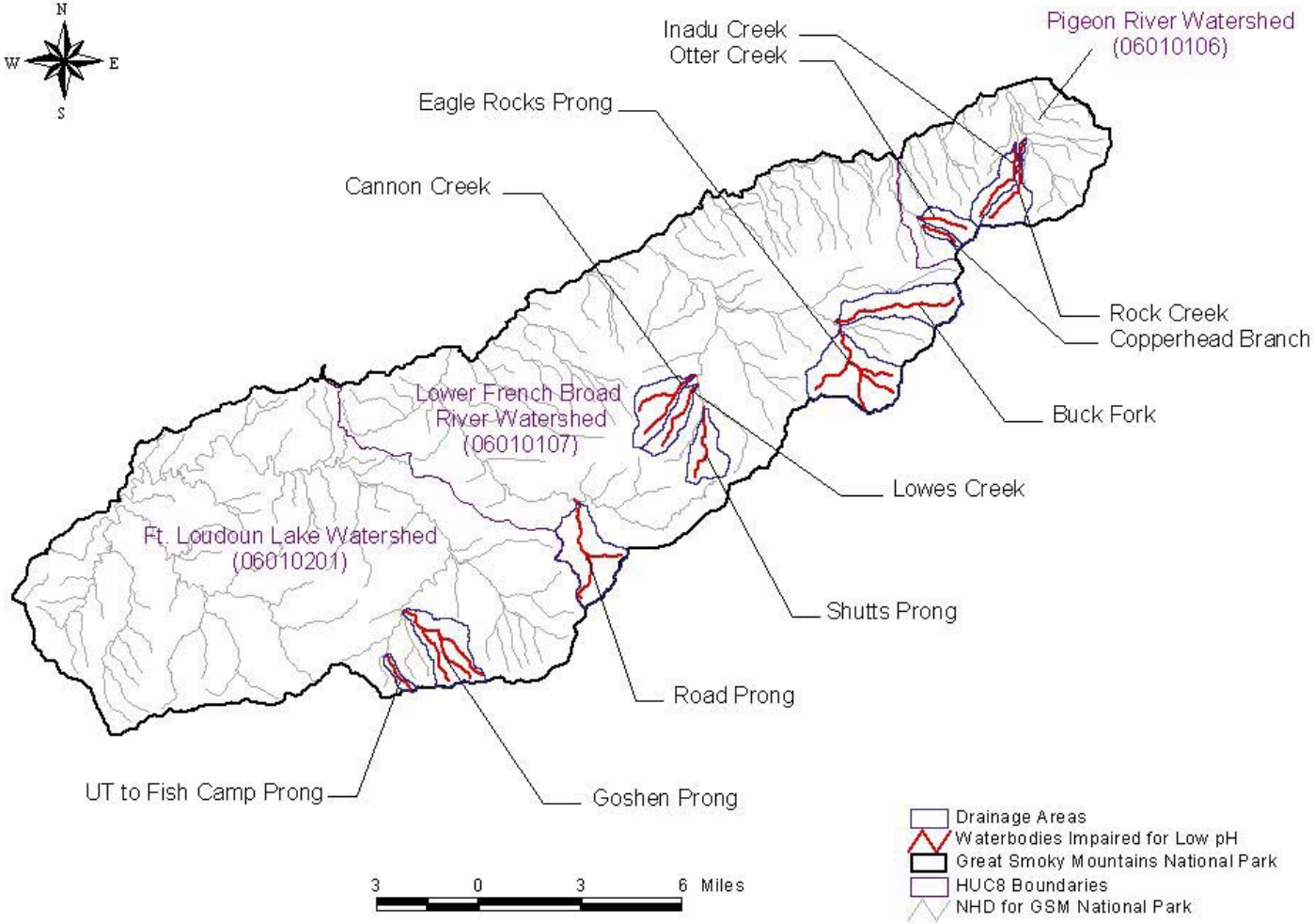

Figure 4 Great Smoky Mountains National Park pH-Impaired Segments

4.0 TARGET IDENTIFICATION

The allowable instream range of pH for the Great Smoky Mountains National Park is established in *State of Tennessee Water Quality Standards, Chapter 1200-4-3 General Water Quality Criteria, October, 2007* (TDEC, 2007) for applicable use classifications. The Fish & Aquatic Life criteria pH range for "all other wadeable streams" of 6.0 to 9.0 is the most stringent for the waterbodies covered by this TMDL. The criteria were approved by the Environmental Protection Agency (EPA) in October 2007.

According to the National Acid Precipitation Assessment Program Report to Congress (NAPAP, 2005), "the effect of acid deposition on an ecosystem depends largely upon the ecosystem's ability to neutralize the acid." The ability of a system to neutralize acid is referred to as acid neutralizing capacity (ANC). ANC is often used in models to calculate acidification levels from pollution in different geographical areas, and as a basis for calculating critical loads for forest soils and surface waters. In order to facilitate analysis of existing pollutant loads and load reductions required to restore the Great Smoky Mountains National Park to fully supporting all of its designated use classifications, ANC will be used as a surrogate parameter for TMDL development.

Whenever sufficient monitoring data were available, a site-specific target ANC value was determined by means of regression analysis. If monitoring data were not available, an ANC of 50 μeq/l, or 2.5 mg/l $CaCO_3$, was selected at the default numerical target for this TMDL. This target is based on a review of literature values. (See Appendix C.)

Note: In Tennessee, a waterbody is considered impaired whenever 10% or more of sample measurements do not meet the numeric water quality criteria. Therefore, for the purposes of this TMDL, a waterbody will be considered no longer impaired when at least 90% of sample measurements meet the numeric water quality criteria.

In order to characterize ANC over the range of flow conditions encountered in the subwatersheds, the target ANC is expressed by means of a target load duration curve. A sample target load duration curve, using the default minimum ANC concentration, is presented in Figure 5. In order to meet Tennessee Water Quality Standards for pH, this TMDL requires that ANC loads of streams in the Great Smoky Mountains National Park meet, or exceed, the loads per unit area specified in the target load duration curve.

Table 3. Site-Specific Target ANC Values

Monitoring Site	Site Description	Target ANC (μeq/L)
4	Lower Rock Creek	35.158
137	Upper Rock Creek	14.938
138	Inadu Creek	10.376
103	Otter Creek	10.121
104	Copperhead Branch	25.304
45	Shutts Prong	14.732
47	Lower Cannon Creek	18.65
71	Lower Road Prong	25.056
234	Upper Road Prong	20.301
213	Goshen Prong	17.824
218	UT to Fish Camp Prong	19.581
	Eagles Rock Prong	6.201

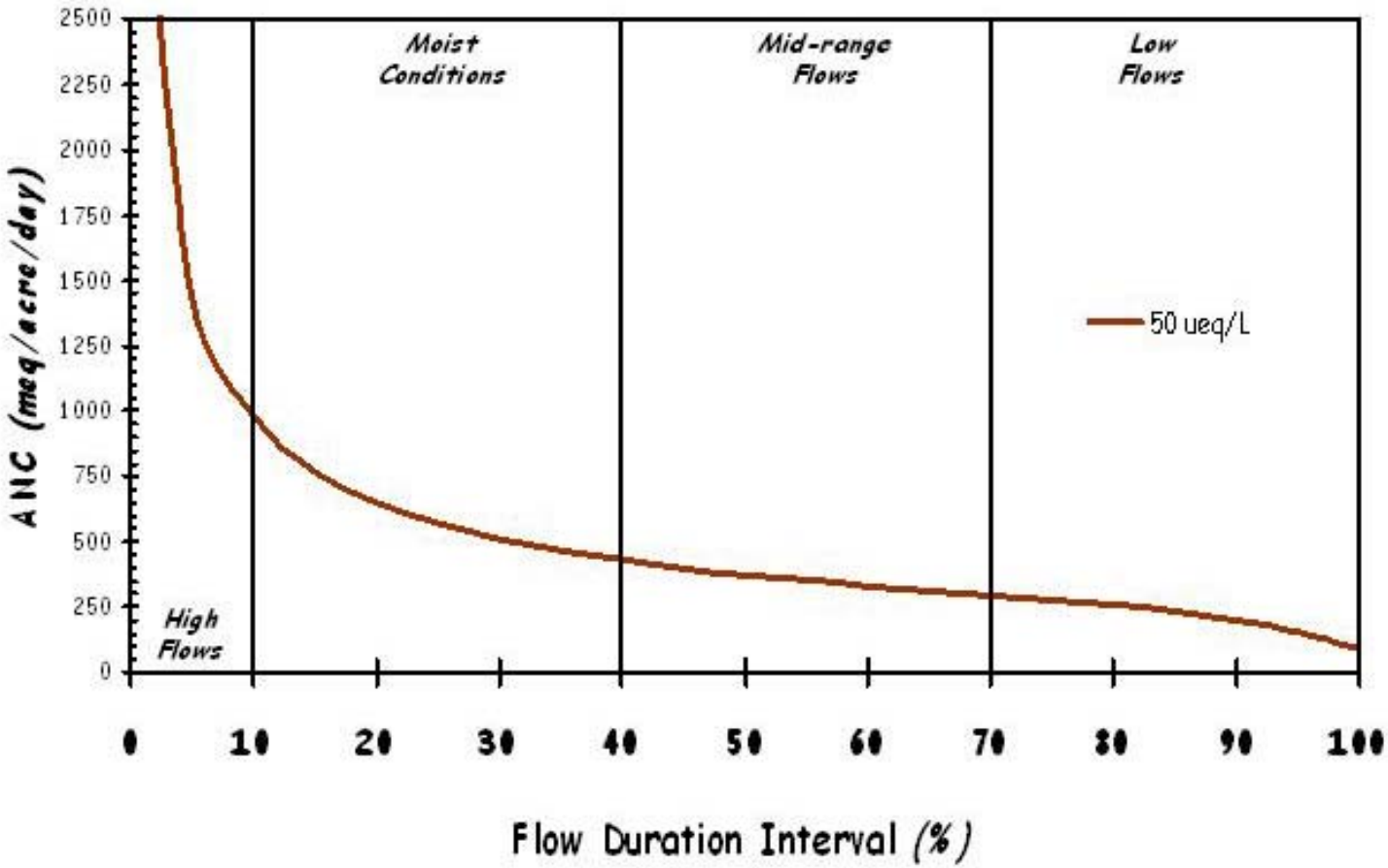

Figure 5 Sample Target ANC Load Duration Curve (using default minimum ANC concentration)

5.0 WATER QUALITY ASSESSMENT AND DIFFERENCE FROM TARGET

A park-wide stream survey began in October 1993 to identify potential impacts of acid deposition on GSM streams and monitor long-term changes in stream acidification. Monitoring was conducted by personnel from the University of Tennessee at Knoxville. Most of the GSM streams were found to be low in alkalinity (acid neutralizing capacity, or ANC), and exhibit chronic and episodic acidification (lowered pH) (Robinson et al, 2005, 2008).

The following water quality monitoring stations have provided data for waterbodies identified as impaired for low pH in the Great Smoky Mountains National Park

Pigeon River Watershed (06010106)

- #4 – Lower Rock Creek 35.761329, -83.210440
- #137 – Upper Rock Creek 35.742499, -83.216301
- #138 – Inadu Creek 35.742499, -83.226991
- #103 – Otter Creek 35.730604, -83.256785
- #104 – Copperhead Branch 35.727480, -83.263783

Lower French Broad River Watershed (06010107)

- #45 – Shutts Prong 35.659564, -83.397543
- #47 – Lower Cannon Creek 35.680200, -83.398746
- #71 – Lower Road Prong (above barrier cascade) 35.634404, -83.470316
- #234 – Upper Road Prong 35.609752, -83.450428

Ft. Loudoun Lake Watershed (06010201)

- #213 – Goshen Prong (above Fish Camp Prong) 35.598569, -83.567503
- #218 – Unnamed Trib to Fish Camp Prong 35.564523, -83.568445

The locations of these monitoring stations are shown in Figure 6. Water quality monitoring results for these stations are tabulated in Appendix B. Violations of the pH criterion are indicated in red. Note that 86% of the time, when a pH violation occurred, the ANC was less than the site specific target ANC. Also, 82% of the time, when the ANC was less than the site specific target ANC, a pH violation occurred. . Statistics for the monitoring results are summarized in Table 4.

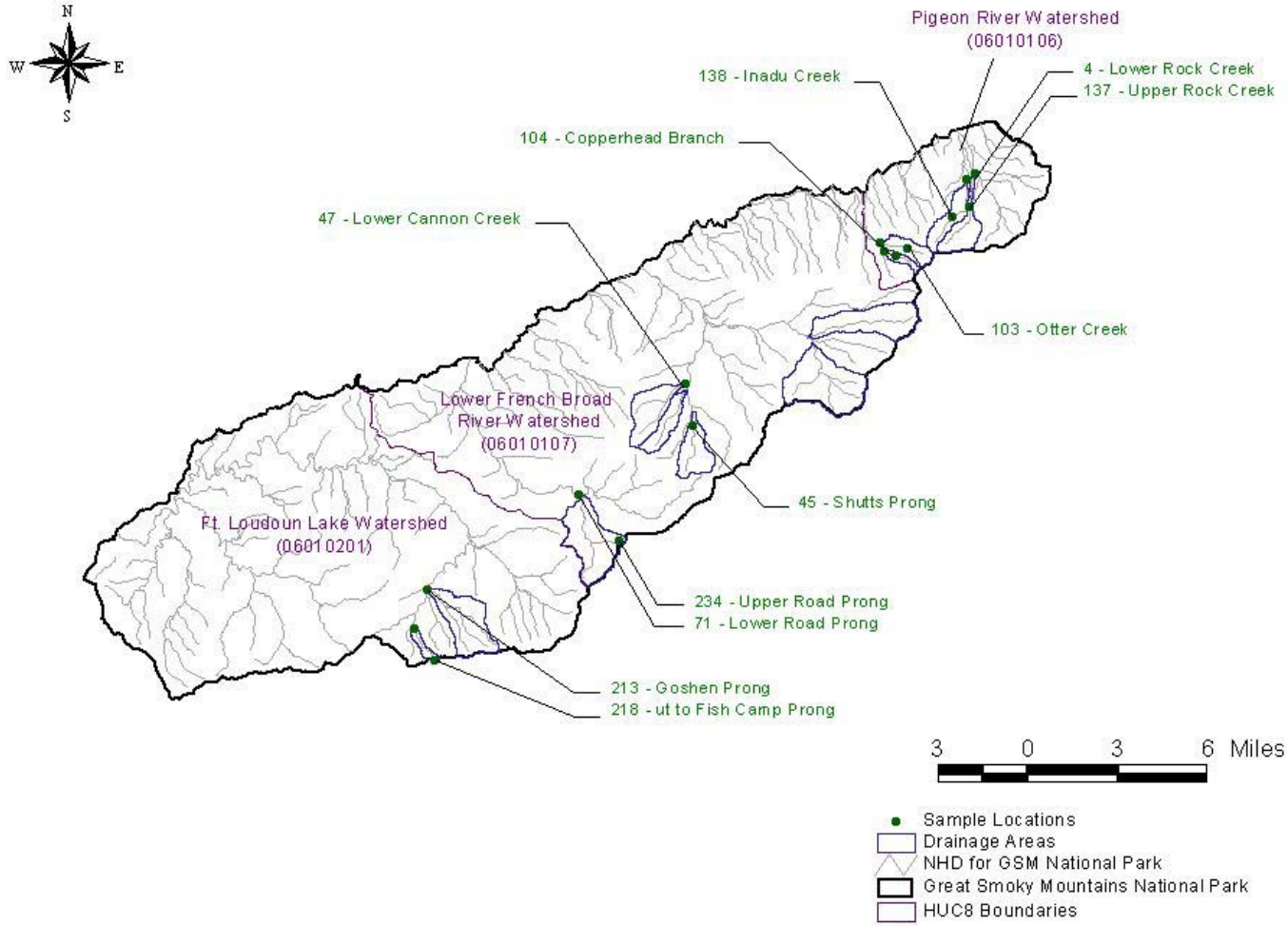

Figure 6 Monitoring Stations in the Great Smoky Mountains National Park

Table 4 Summary of Water Quality Monitoring Data

Monitoring Station		Date Range	Parameter	Data Pts.	Target	Min.	Avg.	Max.	No. Outside Target Range
No.	Description				(μeq/L)	(μeq/L)	(μeq/L)	(μeq/L)	
4	Lower Rock Creek	1993 – 2007	pH [a]	66	6.0-9.0	5.22	5.92	6.99	29
			ANC	66	35.158	-2.56	44.63	133.59	38
45	Shutts Prong	1993 – 2003	pH [a]	48	6.0-9.0	5.20	5.53	6.11	46
			ANC	48	14.732	-7.92	4.56	19.45	40
47	Lower Cannon Creek	1994 – 2003	pH [a]	43	6.0-9.0	5.58	5.914	6.29	24
			ANC	43	18.65	-3.35	16.25	115.45	34
71	Lower Road Prong	1993 – 2007	pH [a]	69	6.0-9.0	5.42	6.038	6.52	20
			ANC	69	25.056	-1.29	29.31	159.34	30
103	Otter Creek	1993 – 2003	pH [a]	46	6.0-9.0	4.83	5.473	6.32	44
			ANC	46	10.121	-11.64	2.51	18.31	41
104	Copperhead Branch	1993 – 2003	pH [a]	45	6.0-9.0	5.01	5.575	6.44	38
			ANC	45	25.304	-9.46	10.82	161.56	41
137	Upper Rock Creek	1993 – 2007	pH [a]	71	6.0-9.0	5.26	5.78	6.52	55
			ANC	71	14.938	-1.88	12.01	47.94	53
138	Inadu Creek	1993 – 2003	pH [a]	45	6.0-9.0	5.17	5.551	6.52	42
			ANC	45	10.376	-27.77	4.95	37.88	39
213	Goshen Prong	1993 – 2003	pH [a]	45	6.0-9.0	5.71	6.054	6.49	12
			ANC	45	17.824	-8.73	20.80	53.91	18
218	Ut to Fish Camp Prong	1994 – 2003	pH [a]	52	6.0-9.0	4.24	5.028	6.28	50
			ANC	52	19.581	-34.65	5.24	44.44	43
234	Upper Road Prong	1993 – 2007	pH [a]	55	6.0-9.0	5.12	5.758	6.48	39
			ANC	55	20.301	2.42	18.22	76.08	42
	Eagles Rock Prong	2006 – 2008	pH [a]	31	6.0-9.0	4.43	5.34	6.07	30
			ANC	31	6.201	-17.66	-0.80	9.22	27

[a] pH is expressed in standard units (s.u.); average is calculated by converting to microequivalents per liter of the hydrogen ion concentration.

6.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of individual sources, or source categories, of low pH in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either point or non-point sources. A point source can be defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Non-point sources include all other sources of pollution.

6.1 Point Sources

There are no known point sources of significant acidity loading in the Great Smoky Mountains National Park.

6.2 Non-point Sources

The source of acidity to these waterbodies has not been determined at this time. One possible source is anakeesta rock. Anakeesta formations have low acid-buffering capacity and contain rock rich in iron sulfide rich mineral, which when exposed can cause acidic runoff. While many of these geological formations have been mapped, there maybe areas within the Park that are unknown at this time.

Another possible source of acidity to these waterbodies is from wet and dry atmospheric deposition. The Great Smoky Mountains receive some of the highest measured amounts of sulfate and nitrate deposition in the U.S. (NADP, 2008). As previously noted, the ultimate source of atmospheric acidity is primarily individual smokestacks and mobile sources of air pollution, both within the state and out-of-state. (See Appendix A.)

Smokestacks, and the atmospheric acid they appear to emit, meet the respective Clean Water Act definitions of “point source” and “pollutant” (USEPA, 2002). However, smokestack-related atmospheric acid has not traditionally been regulated under the CWA. Therefore, for the purposes of this TMDL, the total pollutant load is allocated to nonpoint sources. (This is similar to the way that EPA treats unregulated stormwater discharges.) Because of the difficulty of determining the specific air contaminant sources polluting Tennessee’s waters, no attempt has been made to sub-allocate the load allocation among either different geographic areas or types of sources of atmospheric acid.

7.0 DEVELOPMENT OF TOTAL MAXIMUM DAILY LOAD

The Total Maximum Daily Load (TMDL) process quantifies the amount of a pollutant that can be assimilated in a waterbody, identifies the sources of the pollutant, and recommends regulatory or other actions to be taken to achieve compliance with applicable water quality standards based on the relationship between pollution sources and in-stream water quality conditions. A TMDL can be expressed as the sum of all point source loads (Waste Load Allocations), non-point source loads (Load Allocations), and an appropriate margin of safety (MOS) which takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

The objective of a TMDL is to allocate loads among all of the known pollutant sources throughout a watershed so that appropriate control measures can be implemented and water quality standards achieved. 40 CFR §130.2 (i) states that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or other appropriate measure.

7.1 TMDL Representation

In general, waterbodies become impaired due to excessive loading of particular pollutants that result in concentrations that violate instream water quality standards. A TMDL establishes the maximum load that can be assimilated by the waterbody, without violating standards, and allocates portions of this load to point and non-point sources. This normally involves reductions in loading from existing levels, with WLAs & LAs of zero load reduction as the ideal.

The use of ANC as a surrogate parameter, however, requires a different approach. Existing levels of ANC in impaired subwatersheds may be negative, while target values are positive. The concept of a “maximum ANC load” does not appropriately represent the desired target condition. ANC targets can be achieved by reducing acidity, increasing alkalinity, or some combination of both.

The ANC TMDL for the Great Smoky Mountain National Park watershed is considered to correspond to the target load duration curve (see Figure 5) as developed in Appendix D.

7.2 Margin of Safety

There are two methods for incorporating an MOS in the analysis: a) implicitly incorporate the MOS using conservative model assumptions to develop allocations; or b) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

For development of ANC TMDLs, an implicit MOS was incorporated through the use of conservative modeling assumptions. These include: 1) the use of a 14-year continuous simulation that incorporates a wide range of meteorological events, 2) the use of the load duration curve, which addresses pollutant loading over the entire range of flow, and 3) the use of a positive ANC target of 50 μeq/L (based on analysis of a literature search) or a site-specific ANC (when available) (see Appendix C).

7.3 Determination of Total Maximum Daily Loads

The TMDLs for ANC for pH-impaired streams in the GSMNP watershed are presented in Table 5. The TMDLs can also be represented by the target load duration curves developed in Appendix D (ref: Figures D-2 thru D-3). The target load duration curves were developed on a unit area basis and are equivalent to the TMDL equations specified for each impaired waterbody.

7.4 Determination of WLAs, & LAs

As previously stated, the TMDL can be expressed as the sum of all Waste Load Allocations (WLAs), Load Allocations (LAs), and an appropriate margin of safety (MOS). Since there are currently no point sources of significant acidity loading in the GSMNP, the WLA has been set to zero. Therefore, for all waterbodies in the GSMNP, the LA is equal to the TMDL. The TMDL, WLA, and LA for pH, using ANC as a surrogate for pH, are summarized in Table 5 and presented as a load duration curve in Figure 5.

7.5 Seasonal Variation

The target load duration curves, the TMDLs, and LAs are applicable over the entire range of flow for all waterbodies in the GSMNP subwatershed in all seasons.

Table 5 TMDLs, WLAs[a], & LAs expressed as daily loads for Impaired Waterbodies in the Great Smoky Mountains National Park

Impaired Waterbody Name	Impaired Waterbody ID	TMDL	LAs	Minimum Concentration[b]
		[meq/acre/day]	[meq/acre/day]	[μeq/L]
Rock Creek	TN06010106004 – 0500	99.0 x Q	99.0 x Q	35.158
Inadu Creek	TN06010106004 – 0610	33.7 x Q	33.7 x Q	10.376
Otter Creek	TN06010106004 – 0810	42.2 x Q	42.2 x Q	10.121
Copperhead Branch	TN06010106004 – 0820	318.5 x Q	318.5 x Q	25.304
Buck Fork	TN06010107007 – 0700	65.1 x Q	65.1 x Q	50
Eagle Rocks Prong	TN06010107007 – 0900	5.9 x Q	5.9 x Q	6.201
Shutts Prong	TN06010107007 – 1120	36.1 x Q	36.1 x Q	14.732
Lowes Creek	TN06010107007 – 1130	170.9 x Q	170.9 x Q	50
Cannon Creek	TN06010107007 – 1140	38.0 x Q	38.0 x Q	18.65
Road Prong	TN06010107010 – 1100	29.4 x Q	29.4 x Q	25.056
Goshen Prong	TN06010201032 – 0510	24.3 x Q	24.3 x Q	17.824
Unnamed Trib to Fish Camp Prong	TN06010201032 – 0530	218.3 x Q	218.3 x Q	19.581

Notes: Q = Mean Daily Flow (cfs).

a. There are currently no point sources in the Great Smoky Mountains National Park; therefore, there is no required load reduction for point sources (WLA). Any future point sources must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

b. The TMDL is also expressed in terms of minimum allowable water column concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

8.0 IMPLEMENTATION PLAN

The TMDLs and LAs developed in Section 7 are intended to be the first step in a long-term effort to restore the water quality of impaired waterbodies in the Great Smoky Mountains National Park through reduction of excessive acidity. Successful implementation relies on participation at the federal, state, local, and non-governmental levels.

The issue of acid deposition is not only a state problem; it is a regional and national problem and will require regional and national action. Therefore, implementation of this TMDL will involve participation of multiple stakeholders and partnerships. EPA began to address acid rain and other water quality impairing air contaminants under Title IV of the Clean Air Act. However, years after the Clear Air Act amendments of 1990, the problem of acid impaired waters remains. The solution is for EPA working with up-wind states to achieve significant reductions in atmospheric acid from stationary and mobile sources. (VTDEC, 2003)

There is a need for quantitative information to guide and manage decreases in atmospheric sulfur and nitrogen deposition that would facilitate the recovery of the Park from elevated acidic deposition. A “critical load” is an air quality framework that establishes the level of deposition of an air pollutant below which there is no ecological effect, given current knowledge (Burns et al., 2008). Critical loads can be used to guide atmospheric emission reduction programs. The National Park Service is in the process of developing an Implementation Plan that will provide a recommended strategy to identify critical loads that can indicate how the pollution can be reduced in order to address load allocations. (This Implementation Plan will be available on the National Park Service web site once it has been developed.)

The National Park Service has contracted with Syracuse University to use a dynamic forest watershed element transport model, PnET-BGC, to quantify the response of soil and streams in watersheds of the GSM to future decreases in atmospheric deposition of nitrogen and sulfur. PnET-BGC is a comprehensive forest-soil-water model that links a carbon [C], nitrogen [N], and water balance model, PnET-CN, with a biogeochemical model, BGC. PnET-BGC extends the simulations of PnET-CN to include the cycling of all major elements (i.e., C, N, P, S, Ca, Mg, K, Na, Al, Cl, Si). Both major biotic and abiotic processes are represented in PnET-BGC. A thorough description of the model including the processes depicted and a detailed sensitivity analysis of parameter values is provided in Gbondo-Tugbawa et al. (2001).

The project will particularly focus analysis on critical chemical indicators of stream acidification stress, including pH, ANC, sulfate, nitrate, and aluminum speciation. From this project, there should be improved quantitative understanding of how watersheds of the GSM will respond to anticipated decreases in acidic deposition, both in terms of the magnitude of chemical inputs required and the time frame for recovery. This information will be used in the development of critical loads of atmospheric sulfur and nitrogen deposition for the Park.

In addition to the proposed work with the PnET-BGC model, EPA has initiated a companion modeling effort using another dynamic model, Model of Acidification of Groundwater in Catchments (MAGIC) (Cosby et al., 1985a,b,c) in conjunction with the University of Virginia. The MAGIC model will be used to estimate future changes in stream chemistry in response to Base Case and Aggressive Emissions Control scenarios. MAGIC can be used to estimate critical loads for stream resource protection in the GSM.

The goal of the modeling efforts is to establish the levels of atmospheric deposition of N and S to GSM watersheds that are necessary to achieve aquatic recovery in impaired streams. Given that

recognized leaders in the field of critical load modeling are collaborating on the MAGIC and PnET-BGC modeling efforts, the critical loads generated by these models should be solid and defendable values by which to manage load allocations.

Increasing public awareness and understanding of air pollution and its impacts on water quality is another key step. Lacking direct authority under the Clean Air Act to regulate new or existing sources, the National Park Service must work with the community, regulators, and source industries to inform and influence permit decisions (Shaver et al., 1994). Providing specific information on critical load thresholds that meet TMDL objectives is important in making air permit decisions as the load is directly linked to a water quality regulation. Public understanding and support for this approach can only make the program more effective.

Required LAs will be implemented in several steps to reduce acidity and/or increase alkalinity so as to result in an increase of acid neutralizing capacity. In order to meet Tennessee Water Quality Standards for pH, this TMDL requires that ANC (as $CaCO_3$) loads of streams in the Great Smoky Mountains National Park meet, or exceed, the loads per unit area specified in the target load duration curve (ref.: Figure 5) and Table 5.

TMDLs are developed based on the best data available at the time, and often involve a degree of uncertainty. For example, significant uncertainty may exist whenever a surrogate it used to interpret a narrative standard. As the science and available data for acid deposition continue to grow, more advanced approaches to TMDLs related to acid deposition may be developed. These new approaches will be applied, as appropriate, through the adaptive management process to enhance the effectiveness of TMDLs for providing a sound basis for water quality management decisions.

Adaptive Implementation, in the TMDL context, is an iterative process of taking action steps of limited scope to make progress toward attaining water quality standards in accordance with available data and information while continuing to improve our understanding of the water quality impairment and its solutions, so that we can continue to make progress. A National Research Council report (2001) suggests that adaptive implementation include “immediate actions, an array of possible long-term actions, success monitoring, and experimentation for model refinement”. By using the adaptive implementation approach, one can utilize the new information available from monitoring following initial TMDL implementation efforts to appropriately identify the next suite of implementation activities.

Several steps can be taken to reduce uncertainty regarding sources and to assess progress in attaining water quality standards. In locations where anakeesta formations may be contributing to acidity, soil and/or rock analysis is recommended to determine whether anakeesta is present. Water quality monitoring will continue to be performed. Water quality monitoring is the mechanism for tracking water quality improvements and thus determining and evaluating the successful implementation of the TMDL. The National Park Service will also continue to maintain the current acid deposition monitoring stations. Wet deposition of nitrogen, sulfur and the major cations are measured at Elkmont station, which is part of the National Atmospheric Deposition Program (NAPD).

Implementation of TMDLs can take many years and, when uncertainty about the effectiveness of implementation activities exists, TMDLs would benefit from containing elements that would facilitate adaptive implementation such as, for example, provisions for a flexible load allocation/waste load allocation scheme. In most cases, adaptive implementation is not anticipated to lead to the re-opening of a TMDL. Instead, it is a tool used to improve implementation strategies.

9.0 PUBLIC PARTICIPATION

In accordance with 40 CFR §130.7, the proposed TMDL for the Great Smoky Mountains National Park was placed on Public Notice for a 60-day period and comments solicited. Steps that were taken in this regard include:

1) Notice of the proposed TMDL was posted on the Tennessee Department of Environment and Conservation website. The announcement invited public and stakeholder comment and provided a link to a downloadable version of the TMDL document.

2) Notice of the availability of the proposed TMDL (similar to the website announcement) was included in one of the NPDES permit Public Notice mailings which is sent to approximately 90 interested persons or groups who have requested this information.

3) A letter was sent to water quality partners in the Great Smoky Mountains National Park advising them of the proposed TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following partners:

City of Gatlinburg, TN
City of Pigeon Forge, TN
NRCD RC&D Office (Knoxville)
Sevier County Soil Conservation District
US DOI – Fish & Wildlife Service
US DOI – National Park Service – GSMNP
Tennessee Valley Authority (water)
Tennessee Department of Agriculture – NRCS
Tennessee Wildlife Resources Agency
French Broad Riverkeeper
The Nature Conservancy
North Carolina DEHNR, DWQ, Modeling and TMDL Unit

4) A letter was sent to stakeholders in the air sector near the Great Smoky Mountains National Park advising them of the proposed TMDLs and their availability on the TDEC website. The letter also stated that a written copy of the draft TMDL document would be provided upon request. A letter was sent to the following partners:

Eastman Chemical Company
Atibi-Bowater, Calhoun, TN
Tate & Lyle, Loudon, TN
ALCOA Aluminum
DOE – Oak Ridge
Tennessee Valley Authority (air)
Knox County Dept. of Air Quality Mgmt
Evergreen Packaging Group, Canton, NC
Domtar Corp., Kingsport Paper Mill
Progress Energy Carolinas, Asheville Steam Electric Plant
Appalachian Power, Clinch River Plant

No comments were received during the public notice period.

10.0 FURTHER INFORMATION

Further information concerning Tennessee's TMDL program can be found on the Internet at the Tennessee Department of Environment and Conservation website:

www.state.tn.us/environment/wpc/tmdl.htm

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

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APPENDIX A

Acid Deposition

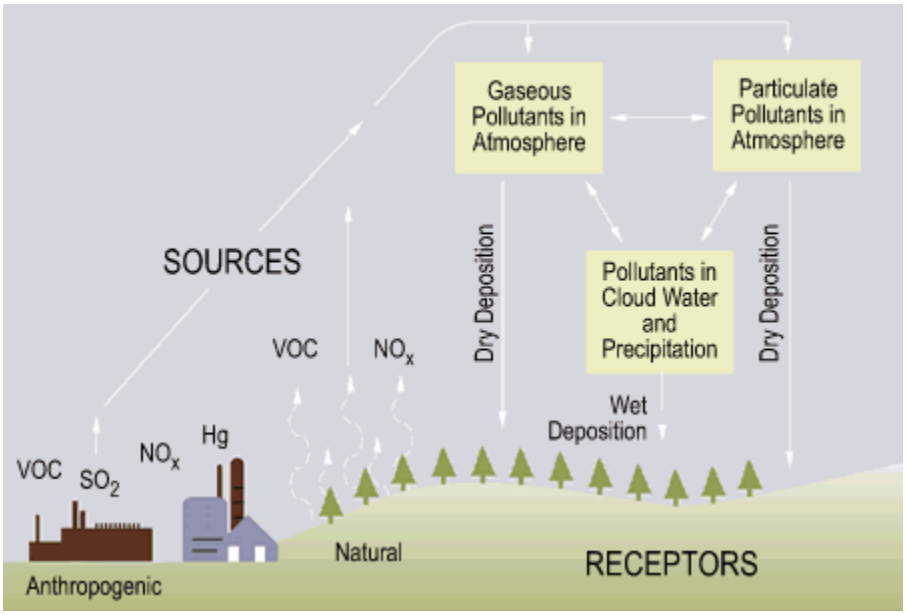
The following information regarding acid deposition was taken from the U.S. EPA and DOI, National Park Service websites (USEPA, 2008, and National Park Service, 2008, respectively). More detailed discussion can be found on the individual websites.

Definition of Acid Deposition

"Acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emission of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) resulting from fossil fuel combustion. In the United States, roughly 2/3 of all SO_2 and ¼ of all NO_x come from electric power generation that relies on burning fossil fuels, such as coal. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.

Normally rain water is slightly acidic, with a pH between 4.9 and 6.0, because in the atmosphere, water reacts with carbon dioxide to form a weak carbonic acid. (National Park Service, 2008) Pure water would have a neutral pH of 7. Acid rain occurs when SO_2 and NO_x react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid. (USEPA, 2008)

Wet deposition refers to acidic rain, fog, and snow. If the acid chemicals in the air are blown into areas where the weather is wet, the acids can fall to the ground in the form of rain, snow, fog, or mist. As this acidic water flows over and through the ground, it affects a variety of plants and animals. The strength of the effects depends on several factors, including how acidic the water is; the chemistry and buffering capacity of the soils involved; and the types of fish, trees, and other living things that rely on the water.



In areas where the weather is dry, the acid chemicals may become incorporated into dust or smoke and fall to the ground through dry deposition, sticking to the ground, buildings, homes, cars, and trees. About half of the acidity in the atmosphere falls back to earth through dry deposition. Dry deposited gases and particles can be washed from these surfaces by rainstorms, leading to increased runoff. When that happens, the dry deposition adds to the acids in the precipitation, making the runoff even more acidic.

Prior to falling to the earth, SO_2 and NO_x gases and their particulate matter derivatives, sulfates and nitrates, contribute to visibility degradation and harm public health. (USEPA, 2008)

Results of Acid Deposition

Acid rain causes acidification of lakes, streams, and sensitive forest soils and can damage trees and other plants. The presence of sulfur on and in the soil and water releases aluminum, making it available to plants, soil microbes, fish and other organisms. Acid particles also alter the nutrient make-up of forest soils. This can result in impairment of plant growth and development because nutrients that would otherwise be available to plants are diminished. These chemical alterations are particularly acute at high elevation sites because nitrogen is limited in those soils to begin with. Nutrient deficiency can lead to susceptibility to disease. (National Park Service, 2008)

In addition, acid deposition accelerates the decay of building materials and paints, including irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage. (National Park Service, 2008)

Acid deposition penetrates deeply into the fabric of an ecosystem, changing the chemistry of the soil as well as the chemistry of the streams and narrowing, sometimes to nothing, the space where certain plants and animals can survive. Because there are so many changes, it takes many years for ecosystems to recover from acid deposition, even after emissions are reduced and the rain becomes normal again. For example, while the visibility might improve within days, and small or episodic chemical changes in streams improve within months, chronically acidified lakes, streams, forests, and soils can take years to decades or even centuries (in the case of soils) to heal. (Almanac of Policy Issues, 2008)

Acid rain's pH, and the chemicals that cause acid rain, are monitored by two networks, both supported by EPA. The National Atmospheric Deposition Program measures wet deposition, and its Web site features maps of rainfall pH (follow the link to the isopleth maps) and other important precipitation chemistry measurements. The Clean Air Status and Trends Network (CASTNET) measures dry deposition. Its web site features information about the data it collects, the measuring sites, and the kinds of equipment it uses. (USEPA, 2008).

Acid Deposition and the Great Smoky Mountains National Park

Air quality is a major Park concern. Wind currents moving toward the southern Appalachians transport pollutants from urban areas, industrial sites, and power plants located both near and far. The height and physical structure of the mountains, combined with predominant weather patterns, tend to trap and concentrate human-made pollutants in and around the national park. (National Park Service, 2008) Often mountainous regions tend to receive the most deposition simply because of their higher rainfall.

Plants and animals in Great Smoky Mountains National Park are threatened by airborne sulfur and nitrogen pollution. The park receives the highest sulfur and nitrogen deposits of any monitored

national park. The average acidity (pH) of rainfall in the park is 4.5, 5-10 times more acidic than normal rainfall (5.0-5.6). Clouds with acidity as low as pH 2.0 bathe the high elevation forests during part of the growing season. (National Park Service, 2008)

Acidic deposition, combined with the presence of acidic bedrock threatens aquatic ecosystems. (Uhler, 2008) Research shows that certain high elevation soils in the park are receiving so much airborne nitrogen that they are suffering from advanced nitrogen saturation. This condition limits the availability of forest nutrients, especially calcium, to plants and causes the release of toxic aluminum that can hurt vegetation and aquatic organisms. Mountain streams and forest soils are being acidified to the point that the health of the park's high elevation ecosystems is in jeopardy. Nitrate levels in some streams are approaching the public health standard for drinking water. (National Park Service, 2008)

Continued efforts by the EPA and state regulatory agencies to reduce sulfur dioxide (SO_2) and nitrogen dioxide (NO_x) emissions in the eastern U.S. have reduced sulfate and nitrate deposition measured at the park beginning in the late 1990s. Despite these deposition reductions, stream pH continues to decline at elevations below 3,000 feet.

The University of Tennessee at Knoxville has been monitoring atmospheric deposition rates of acidic compounds, stream water quality and flow, and soil solution chemistry within the Noland Divide portion of the GSMNP since 1991 (Smoot, et al, 2000;Roby, et al, 2004; Robinson, et al, 2005; Jackson, et al, 2006; Neff, et al, 2007; Smith, 2007). Based on this research, the following observations can be made:

- For pH and ANC, values decrease with increases in elevation.
- For nitrate and sulfate (below 4500'), values increase with increases in elevation.
- 77% of the sites sampled have a median pH < 6.5.
- 97% of all sampled surface waters have median ANC values below 200 μeq/L, the point at which water is considered sensitive to decreases in pH.
- Seasonal trends were found to be statistically significant for pH and ANC. Values were higher during sampling periods that are typically drier than other times of the year.
- Time trend analysis revealed a statistically significant decreasing trend in pH over time of 0.0080 units per year, particularly at lower elevations.

APPENDIX B

Monitoring Data for Subwatersheds in the Great Smoky Mountains National Park

Table B-1 GSMNP Monitoring Data

	Lower Rock Creek						35.761329 N				
	Site #4						83.210440 W				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/23/93			6.68	103.11	17.37	7.31	0.00	24.19	31.50		
10/23/93			6.66	101.59	17.79	7.26	0.00	24.11	31.37		
5/23/94			5.94	10.16	13.13	10.83	24.15	51.71	86.68		
8/20/94	Y		5.85	8.82	13.06	11.55	25.62	47.79	84.96		
2/25/95			6.53	80.60	12.50	15.82	4.35	16.86	37.03		
3/26/95			6.55	84.91	12.70	8.82	6.19	18.28	33.29		
4/15/95			6.57	73.33	16.49	15.00	10.41	21.58	46.99		
5/12/95		Y	5.95	13.46	14.94	11.63	35.35	49.87	96.85		
7/21/95			5.98	13.99	14.27	14.82	29.53	50.93	95.28		
8/15/95			6.00	15.27	16.32	10.15	22.39	48.06	80.60		
10/13/95	Y		5.98	25.04	14.60	11.40	20.48	45.17	77.05		
12/17/95		Y	6.33	55.00	13.79	12.30	28.45	43.44	84.18		
2/27/96		Y	5.79	17.15	14.59	13.68	49.24	48.75	111.67		
5/15/96	Y		5.94	28.28	15.21	12.16	32.39	41.89	86.44		
8/15/96			5.54	10.61	1.17	11.24	31.30	40.50	83.04		
10/24/96		Y	6.16	27.28	11.15	14.15	0.00	47.86	62.01		
3/16/97			5.74	5.55	14.52	10.32	39.40	44.72	94.44		
5/18/97			5.87	14.93	13.51	12.13	28.81	38.75	79.69		
8/15/97			5.99	17.16	13.90	9.88	24.28	40.91	75.07		
10/17/97		Y	6.09	21.92	12.64	34.45	16.19	36.93	87.57		
3/13/98			6.55	63.75	12.15	9.22	5.86	20.16	35.24		
5/15/98	Y		6.49	75.67	12.30	14.55	4.63	19.39	38.56		
8/17/98	Y		6.13	127.92	16.70	13.66	4.86	17.46	35.97		
10/15/98			6.82	133.59	16.40	11.75	2.72	15.17	29.63		
3/21/99	Y		6.34	71.39	13.50	12.53	3.44	20.24	36.21		
5/15/99		Y	6.44	80.20	13.60	14.28	5.02	16.39	35.69		
8/15/99			6.35	56.32	9.50	13.93	4.98	17.63	36.54		
10/15/99			6.46	90.13	19.40	12.78	0.00	17.32	30.10		
3/15/00			6.01	7.61	15.30	17.30	46.92	47.66	111.88		
5/15/00			5.63	9.86	14.70	14.15	37.15	50.06	101.35	63.30	
8/15/00			6.57	105.07	13.20	11.52	2.15	15.52	29.19	58.35	
11/15/00			6.56	84.16	13.95	12.27	0.00	24.72	36.98	54.50	
3/15/01		Y	6.59	67.78	11.57	15.28	4.09	18.20	37.58	43.00	
5/15/01			6.41	107.20	15.10	12.33	3.23	16.00	31.56	68.25	
8/15/01			6.57	88.28	13.65	11.43	5.02	20.07	36.52	52.95	
11/12/01			6.56	99.89	14.3	14.45	0.00	13.42	27.87	46.1	
3/25/02			6.26	67.09	12.80	8.92	0.00	18.24	27.16	41.75	
5/20/02			6.34	83.46	11.80	8.61	0.00	15.16	23.77	49.95	
8/16/02		Y	6.97	123.56	18.05	9.29	6.66	15.85	31.80	70.00	
11/18/02	Y		6.67	51.22	16.49	10.02	18.87	39.94	68.83	40.80	
3/18/03		Y	6.95	98.80	13.22	14.60	3.27	17.42	35.29	44.00	
5/19/03		Y	6.99	70.82	13.04	18.01	4.28	15.51	37.80	42.95	
8/15/03	Y		6.88	102.65	13.62	16.83	4.89	16.24	37.96	52.79	0.102
11/13/03		Y	6.41	89.20	15.81	25.77	0.00	21.91	47.68	60.28	0.055

Table B-1 (cont'd) GSMNP Monitoring Data

	Lower Rock Creek (cont'd)						**35.761329 N**				
	Site #4						**83.210440 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
3/20/04		Y	5.48	7.85	12.25	11.33	26.81	40.95	79.08	50.31	0.027
5/15/04			5.67	20.54	12.87	45.25	19.01	32.60	96.86	54.07	0.039
7/19/04		Y	5.54	10.68	12.51	36.27	23.46	25.61	85.33	57.74	0.044
9/25/04			5.69	15.40	11.58	7.25	11.83	38.86	57.95	41.42	0.047
11/20/04			5.81	19.44	13.00	3.85	20.48	46.00	70.33	43.96	0.025
1/20/05			5.64	18.55	12.74	11.88	26.60	41.61	80.10	45.86	0.032
3/19/05			5.99	14.65	12.73	4.29	24.87	43.02	72.18	44.77	0.071
5/21/05		Y	5.86	28.73	14.66	2.39	28.98	46.74	78.10	52.39	0.088
7/16/05	Y		6.02	34.98	13.99	10.32	25.80	42.59	78.71	44.74	0.103
9/17/05		Y				10.32	21.81	44.53	76.66	47.64	0.051
11/19/05			6.15	13.20	16.17	13.41	41.98	46.25	101.64	56.13	0.033
1/21/06	Y		5.83	12.03	13.86	9.86	33.72	40.80	84.38	46.52	0.050
3/18/06			6.06	9.41	14.48	10.14	34.11	42.11	86.36	51.79	0.082
5/20/06	Y		5.53	-1.27	16.52	7.12	30.23	52.62	89.97	61.98	0.170
7/15/06	Y		5.37	21.03	13.98	9.92	25.08	39.70	74.70	46.41	0.175
9/16/06			5.89	4.15	12.75	9.00	26.49	46.85	82.35	44.45	0.067
11/20/06			5.48	3.49	13.55	10.08	28.84	46.04	84.96	47.72	0.032
1/20/07			5.39	-2.56	13.77	10.05	40.01	42.87	92.93	47.92	0.037
3/17/07		Y	5.36	0.69	17.83	13.08	57.23	48.46	118.78	66.15	0.000
5/20/07			6.08	12.55	14.62	9.99	38.63	44.19	92.81	49.84	0.034
7/21/07			5.95	3.20	14.85	8.98	41.15	46.79	96.92	59.23	0.079
9/15/07		Y	5.22	5.48	12.52	10.27	33.81	46.82	90.89	50.36	0.060
11/17/07			6.19	9.40	14.67	17.35	22.73	49.37	89.45	51.48	0.028

Table B-1 (cont'd) GSMNP Monitoring Data

	Shutts Prong						**35.659564 N**				
	Site #45						**83.397543 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/23/93			5.47	4.23		16.71	21.24	56.62	94.57		
1/15/94		Y	5.23	-1.59		17.44	35.20	76.43	129.07		
2/20/94			5.23	-5.77		16.69	44.35	105.98	167.01		
3/21/94			5.23	-2.29		15.69	32.17	78.57	126.43		
5/15/94	Y		5.38	-0.12	18.79	9.61	25.67	100.05	135.33		
8/15/94			5.61	3.48	14.81	12.34	23.66	64.36	100.36		
12/11/94	Y		5.39	0.34	22.40	26.84	70.27	142.14	239.25		
1/22/95			5.61	1.46	12.10	13.69	39.52	89.75	142.96		
2/19/95		Y	5.47	3.82	16.36	10.87	34.13	84.53	129.53		
3/19/95			5.72	0.50	17.17	12.41	35.86	85.60	133.86		
4/9/95			5.82	10.12	19.53	11.42	31.68	77.12	120.22		
5/20/95		Y	5.60	5.07	20.40	12.74	32.68	101.50	146.92		
6/18/95			5.52	0.27	19.41	11.11	29.12	87.39	127.61		
7/16/95			5.61	15.51	21.70	24.00	31.29	78.59	133.88		
8/15/95			5.42	4.09		9.31	34.26	94.23	137.80		
9/15/95			5.82	7.69	18.90	11.08	29.43	81.06	121.56		
10/22/95			5.85	19.16	19.98	16.49	16.88	97.08	130.45		
3/17/96		Y	5.45	2.44	18.44	16.64	42.00	107.38	166.03		
5/19/96			5.54	2.34	20.90	18.29	37.79	111.30	167.38		
8/18/96		Y	5.47	-0.77	20.00	11.26	22.11	93.59	126.96		
10/22/96		Y	6.11	18.06	15.99	12.77	18.64	75.67	107.09		
3/16/97			5.38	-0.48	17.46	11.32	34.32	71.33	116.96		
5/18/97			5.51	7.00	18.98	10.46	30.33	73.89	114.68		
8/16/97			5.84	19.45	20.70	10.43	31.06	81.97	123.47		
10/21/97		Y	5.74	15.72	31.50	35.89	32.76	119.91	188.55		
3/21/98		Y	5.22	-2.34	19.24	34.05	31.24	88.74	154.02		
5/18/98			5.65	4.32	17.20	14.53	28.58	77.26	120.37		
8/18/98		Y	5.39	3.46	20.90	14.21	32.94	105.51	152.65		
10/17/98			5.67	15.74	22.00	22.02	34.69	99.48	156.18		
3/21/99	Y		5.38	-7.92	19.68	16.44	32.08	91.60	140.12		
5/15/99		Y	5.51	3.50	17.60	16.08	0.00	77.10	93.19		
8/21/99		Y	5.76	6.05	7.50	13.78	32.45	102.87	149.10		
10/16/99			6.06	8.06	25.90	23.51	24.62	106.55	154.68		
3/18/00		Y	5.20	-5.87	22.10	19.83	39.03	100.42	159.28		
5/20/00	Y		5.78	14.98	18.50	17.37	31.52	80.85	129.74	54.00	
8/19/00		Y	5.66	0.84	16.10	14.10	28.82	78.82	121.73	50.25	
11/18/00		Y	5.86	7.71	21.00	21.66	27.00	107.42	156.08	71.25	
3/24/01			5.44	-1.56	17.28	15.11	27.84	87.64	130.59	15.35	
5/19/01		Y	5.80	9.43	20.90	42.01	32.74	82.97	157.71	64.80	
8/18/01		Y	5.70	3.64	16.55	17.94	22.85	81.85	122.64	50.00	
11/17/01			5.87	15.55	18.23	21.48	27.68	82.34	131.50	52.25	
3/23/02			5.47	-4.97	19.50	14.40	33.34	81.31	129.06	68.05	
8/17/02	Y		5.71	6.08	21.10	15.65	32.00	99.53	147.18	71.83	
11/16/02		Y	5.36	-0.52	21.00	12.45	20.65	94.84	127.95	77.50	
3/15/03		Y	5.54	-0.20	18.00	13.89	30.17	81.85	125.91	66.40	
5/17/03	Y		5.77	5.76	17.84	17.58	18.39	79.79	115.76	66.50	
8/16/03	Y		5.53	2.23	21.60	23.91	24.09	96.89	144.89	91.12	0.117
11/15/03		Y	5.52	5.40	20.90	21.69	34.48	84.07	140.24	82.98	0.085

Table B-1 (cont'd) GSMNP Monitoring Data

	Lower Cannon Creek						**35.680200 N**				
	Site #47						**83.398746 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
12/15/94			6.04	11.65	15.39	32.19	69.43	176.08	277.70		
1/22/95			5.90	8.04	12.41	12.52	29.58	41.22	83.33		
2/19/95		Y	5.79	7.94	10.79	12.01	28.15	37.11	77.27		
3/19/95			6.03	18.64	10.12	9.98	22.57	32.84	65.39		
4/9/95			6.10	8.69	19.30	10.57	23.82	35.73	70.13		
5/20/95		Y	5.80	9.67	12.81	10.95	24.29	48.55	83.80		
6/18/95			6.09	9.18	12.31	9.79	19.55	43.73	73.07		
7/16/95			6.08	15.47	11.75	13.12	16.77	51.34	81.23		
8/15/95			6.03	14.82	14.16	8.92	19.64	51.61	80.17		
9/9/95			6.11	16.54	12.00	9.33	16.50	37.37	63.20		
10/22/95			6.07	22.66	12.03	13.96	10.44	37.10	61.49		
12/17/95			5.86	11.42	12.36	11.69	27.87	40.90	80.45		
3/17/96		Y	5.87	9.96	12.13	15.30	34.25	50.35	99.90		
5/19/96			5.91	32.24	15.39	26.54	28.57	50.87	105.99		
10/22/96		Y	6.17	20.36	9.65	15.33	11.18	46.11	72.62		
3/16/97			5.93	5.60	12.47	12.68	29.26	36.88	78.81		
5/18/97			6.09	15.25	10.91	8.30	20.46	30.07	58.83		
8/16/97			6.07	90.03	11.38	4.94	21.05	32.42	58.41		
10/21/97		Y	6.04	115.45	11.31	26.46	16.84	42.70	85.99		
3/21/98		Y	5.66	8.16	13.49	45.10	28.02	43.87	116.99		
5/18/98			5.93	11.05	10.70	11.55	19.78	33.41	64.74		
8/18/98		Y	5.58	9.19	12.00	9.83	20.71	47.36	77.90		
10/17/98			5.71	17.94	12.40	14.18	14.89	41.87	70.94		
3/21/99	Y		5.76	-3.35	11.36	16.04	22.50	38.61	77.14		
5/15/99		Y	5.77	10.37	10.50	12.41	15.34	37.33	65.08		
8/21/99		Y	5.92	20.58	7.00	10.03	21.23	47.84	79.09		
10/16/99			5.91	2.88	16.70	14.65	19.99	44.81	79.45		
3/18/00		Y	5.69	-2.76	14.80	20.93	41.19	44.32	106.44		
5/20/00	Y		5.92	10.57	10.33	14.94	22.23	30.96	68.12	35.55	
8/19/00		Y	5.87	8.97	9.80	17.68	18.42	33.63	69.72	34.50	
11/18/00		Y	5.87	12.03	11.42	22.44	16.67	43.35	82.45	38.25	
3/24/01			5.84	6.75	10.75	17.15	20.25	34.97	72.38	37.40	
5/19/01		Y	6.01	9.85	10.54	15.05	20.39	27.74	63.18	32.85	
8/18/01		Y	6.03	12.35	9.29	13.39	12.17	33.80	59.37	32.65	
11/17/01			5.97	18.96	10.8	19.24	13.68	32.84	65.76	66.4	
3/23/02			5.98	5.98	12.60	9.99	25.18	34.54	69.71	41.10	
5/18/02	Y		5.81	2.79	13.00	11.63	18.69	51.22	81.54	57.65	
8/17/02	Y		6.29	19.98	12.80	15.57	10.21	41.72	67.49	42.95	
11/16/02		Y	6.05	21.68	12.44	10.55	17.19	36.29	64.03	36.90	
3/15/03		Y	6.03	10.30	11.93	14.76	22.85	35.21	72.82	37.75	
5/17/03	Y		6.05	13.23	10.44	16.36	13.64	34.73	64.73	34.40	
8/16/03	Y		6.14	14.75	10.81	14.79	12.91	34.24	61.95	43.77	0.070
11/15/03		Y	5.72	13.09	13.61	20.23	20.29	40.59	81.11	52.54	0.106

Table B-1 (cont'd) GSMNP Monitoring Data

	Lower Road Prong						**35.634404 N**				
	Site #71						**83.470318 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/15/93			6.48	59.80	20.00	18.88	22.98	44.85	86.71		
2/15/94			6.14	18.65	16.81	16.74	41.94	38.07	96.75		
2/15/94			6.14	18.65							
3/15/94			6.19	19.76	14.82	14.85	39.78	37.98	92.61		
12/10/94		Y	6.39	26.82	15.97	25.97	59.07	159.51	244.54		
1/21/95			6.21	19.15	16.37	49.38	40.29	51.06	140.74		
2/22/95		Y	5.88	13.96	12.60	10.70	36.79	45.22	92.70		
3/18/95			6.25	23.21	13.98	11.56	35.00	42.98	89.54		
4/8/95			6.34	36.71	16.94	21.77	32.04	38.86	92.66		
5/21/95			6.10	25.16	14.77	14.62	34.05	48.67	97.34		
6/17/95		Y	6.19	26.70	15.97	10.21	27.75	49.65	87.61		
7/15/95			6.25	44.72	17.37	14.86	31.91	43.34	90.11		
8/15/95			6.19	41.57	16.64	11.04	29.06	42.82	82.92		
9/10/95			6.46	44.12	16.95	10.89	30.51	43.89	85.30		
10/21/95		Y	6.17	42.00	17.22	14.94	23.83	44.57	83.34		
12/16/95		Y	6.09	25.95	15.09	11.95	33.56	45.28	90.79		
3/16/96	Y		6.02	21.91	15.63	12.31	42.83	50.87	106.00		
8/17/96			6.26	25.53	16.64	11.77	33.81	44.70	90.28		
10/19/96		Y	6.35	52.79	15.40	14.44	20.79	44.77	80.01		
10/19/96		Y	6.45	53.28							
3/15/97		Y	5.69	8.19	16.10	11.61	38.36	48.47	98.44		
5/19/97			6.38	26.16	15.42	10.31	29.95	40.36	80.63		
8/17/97		Y	6.42	37.18	17.01	22.39	29.93	42.31	94.64		
10/18/97	Y		6.32	159.34	17.18	33.31	22.13	49.62	105.07		
3/21/98		Y	5.71	4.37	14.80	30.55	37.11	47.24	114.89		
5/16/98			5.92	18.91	14.00	13.89	31.16	41.86	86.91		
8/15/98	Y		5.85	37.58	15.70	16.21	28.76	49.09	94.06		
10/18/98			6.37	41.44	16.70	16.36	24.25	49.76	90.38		
3/20/99		Y	5.96	20.12	15.78	15.04	33.76	44.50	93.29		
5/15/99		Y	6.03	19.73	14.70	17.02	29.50	45.47	91.99		
8/21/99		Y	6.28	13.54	14.69	15.98	28.59	49.34	93.91		
10/16/99			6.12	20.89	19.00						
3/18/00		Y	5.74	11.46	15.30	18.11	41.91	46.85	106.88		
5/20/00	Y		6.15	32.97	13.07	14.77	30.67	40.90	86.33	62.55	
8/19/00		Y	6.39	35.98	14.10	14.91	29.92	42.04	86.87	62.90	
11/18/00		Y	6.25	32.39	15.62	17.72	31.16	45.68	94.56	73.40	
3/24/01			6.03	23.05	5.36	37.90	34.71	44.89	117.51	68.05	
5/19/01		Y	6.27	23.34	15.46	14.57	33.11	43.96	91.64	71.95	
8/18/01		Y	6.32	31.97	14.51	13.57	27.90	43.22	84.69	65.40	
11/17/01			6.17	42.85	15.92	22.23	34.17	43.07	99.47	93.65	
3/23/02			5.78	59.14	16.00	15.56	37.53	40.26	93.35	66.05	
5/18/02	Y		5.42	-1.29	15.60	13.15	35.04	50.94	99.12	74.25	
11/16/02		Y	6.15	26.84	15.45	10.73	29.13	41.30	81.17	57.55	

Table B-1 (cont'd) GSMNP Monitoring Data

	Lower Road Prong (cont'd)						**35.634404 N**				
	Site #71						**83.470318 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
3/15/03		Y	6.26	14.84	15.31	14.49	40.06	43.00	97.54	61.65	
5/17/03	Y		6.23	26.83	14.30	18.15	30.45	36.78	85.38	58.65	
8/16/03	Y		6.51	41.09	16.63	18.35	24.92	38.66	81.93	74.20	0.071
11/15/03		Y	6.12	33.03	17.19	21.32	33.95	40.12	95.39	84.78	0.086
3/20/04		Y	5.84	19.94	15.83	12.50	35.89	39.33	87.72	78.51	0.084
5/16/04			5.91	30.58	15.34	21.84	19.48	22.38	63.69	72.75	0.080
7/17/04	Y		5.84	38.27	15.36	16.32	23.70	29.70	69.73	79.69	0.075
9/25/04			5.94	25.93	14.36	8.62	28.18	45.61	82.41	59.00	0.012
11/20/04			6.10	32.27	15.45	4.36	32.47	43.02	79.85	69.70	0.027
1/24/05			5.92	30.50	15.36	12.93	34.22	41.35	88.50	70.76	0.025
3/19/05			6.31	25.29	15.07	5.86	32.84	42.72	81.42	68.22	0.084
5/21/05		Y	6.19	41.16	15.52	4.11	32.51	49.77	86.39	63.99	0.070
7/16/05	Y		6.17	20.08	15.07	10.16	33.02	45.12	88.30	63.24	0.070
9/17/05		Y				12.28	31.19	44.41	87.88	69.79	0.058
11/21/05	Y		6.38	23.80	18.89	13.19	51.98	48.45	113.62	79.58	0.012
1/21/06	Y		5.76	8.35	15.67	10.77	45.15	46.24	102.16	59.73	0.156
3/18/06			6.28	17.71	16.59	11.25	46.13	41.07	98.45	62.38	0.032
5/21/06		Y	5.96	11.93	17.28	9.18	50.38	48.50	108.06	69.50	0.077
7/23/06		Y	5.53	14.67	15.82	9.56	42.21	50.86	102.63	68.92	0.085
9/16/06			6.15	34.01	16.57	10.88	35.82	45.79	92.49	70.59	0.048
11/20/06			5.73	11.85	16.18	11.18	48.75	44.41	104.34	67.46	0.045
1/20/07			5.90	13.59	16.40	11.66	55.40	44.10	111.16	69.77	0.024
3/17/07		Y	5.45	5.08	18.22	11.57	67.12	48.44	127.13	80.07	0.041
5/19/07			6.42	23.37	17.37	11.22	44.98	44.03	100.23	69.89	0.040
7/21/07			6.52	41.64	17.58	10.42	35.45	51.51	97.37	81.73	0.065
9/15/07		Y	6.47	31.17	19.13	13.71	40.12	58.16	111.99	90.21	0.076
11/17/07			6.51	39.18	19.76	17.74	44.88	58.61	121.22	84.72	0.142

Table B-1 (cont'd) GSMNP Monitoring Data

	Otter Creek						**35.730604 N**				
	Site #103						**83.256785 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/15/93			5.83	6.64	18.18	22.80	38.58	65.56	126.93		
2/15/94			5.40	-3.94	21.80	18.55	57.51	50.63	126.69		
3/15/94			5.55	0.04	16.42	12.53	49.66	67.26	129.45		
5/15/94	Y		5.67	6.92	21.80	29.70	38.37	69.57	137.63		
8/15/94			5.65	-0.21	15.90	11.57	32.59	74.72	118.88		
2/19/95		Y	5.31	0.86	20.60	12.60	52.13	73.27	137.99		
3/25/95			5.71	3.08	17.31	10.17	47.39	71.56	129.12		
4/15/95			5.76	5.09	19.61	12.33	41.02	65.75	119.10		
5/23/95			5.66	6.27	20.50	14.10	46.93	75.32	136.35		
7/21/95			5.75	8.55	18.07	21.76	45.17	79.85	146.77		
8/20/95	Y		5.78	12.41	20.80	9.50	40.35	73.44	123.30		
9/15/95			5.75	8.19	18.63	9.71	43.35	71.70	124.77		
10/12/95			5.78	8.20	22.40	12.94	48.86	70.26	132.06		
11/19/95			5.69	4.72	20.90	14.41	58.44	69.39	142.24		
12/15/95			5.60	5.70	18.62	12.35	61.30	68.29	141.94		
3/15/96			5.42	0.93	20.40	12.95	68.42	64.00	145.37		
5/15/96	Y		5.45	2.02	22.80	12.02	60.18	66.50	138.70		
8/19/96		Y	5.82	5.62	22.90	18.17	54.00	68.09	140.26		
10/17/96		Y	5.80	14.16	18.93	17.64	48.46	67.91	134.00		
3/16/97			5.13	-3.11	21.90	13.46	63.31	66.24	143.01		
5/15/97			5.52	0.67	20.50	14.28	55.64	65.90	135.82		
8/15/97			5.55	1.47	19.21	11.07	48.57	64.18	123.82		
3/14/98			5.30	-2.01	23.00	26.79	63.79	66.00	156.58		
5/15/98	Y		5.28	-1.19	18.00	14.72	46.45	68.07	129.23		
8/15/98	Y		5.40	1.89	16.40	14.46	40.55	67.34	122.34		
10/15/98			5.56	12.00	22.10	23.72	52.81	67.32	143.86		
3/21/99	Y		5.13	-4.14	21.80	17.42	57.51	67.23	142.16		
5/15/99		Y	5.42	-1.87	19.20	21.88		66.68	88.57		
8/15/99			6.17	2.36	12.80	14.03	39.94	65.65	119.62		
10/15/99			5.87	-0.23	23.80	19.52	56.09	66.15	141.75		
3/15/00			4.97	-9.72	23.70	20.06	88.72	64.39	173.16		
5/15/00			4.83	-11.64	20.90	14.11	70.98	65.10	150.19	72.75	
8/15/00			5.53	-3.30	16.90	19.06	52.70	63.78	135.54	78.15	
11/15/00			5.40	-1.44	18.10	42.92	63.63	65.84	172.38	88.75	
3/15/01		Y	5.65	3.74	19.60	47.78	66.04	63.58	177.40	89.65	
5/15/01			5.52	2.16	15.31	12.49	44.80	56.59	113.88	71.80	
8/15/01			5.60	-1.67	16.90	14.81	42.08	66.79	123.68	77.20	
11/12/01			5.91	15.45	17.6	17.07	38.27	53.77	109.11	74.6	
3/25/02			5.29	-9.94	21.80	11.41	59.73	61.00	132.14	83.40	
5/20/02			5.49	-8.05	17.90	16.61	52.78	62.15	131.53	7.35	
8/16/02		Y	5.89	7.04	18.51	15.33	44.12	66.46	125.91	82.65	
11/17/02		Y	5.37	1.30	18.92	19.49	45.45	66.04	130.98	46.75	
3/18/03		Y	5.49	5.96	18.88	13.75	44.85	60.09	118.69	77.05	
5/19/03		Y	6.32	18.31	16.73	20.75	32.81	53.84	107.39	72.65	
8/15/03	Y		5.57	1.11	16.05	10.30	26.45	63.47	100.22	67.61	0.119
11/13/03		Y	5.38	5.08	18.16	25.44	38.72	49.41	113.57	69.06	0.053

Table B-1 (cont'd) GSMNP Monitoring Data

	Copperhead Branch						**35.727480 N**				
	Site #104						**83.263783 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/15/93			5.01	-4.25	21.40	13.08	29.31	81.72	124.10		
2/15/94			5.44	0.85	21.30	11.25	50.34	55.80	117.39		
5/15/94	Y		5.71	4.01	17.50	13.11	46.77	56.01	115.89		
8/15/94			5.70	4.21	15.51	14.67	38.18	58.70	111.55		
2/19/95		Y	5.64	7.57		12.28	49.88	61.00	123.17		
3/25/95			5.03	-3.74	20.60	15.51	52.05	82.23	149.79		
4/15/95			6.09	27.56	19.03	12.48	38.04	55.17	105.69		
5/23/95			5.56	3.93	18.36	11.49	49.45	58.69	119.63		
7/21/95			5.86	7.87	16.42	15.29	47.02	63.32	125.63		
8/20/95	Y		6.08	17.82	18.76	9.25	32.65	63.72	105.62		
9/15/95			5.85	11.43	17.27	11.32	42.85	56.01	110.18		
10/12/95			6.44	161.56	26.80	35.77	9.48	40.26	85.52		
11/19/95			5.95	12.18	17.93	12.38	50.19	59.25	121.81		
12/15/95			5.84	17.63	16.62	26.30	51.77	58.47	136.53		
3/15/96			5.92	12.35	18.16	11.81	55.02	55.00	121.82		
5/15/96	Y		5.59	9.86	20.90	12.36	57.89	53.60	123.84		
8/19/96		Y	5.11	-9.46	18.82	10.97	21.23	94.58	126.78		
10/17/96		Y	5.86	61.43	17.54	13.81	57.05	51.87	122.73		
3/16/97			5.36	-2.88	19.90	13.87	62.00	59.71	135.57		
5/15/97			5.52	6.74	21.10	27.18	56.60	53.92	137.70		
8/15/97			5.68	3.17	17.48	11.65	46.42	50.88	108.96		
3/14/98			5.40	-0.70	18.93	12.81	59.34	55.34	127.49		
5/15/98	Y		5.76	10.81	15.90	14.78	35.15	61.13	111.06		
8/15/98	Y		5.66	3.77	15.20	14.01	42.56	57.31	113.88		
10/15/98			5.55	13.73	18.00	23.28	40.61	55.78	119.66		
3/21/99	Y		5.41	1.96	19.40	15.29	51.67	59.46	126.41		
5/15/99		Y	5.45	3.81	17.10	24.65	45.24	55.16	125.05		
8/15/99			6.27	29.00	10.70	13.64	41.97	55.99	111.60		
10/15/99			6.01	0.80	21.70	20.56	53.50	53.23	127.29		
3/15/00			5.63	-3.00	19.50	21.33	72.89	54.40	148.61		
5/15/00			5.12	-5.01	18.50	14.98	65.83	61.12	141.93	79.05	
8/15/00			6.04	1.78	17.20	24.02	51.90	52.53	128.45	71.65	
11/15/00			5.67	2.76	17.46	25.90	58.74	54.03	138.67	74.15	
3/15/01		Y	5.65	1.26	16.52	20.82	49.94	51.51	122.27	70.00	
5/15/01			5.85	14.12	13.81	11.71	31.83	50.41	93.95	57.90	
8/15/01			5.75	0.33	15.76	20.83	54.66	54.86	130.35	67.50	
11/12/01			5.72	11.74	18.9	33.33	49.30	51.21	133.85	71.9	
3/25/02			5.36	-3.56	20.20	19.33	61.79	50.90	132.02	75.65	
5/20/02			5.62	-4.15	17.00	12.02	54.20	50.94	117.15	7.65	
8/16/02		Y	6.00	8.90	17.05	18.67	51.33	51.41	121.40	69.35	
11/17/02		Y	5.52	6.32	18.16	10.35	56.04	51.01	117.41	45.60	
3/18/03		Y	5.71	11.66	18.75	23.35	52.28	53.99	129.62	74.30	
5/19/03		Y	5.95	6.74	16.56	27.90	37.56	48.63	114.10	63.15	
8/15/03	Y		6.24	18.3293	16.23	18.97	25.35	55.49	99.81	67.71	0.014
11/13/03		Y	5.44	5.79	16.68	24.48	38.22	50.74	113.44	68.76	0.077

Table B-1 (cont'd) GSMNP Monitoring Data

	Upper Rock Creek						**35.746158 N**				
	Site #137						**83.216301 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/24/93			6.06	12.35	14.90	19.39	25.19	55.64	100.21		
2/20/94			5.76	7.83	15.75	10.02	34.73	44.54	89.29		
3/19/94			5.91	9.00	12.77	14.49	31.37	44.63	90.48		
3/19/94			6.05	11.61	14.02	16.93	31.65	49.90	98.48		
5/22/94			5.91	11.84	13.47	12.41	28.40	49.43	90.23		
5/22/94			5.91	11.84	13.47	11.84	26.90	49.51	88.25		
8/15/94		Y	6.22	19.04	14.41	12.33	27.67	56.19	96.19		
8/15/94			5.82	3.06	12.42	10.63	21.41	52.43	84.47		
2/25/95			5.83	12.42	14.25				0.00		
3/26/95			5.92	11.37	15.20	10.94	38.24	49.55	98.72		
4/15/95			5.90	10.98	15.95	13.50	51.74	70.68	135.91		
5/12/95		Y	5.75	10.93	17.67	14.49	59.31	83.00	156.80		
7/21/95			5.91	10.70	13.89	13.34	37.92	58.29	109.55		
8/15/95			6.20	21.45	17.17	14.44	29.94	56.60	100.98		
10/13/95	Y		5.92	16.11	17.95	19.85	29.02	51.77	100.63		
12/17/95		Y	5.72	18.96	16.37	17.09	54.55	56.01	127.65		
2/27/96		Y	5.67	19.42	16.22	13.67	50.08	55.54	119.29		
5/19/96			5.84	18.77	17.24	12.20	36.66	48.85	97.71		
8/19/96	Y		6.41	10.36	10.38	10.21	30.88	45.74	86.83		
10/24/96		Y	6.12	14.60	12.56	20.99	15.85	72.12	108.96		
10/24/96		Y	6.11	14.60	12.43	12.88	10.97	54.28	78.13		
3/16/97			5.55	4.67	15.79	10.46	42.93	50.18	103.57		
5/15/97			5.91	12.40	14.73	10.04	32.09	45.31	87.44		
8/16/97			5.83	12.85	15.55	11.49	34.40	46.39	92.28		
10/15/97		Y	5.96	14.05	16.17	60.52	32.62	44.63	137.77		
3/13/98			5.79	7.24	16.38	13.05	41.02	47.76	101.83		
5/15/98	Y		5.64	9.17	13.80	15.11	28.68	48.04	91.84		
8/17/98	Y		5.44	13.31	14.00	15.82	29.78	52.59	98.20		
10/15/98			5.77	17.14	13.80	18.13	28.27	48.26	94.65		
3/21/99	Y		5.83	8.02	18.20	20.01	36.12	50.67	106.80		
5/15/99		Y	5.71	8.42	14.60	15.93		51.50	67.43		
8/15/99			5.86	12.05	10.00	15.60	29.60	52.86	98.06		
10/15/99			5.98	0.90	20.30	15.87	33.75	53.82	103.44		
3/15/00			5.75	1.10	17.40	15.32	55.61	53.75	124.67		
5/15/00			5.32	0.70	15.80	13.19	45.25	55.22	113.65	72.55	
8/15/00			5.86	4.79	12.77	13.27	27.25	57.98	98.50	57.10	
11/15/00			5.84	9.11	15.86	20.93	35.11	53.30	109.34	57.60	
3/15/01		Y	5.93	11.76	14.25	20.43	31.25	47.44	99.12	54.10	
5/15/01			5.78	8.70	14.45	22.03	31.16	52.07	105.26	50.00	
8/15/01			5.96	13.16	11.09	12.22	22.47	45.96	80.65	48.55	
11/12/01			5.97	17.88	14.1	13.58	22.22	45.94	81.73	44.7	

Table B-1 (cont'd) GSMNP Monitoring Data

	Upper Rock Creek (cont'd)						**35.746158 N**				
	Site #137						**83.216301 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
3/25/02			6.07	33.00	18.10	35.46	32.70	43.17	111.34	53.05	
5/20/02			5.86	5.57	13.70	9.64	31.25	49.04	89.93	62.15	
8/16/02		Y	6.12	22.96	15.17	15.80	25.82	52.38	94.00	53.50	
11/18/02	Y		6.00	14.80	12.70	15.17	24.72	40.59	80.48	26.95	
3/18/03		Y	6.14	15.56	14.49	13.60	24.35	45.88	83.83	51.05	
5/20/03		Y	5.61	-1.88	11.99	13.61	24.74	32.75	71.10	39.40	
8/15/03	Y		6.52	47.94	15.78	17.79	23.89	44.93	86.61	60.78	0.000
11/13/03		Y	5.63	10.02	16.72	29.39	24.45	51.33	105.17	63.37	0.099
3/20/04		Y	5.29	4.79	13.48	10.87	30.13	48.11	89.11	61.08	0.097
5/15/04			5.65	18.48	14.79	38.83	37.83	35.40	112.06	61.55	0.043
7/19/04		Y	5.52	9.42	13.35	37.99	34.19	30.18	102.36	55.66	0.057
9/25/04			5.76	12.66	12.68	7.91	17.03	49.05	74.00	43.73	0.037
11/20/04			5.79	19.13	14.21	8.81	24.52	48.96	82.28	49.20	0.000
1/20/05			5.71	25.23	13.79	12.03	27.49	46.70	86.22	49.14	0.028
3/19/05			6.03	22.86	14.18	4.48	26.73	48.21	79.42	50.36	0.096
5/21/05		Y	5.81	24.00	15.61	2.42	31.25	53.21	86.88	53.16	0.047
7/16/05	Y		5.93	33.97	14.29	8.52	27.03	50.63	86.18	50.04	0.106
9/17/05		Y		*	*	10.56	30.79	52.34	93.69	0.00	0.023
11/21/05	Y		6.02	13.80	19.00	12.98	58.88	53.75	125.61	66.25	0.000
1/21/06	Y		5.75	4.91	15.39	14.45	36.58	46.33	97.36	54.03	0.050
3/18/06			5.92	5.66	15.68	11.87	37.58	49.10	98.55	57.86	0.072
5/20/06	Y		5.39	2.40	17.63	12.19	42.45	65.97	120.60	72.69	0.184
7/15/06	Y		6.00	9.34	13.82	9.77	24.92	45.84	80.53	46.63	0.043
9/16/06			5.88	4.62	13.98	9.06	27.93	56.07	93.06	49.03	0.070
11/20/06			5.50	2.33	14.93	13.21	33.66	53.18	100.05	52.79	0.042
1/20/07			5.46	0.75	14.85	14.91	41.96	50.37	107.24	54.56	0.031
3/17/07		Y	5.26	-0.09	17.21	10.64	56.46	56.13	123.23	63.94	0.032
5/20/07			5.95	4.42	15.81	10.01	39.06	53.21	102.28	51.27	0.037
7/21/07			5.84	0.31	15.93	8.55	35.13	54.49	98.18	61.80	0.079
9/15/07		Y	6.00	10.14	14.37	11.08	37.48	54.26	102.82	51.48	0.046
11/17/07			6.06	11.11	16.96	17.61	38.91	56.27	112.79	56.30	0.049

Table B-1 (cont'd) GSMNP Monitoring Data

	Inadu Creek						**35.742499 N**				
	Site #138						**83.226991 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/24/93			5.82	7.23	12.97	19.89	25.91	37.58	83.38		
2/20/94			5.43	-1.09	14.36	18.63	61.58	63.59	143.79		
3/19/94			5.51	-0.98	11.68	12.92	36.81	35.38	85.11		
5/15/94	Y		5.55	2.44	12.85	11.99	31.80	35.94	79.73		
8/15/94		Y	5.45	-1.24	10.94	10.84	25.89	39.79	76.52		
10/15/94		Y	5.59	6.67	13.66	21.87	23.23	38.34	83.44		
2/25/95			5.42	7.94	15.48						
3/15/95			5.64	3.41	13.10	11.38	37.86	37.51	86.75		
4/15/95			5.49	3.02	14.32	21.95	58.02	47.73	127.69		
5/12/95		Y	5.52	6.10	14.83	14.35	56.63	54.61	125.59		
7/21/95			5.57	-0.77	13.33	12.57	34.98	41.99	89.54		
8/23/95			5.70	10.00	13.79	13.92	30.79	40.19	84.89		
10/13/95	Y		5.80	7.81	14.45	15.12	27.64	39.27	82.03		
2/27/96		Y	5.49	23.12	16.66	31.01	54.05	40.77	125.82		
5/15/96	Y		5.45	7.82	15.79	13.62	40.17	35.90	89.69		
8/15/96			5.38	0.39	13.65	11.92	36.99	36.21	85.12		
10/24/96		Y	5.85	13.52	11.77	15.71	24.89	38.92	79.52		
3/16/97			5.31	-2.98	13.89	10.08	42.69	36.71	89.48		
5/18/97			5.29	2.70	13.82	11.44	37.87	34.42	83.74		
8/15/97			5.34	0.92	14.49	12.17	38.63	35.78	86.58		
10/17/97		Y	5.77	9.17	12.76	39.82	34.47	33.03	107.32		
3/13/98			5.35	-2.11	14.58	9.89	43.07	34.43	87.39		
5/15/98	Y		5.42	4.33	13.60	20.97	35.38	36.17	92.52		
8/17/98	Y		5.52	4.47	12.60	17.51	33.50	39.36	90.37		
10/15/98			5.27	3.00	13.80	23.86	34.81	39.81	98.47		
3/21/99	Y		5.69	-1.13	15.40	14.59	36.84	37.35	88.78		
5/15/99			5.42	1.47	12.60	18.17	29.77	36.78	84.72		
8/15/99			5.69	-27.77	15.23	18.21	36.51	44.09	98.81		
10/15/99			5.89	0.20	17.50	15.89	30.84	36.94	83.67		
3/15/00			5.54	0.76	15.70	15.19	52.56	42.12	109.87		
5/15/00			5.37	2.40	14.60	11.74	41.06	44.37	97.17	65.35	
8/15/00			5.79	3.39	11.30	20.23	20.28	26.42	66.93	40.00	
11/15/00			5.57	2.60	13.42	23.59	38.63	38.03	100.25	51.05	
3/15/01		Y	5.80	6.01	11.35	20.14	29.46	33.30	82.91	42.60	
5/15/01			5.73	5.52	12.96	16.43	33.47	33.51	83.41	45.40	
8/15/01			5.49	-1.34	11.85	14.02	29.29	36.38	79.69	39.60	
11/12/01			5.91	13.28	12.4	21.23	28.46	33.28	82.96	37.15	
3/25/02			5.62	2.62	14.70	18.28	38.68	33.42	90.38	45.45	
5/20/02			5.59	-0.84	11.30	11.99	32.66	33.24	77.89	50.00	
8/16/02		Y	5.73	9.16	13.65	20.26	31.33	40.46	92.05	42.40	
11/18/02	Y		6.04	26.96	15.40	12.20	24.13	49.20	85.53	33.75	
3/18/03		Y	5.94	8.96	12.54	14.94	27.37	32.03	74.33	39.30	
5/19/03		Y	6.14	14.54	13.82	19.55	17.72	62.47	99.73	47.65	
8/15/03	Y		6.52	37.88	15.92	15.47	22.76	45.60	83.84	70.41	0.073
11/13/03		Y	5.17	3.27	13.76	22.47	31.27	37.31	91.05	60.93	0.101

Table B-1 (cont'd) GSMNP Monitoring Data

	Goshen Prong						**35.598569 N**				
	Site #213						**83.567503 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/15/93			6.49	48.53	11.35	14.28	0.00	25.53	39.81		
2/15/94			6.09	14.12	13.48	16.65	34.03	34.16	84.84		
5/15/94	Y		6.22	21.43	10.26	13.06	21.54	25.70	60.30		
8/15/94			6.11	16.01	9.37	12.25	18.13	29.14	59.53		
1/15/95	Y		6.22	25.15	10.81	13.41	23.79	25.95	63.14		
2/18/95		Y	5.82	13.99	9.87	10.83	28.25	32.16	71.24		
3/15/95			6.31	24.21	10.25	11.55	23.68	26.96	62.18		
4/8/95			6.30	22.31	10.84	12.62	25.02	27.43	65.07		
5/21/95			6.08	19.94	12.04	14.83	30.65	43.57	89.05		
6/18/95			6.10	18.30	18.30	12.50	24.16	31.39	68.04		
7/16/95			6.33	33.69	13.42	16.33	19.99	27.72	64.04		
8/15/95			6.19	25.42	11.98	11.28	18.80	30.67	60.74		
9/9/95			6.40	28.72	11.82	10.43	17.65	29.35	57.43		
10/21/95		Y	6.18	33.17	11.80	12.09	11.17	29.48	52.74		
12/17/95			6.09	23.19	11.36	12.83	26.79	30.20	69.82		
5/19/96			6.15	16.59	12.81	11.03	24.51	29.12	64.67		
8/18/96		Y	6.21	18.85	12.19	12.13	20.14	30.08	62.35		
10/20/96			6.26	31.67	10.68	12.89	9.57	29.49	51.94		
3/15/97		Y	5.90	5.20	12.33	12.69	32.71	35.47	80.88		
5/15/97			6.18	24.10	10.15	12.87	19.85	30.41	63.13		
8/16/97			6.17	27.78	11.58	11.66	18.23	27.41	57.31		
10/19/97	Y		5.88	32.20	11.61	21.46	7.84	32.99	62.29		
3/22/98		Y	5.87	9.00	11.19	34.68	27.56	31.36	93.60		
5/17/98			5.82	15.49	10.30	13.19	21.19	28.88	63.26		
8/16/98	Y		5.71	28.42	11.00						
10/18/98			5.93	33.88	10.20	13.77	6.98	30.42	51.17		
3/21/99	Y		5.76	8.69	11.54	19.89	25.87	31.27	77.03		
5/15/99		Y	6.08	17.77	10.30	15.08	16.57	28.62	60.26		
8/21/99		Y	6.17	21.36	9.77	14.86	20.32	28.49	63.67		
10/16/99			6.17	17.50	16.10	19.14	13.84	32.40	65.38		
3/19/00			5.71	10.19	12.50	19.10	30.50	30.33	79.94		
8/19/00		Y	6.10	21.63	9.96	19.01	19.22	29.82	68.06	34.95	
11/19/00		Y	6.11	19.71	11.17	14.24	22.32	28.72	65.28	37.55	
3/25/01			6.05	12.76	9.56	15.69	21.87	27.06	64.61	34.80	
5/20/01		Y	6.16	12.46	10.95	17.12	19.58	28.45	65.15	37.40	
8/19/01	Y		6.16	20.65	10.25	15.33	17.50	28.66	61.49	30.15	
11/18/01			6.04	24.97	10.7	22.28	18.37	26.78	67.43	32.95	
3/24/02			5.79	-8.73	11.10	11.81	21.33	26.92	60.06	31.95	
5/19/02			6.11	1.71	10.80	15.69	34.63	31.10	81.42		
8/17/02	Y		6.37	27.80	11.59	21.85	16.19	29.91	67.95	35.55	
11/17/02		Y	6.02	7.68	11.91	18.29	24.04	28.35	70.68	30.55	
3/16/03	Y		5.98	13.59	10.55	13.12	26.25	54.17	93.54	31.55	
5/18/03			6.28	15.35	10.82	19.98	18.34	25.03	63.35	29.80	
8/17/03		Y	6.30	53.91	11.24	23.61	15.41	25.93	64.95	44.64	0.016
11/16/03		Y	5.92	25.47	12.52	17.22	23.49	30.32	71.03	54.84	0.067

Table B-1 (cont'd) GSMNP Monitoring Data

	ut to Fish Camp Prong						35.564523 N				
	Site #218						83.568445 W				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
3/15/94			5.25	-0.72	16.50	14.80	46.14	50.73	111.67		
5/15/94	Y		5.74	8.76	12.91	10.79	24.69	45.23	80.71		
8/15/94			5.30	1.99	13.86	10.53	60.32	25.11	95.96		
3/20/95			5.14	2.33	16.40	13.42	46.12	71.87	131.41		
3/20/95			5.13	4.92	17.08	18.01	50.64	63.63	132.28		
4/7/95			6.20	22.84	22.90	19.94	45.98	58.05	123.97		
4/7/95			5.90	9.56	25.20	15.89	45.96	60.52	122.37		
5/14/95	Y		4.94	-3.95	22.20	13.08	49.28	62.67	125.03		
7/15/95			5.38	20.19	24.20	24.35	46.07	66.10	136.52		
8/15/95			5.11	26.67	26.50	26.80	43.52	64.21	134.53		
8/15/95			5.13	26.18	28.10	34.73	44.46	64.12	143.31		
9/15/95			5.27	20.30	22.60	12.55	48.73	72.20	133.48		
9/15/95			5.23	18.41	23.80	21.54	48.45	71.97	141.96		
10/15/95	Y		5.05	7.51	28.80	56.80	46.66	54.57	158.03		
10/15/95	Y		4.95	0.58	23.90	17.68	47.58	56.03	121.29		
12/15/95			5.02	9.68	20.10	20.50	44.09	57.31	121.90		
3/15/96			4.98	-0.95	20.50	13.33	46.30	57.80	117.43		
5/15/96	Y		4.97	2.56	22.70	14.71	45.61	54.14	114.46		
10/15/96			4.24	-4.72	23.80	12.27	96.81	60.17	169.25		
10/15/96			6.28	44.44	28.90	13.37	95.70	59.70	168.77		
3/15/97		Y	4.91	2.05	24.70	26.10	48.14	55.04	129.28		
3/15/97		Y	4.91	2.13	20.20	13.20	46.17	51.81	111.18		
5/20/97		Y	5.01	19.27	24.10	28.96	46.60	54.36	129.92		
8/4/97	Y		4.91	-6.94	25.20	11.63	80.29	72.57	164.49		
8/4/97	Y		4.90	-2.68	25.40	7.34	84.41	69.95	161.70		
10/22/97		Y	5.30	22.05	25.30	44.96	75.69	71.84	192.49		
10/22/97		Y	5.18	28.57	25.00	45.51	75.22	70.98	191.71		
4/7/98			4.79	-2.14	21.40	15.54	56.68	51.34	123.56		
4/7/98			4.77	-6.09	23.10	15.00	56.23	51.25	122.48		
5/18/98			4.96	-1.14	18.40	13.71	56.55	51.46	121.72		
5/18/98			4.97	-2.35	19.20	17.72	56.44	51.34	125.50		
8/17/98	Y		4.96	8.66	25.30	14.72	69.84	68.09	152.65		
8/17/98	Y		4.97	10.85	22.70	17.09	71.13	67.52	155.74		
10/15/98			5.23	22.66	20.10	16.11	28.38	74.21	118.70		
3/22/99			4.95	-1.40	20.00	16.39	37.20	58.57	112.16		
5/15/99		Y	5.18	15.53	20.20	22.35	45.06	60.86	128.27		
8/15/99			5.31	10.30	14.80	15.02	71.59	68.77	155.38		
10/15/99			5.35	-4.57	20.40	22.49	34.40	54.48	111.37		
3/15/00			5.02	-7.53	19.80	17.58	74.03	44.40	136.01		
5/15/00			4.86	-6.16	16.70	14.56	65.08	46.54	126.18	43.95	
8/15/00			5.25	18.80	19.80	23.37	59.40	63.02	145.79	66.70	
11/15/00			5.06	-1.53	18.18	22.54	65.63	46.50	134.67	43.05	

Table B-1 (cont'd) GSMNP Monitoring Data

	ut to Fish Camp Prong (cont'd)						35.564523 N				
	Site #218						83.568445 W				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
3/15/01		Y	4.85	-0.58	19.67	25.85	78.18	44.78	148.81	43.80	
5/15/01			4.86	-0.05	19.49	17.67	86.15	33.93	137.75	43.80	
8/15/01			4.86	4.38	20.60	29.14	60.43	52.01	141.58	29.55	
11/16/01			5.39	-34.65	20.20	36.98	51.02	46.84	134.84	42.20	
3/26/02			5.14	-17.42	21.60	27.44	65.23	42.06	134.73	42.45	
5/21/02			5.42	-10.98	14.60	22.85	69.16	36.47	128.48	46.60	
8/20/02	Y		5.45	-7.18	24.20	18.11	83.00	56.49	157.60	76.55	
11/15/02	Y		5.00	7.20	27.10	24.15	82.96	44.10	151.21	34.00	
3/17/03			5.09	0.84	24.70	21.44	81.10	46.82	149.36	49.35	
5/21/03	Y		4.96	-3.99	21.80	20.39	52.91	50.45	123.75	35.85	

Table B-1 (cont'd) GSMNP Monitoring Data

	Upper Road Prong						**35.609752 N**				
	Site #234						**83.450428 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
10/15/93			6.28	26.82	16.84	21.77	59.72	17.99	99.47		
2/15/94			5.91	6.49	16.16	19.85	66.26	20.91	107.01		
3/15/94			5.93	20.60	16.08	13.43	68.98	22.00	104.41		
5/15/94	Y		5.88	15.92	15.40	17.06	62.53	16.72	96.31		
8/15/94			5.26	5.83	14.29	15.51	49.35	29.39	94.25		
3/22/95		Y	6.18	16.88	14.81	18.01	60.12	27.21	105.34		
4/8/95			6.03	12.25	15.44	18.00	64.42	28.93	111.35		
6/17/95		Y	6.16	14.99	14.99	16.79	61.91	25.84	104.54		
7/18/95			6.20	22.60	15.40	15.54	50.69	22.77	89.01		
8/15/95			5.81	18.29	16.80	13.49	54.66	28.63	96.79		
9/10/95			5.84	21.60	16.47	14.26	57.16	29.00	100.41		
10/17/95			5.96	19.97	16.97	13.65	57.55	28.54	99.73		
3/16/96	Y		5.81	15.77	15.43	14.24	59.66	28.16	102.06		
5/15/96	Y		5.88	18.62	17.45	15.97	62.00	27.98	105.95		
8/20/96			5.80	17.40	17.53	17.67	64.87	29.58	112.13		
10/15/96			6.48	56.68	16.14	12.09	20.69	51.33	84.10		
3/15/97		Y	5.61	11.86	15.97	13.23	57.52	27.23	97.98		
5/15/97			5.90	15.80	16.75	12.54	56.81	26.24	95.59		
10/15/97		Y	5.75	76.08	17.00	27.97	66.09	32.00	126.07		
3/15/98			5.73	13.39	15.60	42.63	61.39	28.47	132.42		
5/18/98			5.42	18.22	16.20	20.58	54.68	27.07	102.34		
10/15/98			5.68	19.67	15.40	21.88	56.08	27.68	105.65		
3/15/99		Y	5.59	13.79	16.40	18.39	56.67	26.61	101.67		
5/15/99		Y	5.91	15.69	15.80				0.00		
8/15/99			5.86	13.36	9.90				0.00		
5/15/00			5.86	11.83	13.70	16.91	54.65	26.41	97.98	48.70	
11/15/00			6.11	17.95	13.64	16.93	52.76	28.18	97.87	49.35	
3/15/01		Y	5.85	11.69	14.14	22.85	55.99	28.19	107.03	51.50	
5/15/01			6.19	21.72	10.00	13.07	27.07	17.48	57.61	34.95	
8/15/01			5.95	19.51	13.53	15.44	52.14	27.54	95.12	49.05	
11/14/01			5.95	27.23	14.1	16.62	45.57	20.17	82.36	46.70	
3/28/02	Y		5.91	8.85	16.40	23.73	53.81	27.60	105.14	53.55	
11/17/02		Y	5.68	3.30	14.11	9.05	42.79	31.28	83.11	37.65	
5/21/03	Y		6.12	14.19	15.73	24.54	55.11	23.70	103.35	50.45	
11/11/03			5.62	15.48	16.63	25.50	54.79	25.26	105.56	64.02	0.058
3/20/04		Y	5.68	13.48	15.50	13.92	56.80	26.19	96.91	55.52	0.046
5/16/04			5.65	20.14	15.56	47.39	41.76	38.88	128.03	66.88	0.035
7/17/04	Y		5.65	18.66	15.54	41.60	55.08	18.32	115.01	70.06	0.005
9/25/04			5.47	15.26	16.22	8.39	53.91	26.39	88.69	62.27	0.000
11/20/04			5.36	19.55	16.31	4.11	52.66	29.13	85.91	60.78	0.009

Table B-1 (cont'd) GSMNP Monitoring Data

	Upper Road Prong (cont'd)						**35.609752 N**				
	Site #234						**83.450428 W**				
Sample Date	Rainfall Event		pH	ANC	Conductivity	Chloride	Nitrate	Sulfate	Total Anions	Calcium	Aluminum
	Definite	Possible	--	µeq/L	uS/cm	µeq/L	µeq/L	µeq/L	µeq/L	µeq/L	mg/L
1/24/05			5.68	21.32	15.98	15.84	52.65	29.68	98.18	52.70	0.024
3/19/05			5.81	18.29	16.49	11.86	49.68	29.59	91.13	55.50	0.044
5/21/05		Y	6.10	35.98	15.74	6.08	53.37	30.11	89.56	52.94	0.035
7/16/05	Y		5.72	43.11	15.99	13.03	56.73	30.37	100.13	64.76	0.033
9/17/05		Y				12.63	57.56	31.87	102.07	57.67	0.021
11/19/05			6.19	22.20	16.76	13.01	57.85	32.03	102.89	52.98	0.059
1/21/06	Y		5.59	13.39	17.88	11.25	61.70	33.47	106.42	55.70	0.048
5/21/06		Y	6.01	10.17	16.71	11.95	64.53	26.72	103.19	50.86	0.000
7/23/06		Y	5.55	9.82	15.79	12.48	62.64	29.93	105.05	108.22	0.109
9/16/06			5.72	12.18	17.00	12.84	63.70	30.24	106.78	55.79	0.034
11/20/06			5.12	2.42	16.10	12.09	67.79	25.67	105.55	53.94	0.000
1/20/07			5.50	3.26	16.22	12.51	72.25	27.75	112.51	54.89	0.000
5/19/07			6.15	9.21	17.21	13.82	70.77	28.72	113.30	59.43	0.000
7/21/07			6.24	22.12	16.50	12.45	65.37	29.52	107.34	62.39	0.027
9/15/07		Y	6.11	17.17	14.81	12.67	61.51	30.44	104.62	49.61	0.000
11/17/07			6.15	13.98	16.53	13.75	60.18	32.19	106.11	54.26	0.000

Table B-1 (cont'd) GSMNP Monitoring Data

Eagles Rock Prong				
Sample Date	Rainfall Event		pH	ANC
	Definite	Possible	--	µeq/L
3/8/06			5.57	-2.05
3/22/06		Y	5.19	-2.47
4/23/06			5.30	-4.71
5/31/06	Y		5.70	-6.56
6/20/06	Y		5.70	5.44
6/27/06			5.20	-3.67
8/4/06		Y	4.93	-3.34
9/8/06			5.29	0.14
9/30/06			5.36	0.17
11/14/06			4.93	-2.70
12/1/06		Y	4.43	-8.10
1/2/07			4.65	-17.33
2/2/07		Y	5.07	-1.09
2/28/07			4.97	-2.38
3/3/07			4.57	-9.36
3/14/07			5.07	-0.40
3/23/07			5.05	-3.93
4/13/07		Y	4.80	-5.11
4/25/07			4.96	-4.24
4/29/07			5.49	-1.53
5/30/07			5.78	5.15
6/15/07	Y		5.77	4.92
7/3/07			5.63	-0.55
7/31/07	Y		5.49	0.30
8/28/07	Y		5.79	1.95
9/14/07	Y		5.95	7.30
10/14/07			5.92	9.22
10/23/07	Y		6.07	7.12
11/4/07			5.92	7.17
1/15/08			5.58	3.12
2/14/08			5.43	2.58

APPENDIX C

Determination of Target ANC

Since there is no numerical criterion for acid neutralization capacity (ANC), several methods were explored in an effort to develop a target ANC.

When adequate monitoring data were available at a given location, the values for pH and ANC were plotted and a regression analysis was performed. (See Figures C-1 through C-12.) The equation for the best-fit line was obtained and used to determine the ANC value at which pH 6.0 would occur. The ANC values obtained using this method are summarized in Table C-1. These values will be considered site-specific target ANC values and will be used to determine the site-specific TMDL. In cases where multiple sampling locations exist on a given waterbody, the location with the highest (most conservative) value for ANC will be used as the site-specific target because it will be the most protective.

Table C-1. Site-Specific Target ANC Values Based on Regression Analysis

Monitoring Site	Site Description	Target ANC (μeq/L)
4	Lower Rock Creek	35.158
137	Upper Rock Creek	14.938
138	Inadu Creek	10.376
103	Otter Creek	10.121
104	Copperhead Branch	25.304
45	Shutts Prong	14.732
47	Lower Cannon Creek	18.65
71	Lower Road Prong	25.056
234	Upper Road Prong	20.301
213	Goshen Prong	17.824
218	UT to Fish Camp Prong	19.581
	Eagles Rock Prong	6.201

For impaired waterbodies with no monitoring data, a different method was required to determine the target ANC concentration. Therefore, a literature search was conducted in an effort to develop a target ANC.

According to Dupont (2002), “It is known that zero ANC is roughly equivalent to a pH of 5.0 units, while 40 μeq/L ANC corresponds approximately to a pH of 6.0, which is recognized in scientific literature as the threshold above which no or very little damage occurs due to acidity. A value of pH 5.0 is generally recognized as the pH under which a lake is highly acidic and where damage to fish populations are the highest.”

In a report for the Shenandoah National Park (SNP) (Sullivan, 2006), "Almost half of the sampled (mostly first order) streams on siliciclastic bedrock in the 1992 survey of small subwatersheds in SNP had ANC in the chronically acidic range (<0 μeq/L) in which lethal effects on brook trout are probable (Galloway et al., 1999). The balance of the small streams on siliciclastic bedrock had ANC in the episodically acidic range (having chronic ANC between 0 and 20 μeq/L) in which sub-lethal or lethal effects in brook trout are possible."

According to research by Lien (1996), "the critical level of ANC varied among fish species, with Atlantic salmon being the most sensitive, followed by brown trout, char, roach, minnow, and pike. Experimental data suggest that rainbow trout may be even more sensitive to acidic water than brown trout and salmon." "An ANC limit = 0 has often been used to estimate critical loading of sulphur and nitrogen to aquatic environments. However, this limit does not protect all of the species from impact. At ANC = 20 μeq/L, damage was reported as <= 10% for all of the species except pike. At ANC = 50 μeq/L, there was no recorded damage to invertebrates and only slight or no declines in fish populations." Other factors, including TOC, inorganic aluminum, and calcium, can also influence the health of fish populations.

The State of Vermont has published a TMDL for 30 Acid Impaired Lakes. In that TMDL, an ANC value of 2.5 mg/L $CaCO_3$ was used as a cutoff in determining impairment. "This value has been used historically based on literature information describing minimal impacts on fish and macroinvertebrate communities at this level of acidic buffering and is considered by VTDEC to be an adequate measure of potential acid stress on aquatic organisms in Vermont's lake systems." (VTDEC, 2003) The Vermont TMDL was approved by EPA Region 1 in September 2003.

The 2.5 mg/L $CaCO_3$ used by the State of Vermont is equivalent to the 50 μeq/L $CaCO_3$ suggested in literature. To convert from mg/L to μeq/L, divide by the equivalent weight (molecular weight divided by valence):

$$\frac{2.5\ \text{mg}}{\text{L}} \times \left[\frac{\text{mmol}}{100\ \text{mg}} \times 2\ (\text{valence})\right] \times \frac{1000\ \mu\text{mol}}{\text{mmol}} = \frac{50\ \mu\text{eq}}{\text{L}}$$

Therefore, based on published literature values, a default target ANC of 50 μeq/L as $CaCO_3$ was selected. This value should provide a pH within the criteria of 6.0 to 9.0 standard pH units for waterbodies with a designated use of Fish & Aquatic Life. This default value will be used to determine the TMDL whenever site-specific values are not availab.e

For this TMDL, the Steady State Water Chemistry model (SSWC) was also utilized to calculate maximum acidity loading and the maintenance of a protective 50 μeq/L $CaCO_3$ ANC. The underlying concept of the SSWC model is that excess base cations in a catchment should be equal to or greater than the acid anion imputs. This balance maintains the lake's ANC to support aquatic communities. The SSWC model has been used widely for critical load determinations across sections of the world where acid deposition is problematic, namely northern Europe and Canada. It has also been used in the northeastern portion of the United States. For a more detailed description of the SSWC model, refer to Appendix A of the Vermont TMDL for 30 Acid Impaired Lakes, available at the following website:

http://www.anr.state.vt.us/dec/waterq/planning/docs/pl_acidtmdl.pdf

Results obtained using the SSWC model are summarized in Table C-2 and included in Tables C-3 thru C-13. Note that total cation concentration is an important factor in determining the ANC limit. Accurate calcium and magnesium measurements were not available prior to 2000. Therefore, SSWC calculations only include monitoring data from 2000 to the present.

The SSWC model, by its nature, is most applicable to lakes. There is some uncertainty when applying a "steady-state" model to a free-flowing waterbody, such as the impaired streams covered in this TMDL. The results of the SSWC model have been used to validate the reasonableness of ANC target values determined using regression analysis. Therefore, the site-specific ANC target values determined using regression analysis will be used when determining TMDLs.

Table C-2. Site-Specific ANC Limits Based on SSWC Model

Monitoring Site	Site Description	Target ANC (μeq/L)
4	Lower Rock Creek	17.458
137	Upper Rock Creek	16.012
138	Inadu Creek	14.747
103	Otter Creek	17.286
104	Copperhead Branch	17.574
45	Shutts Prong	16.809
47	Lower Cannon Creek	13.374
71	Lower Road Prong	19.058
234	Upper Road Prong	18.261
213	Goshen Prong	12.563
218	UT to Fish Camp Prong	15.888
	Average of all sites	16.275

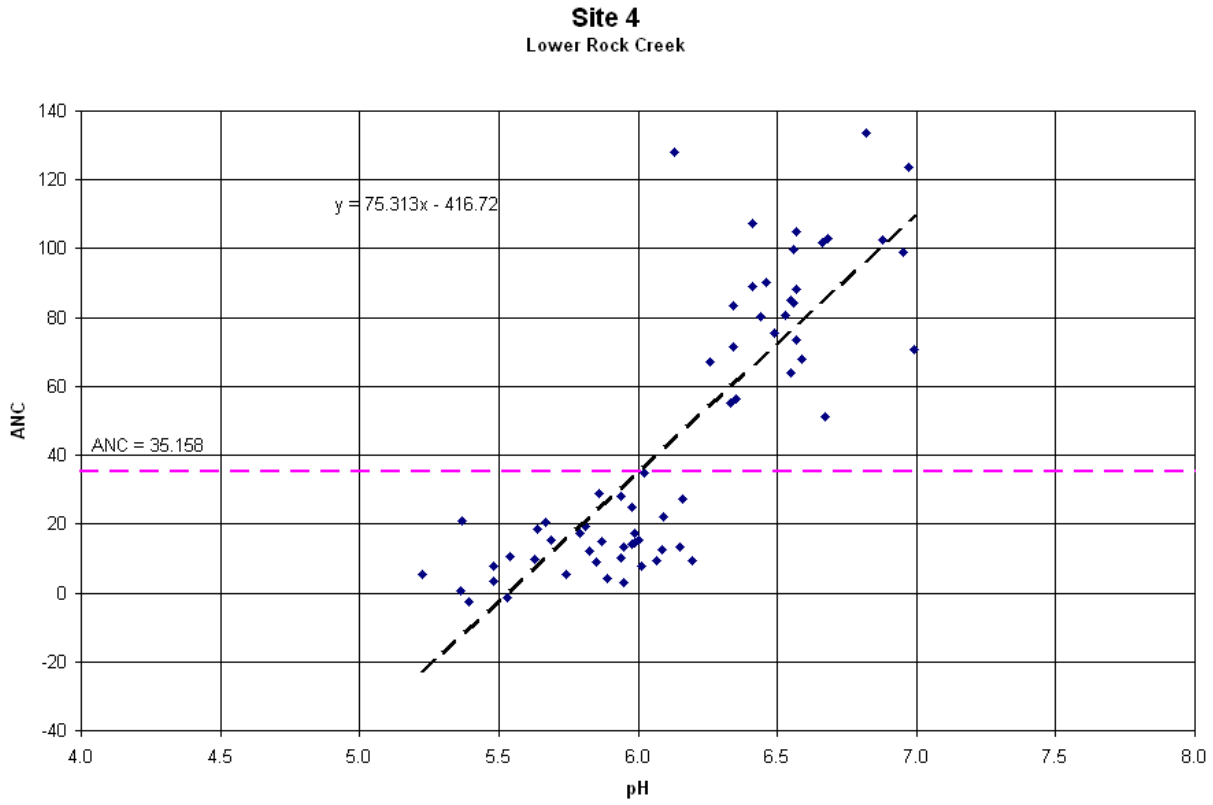


Figure C-1 pH vs ANC for Lower Rock Creek

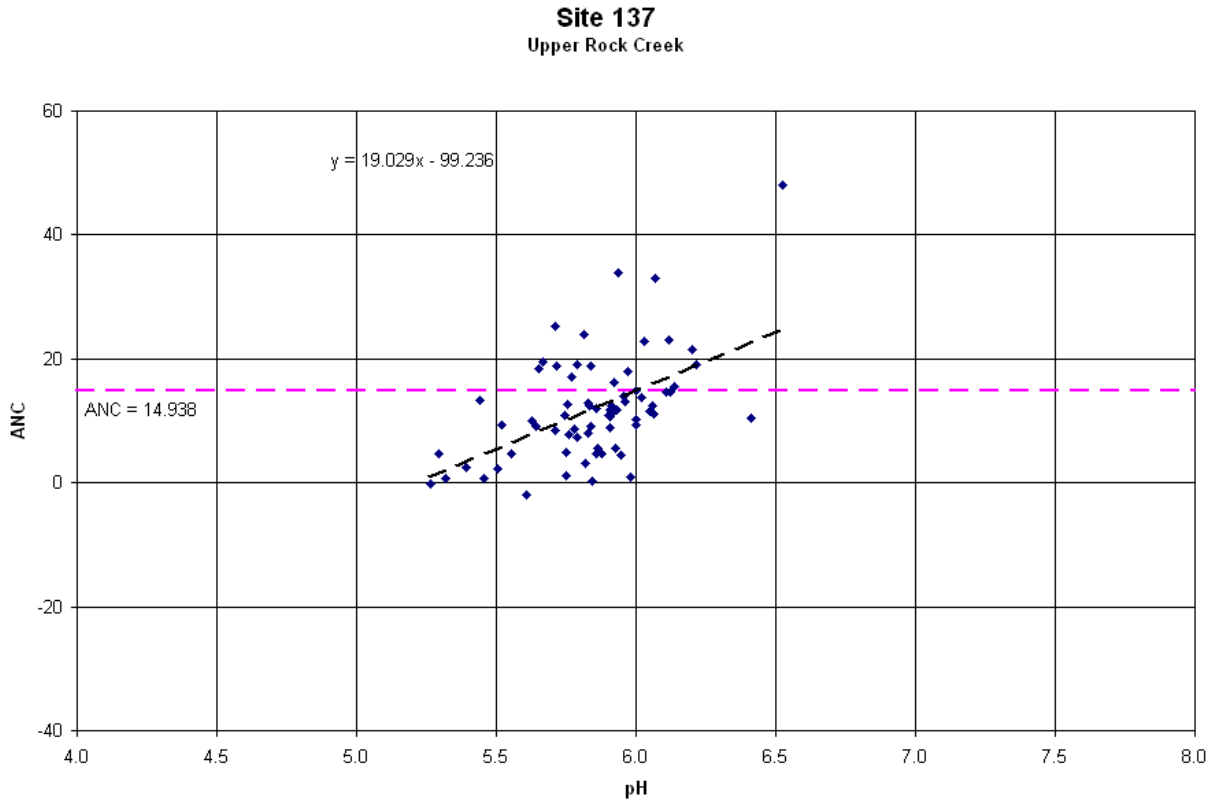


Figure C-2 pH vs ANC for Upper Rock Creek

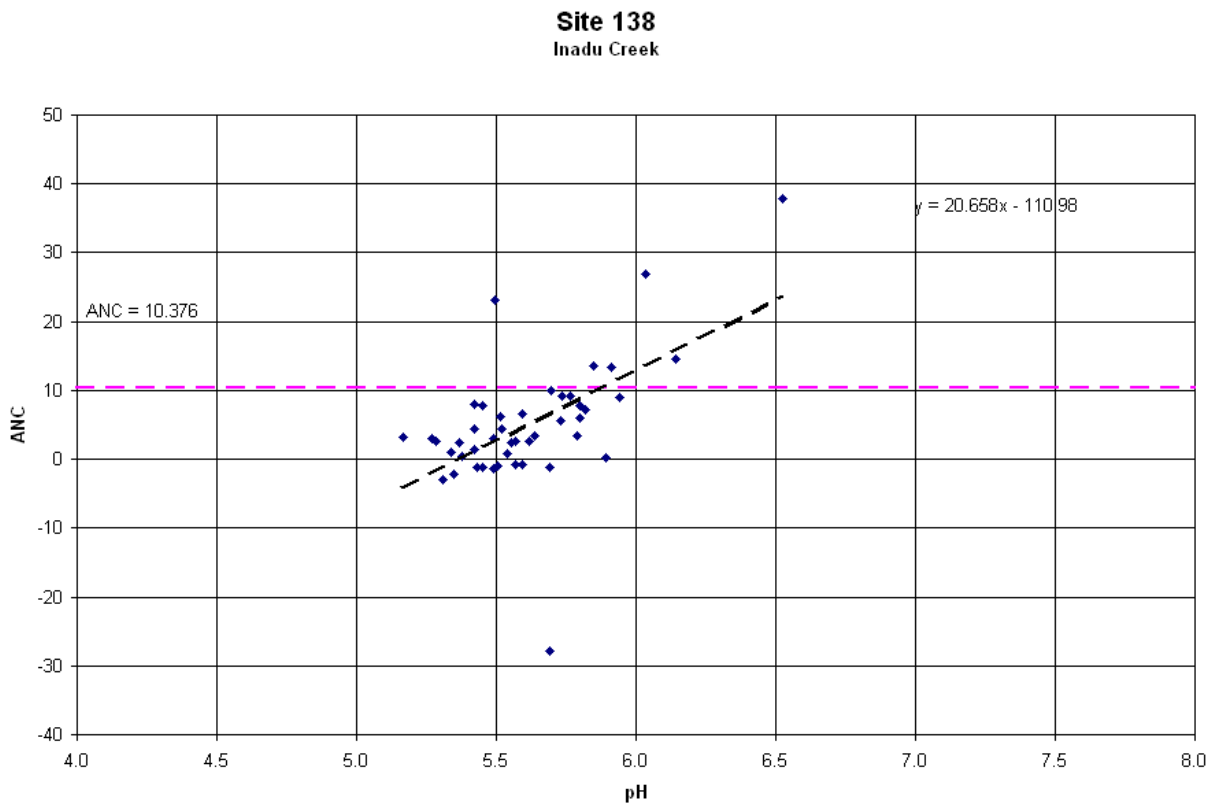


Figure C-3 pH vs ANC for Inadu Creek

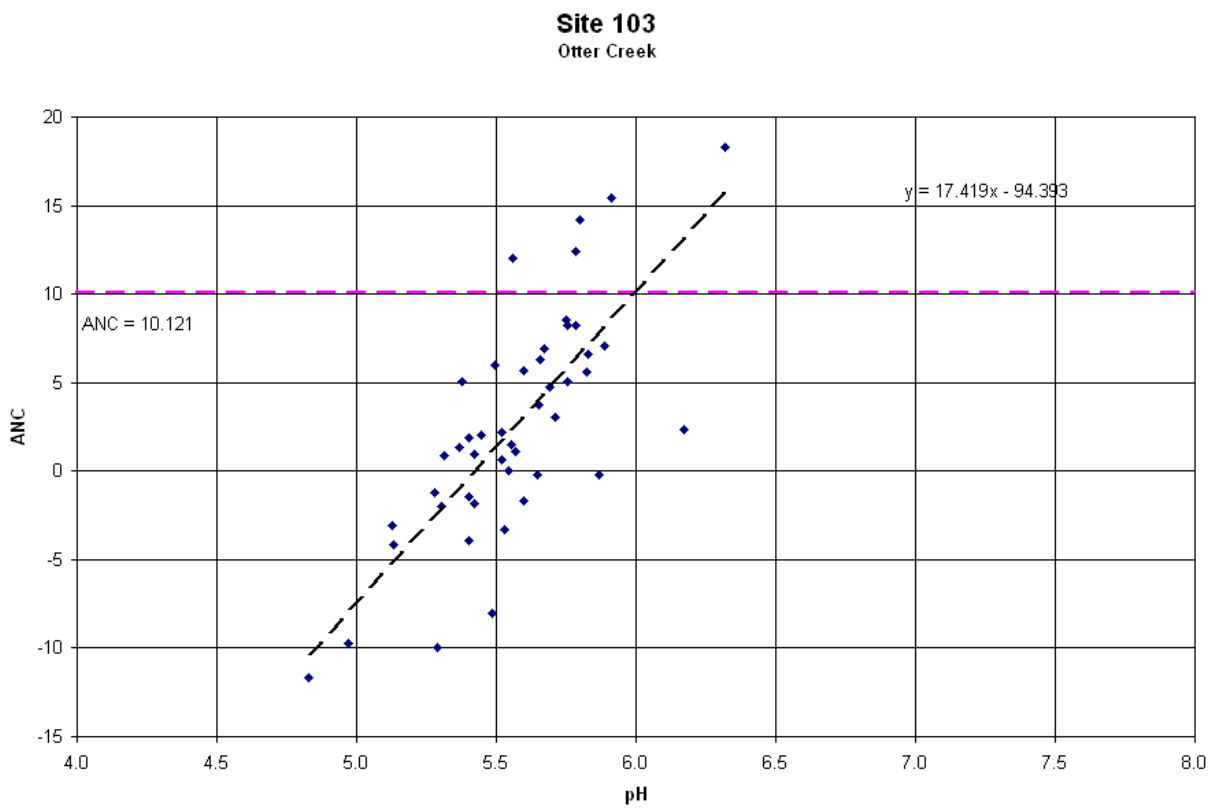


Figure C-4 pH vs ANC for Otter Creek

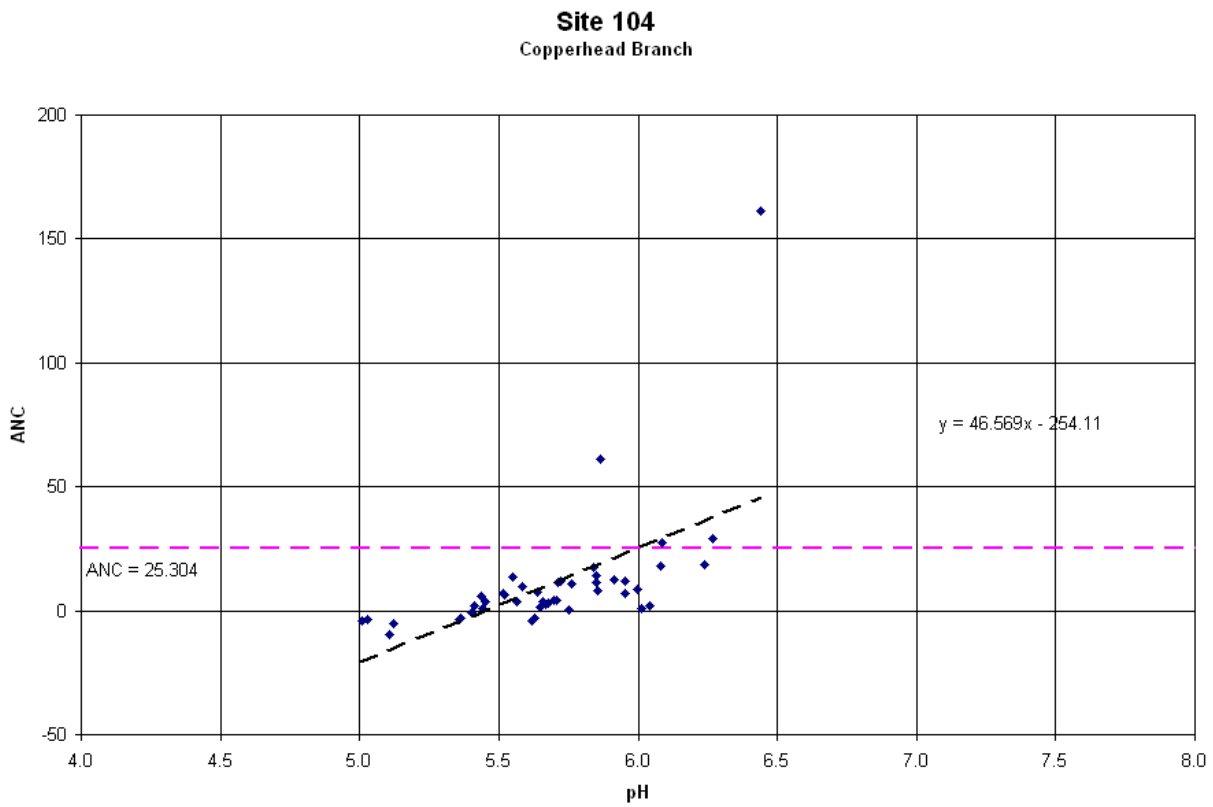


Figure C-5 pH vs ANC for Copperhead Branch

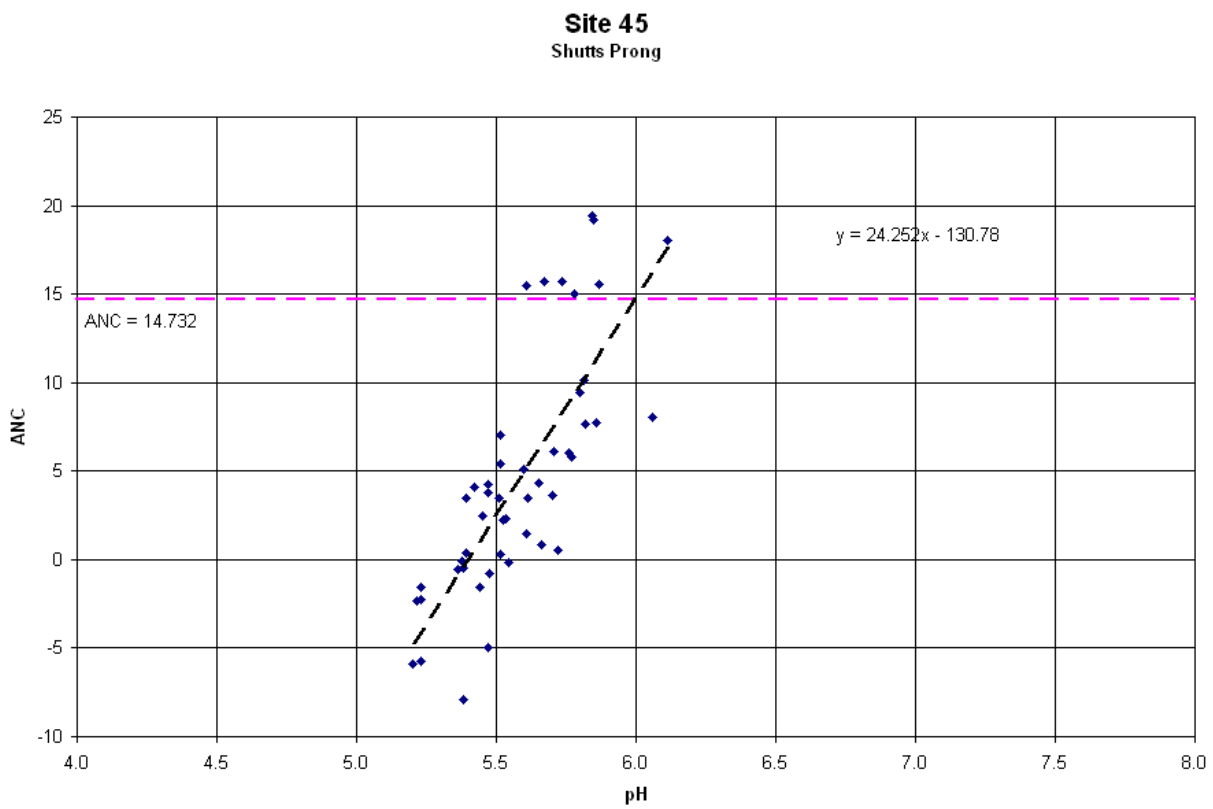


Figure C-6 pH vs ANC for Shutts Prong

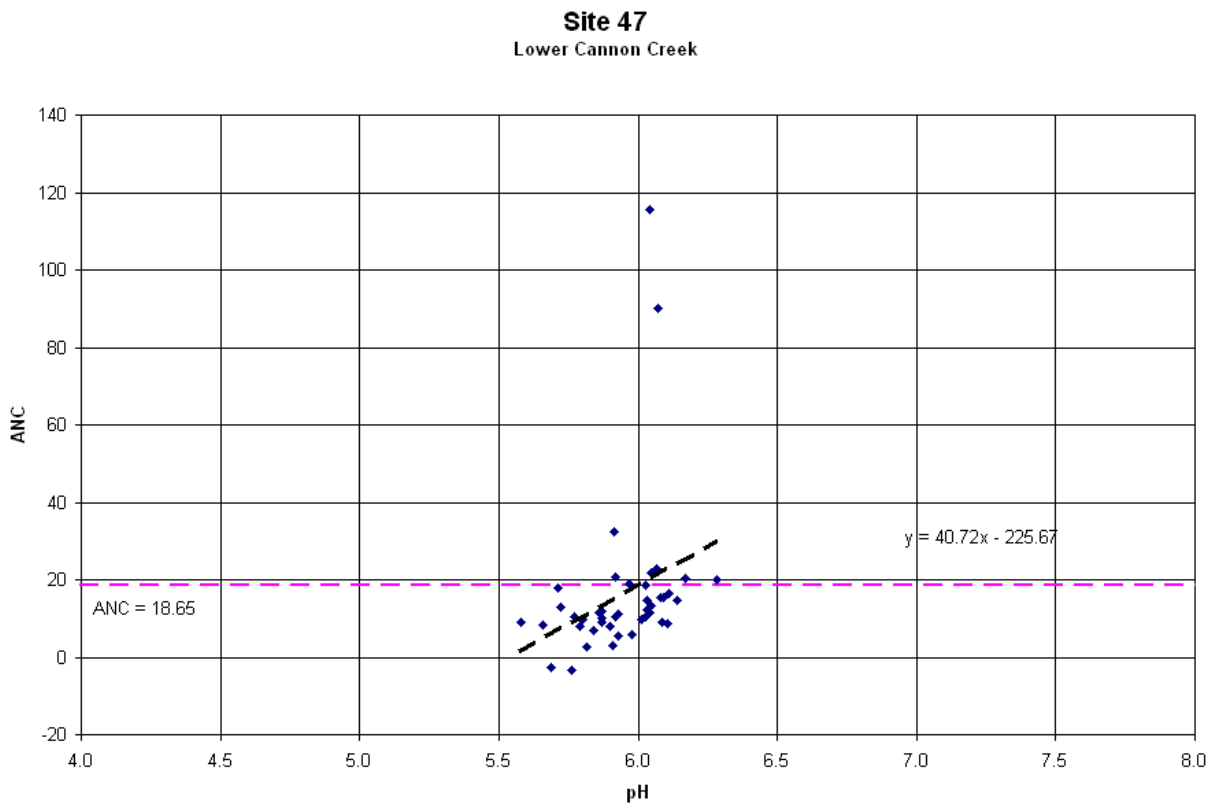


Figure C-7 pH vs ANC for Lower Cannon Creek

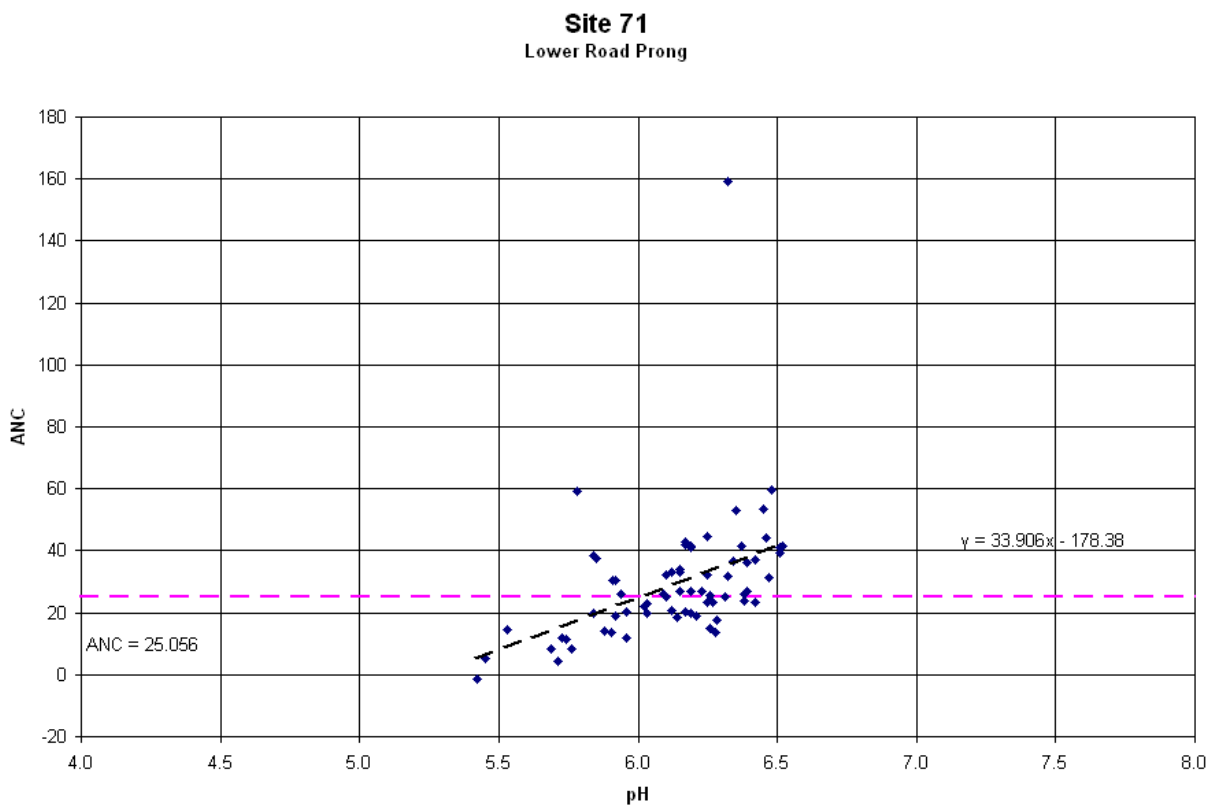


Figure C-8 pH vs ANC for Lower Road Prong

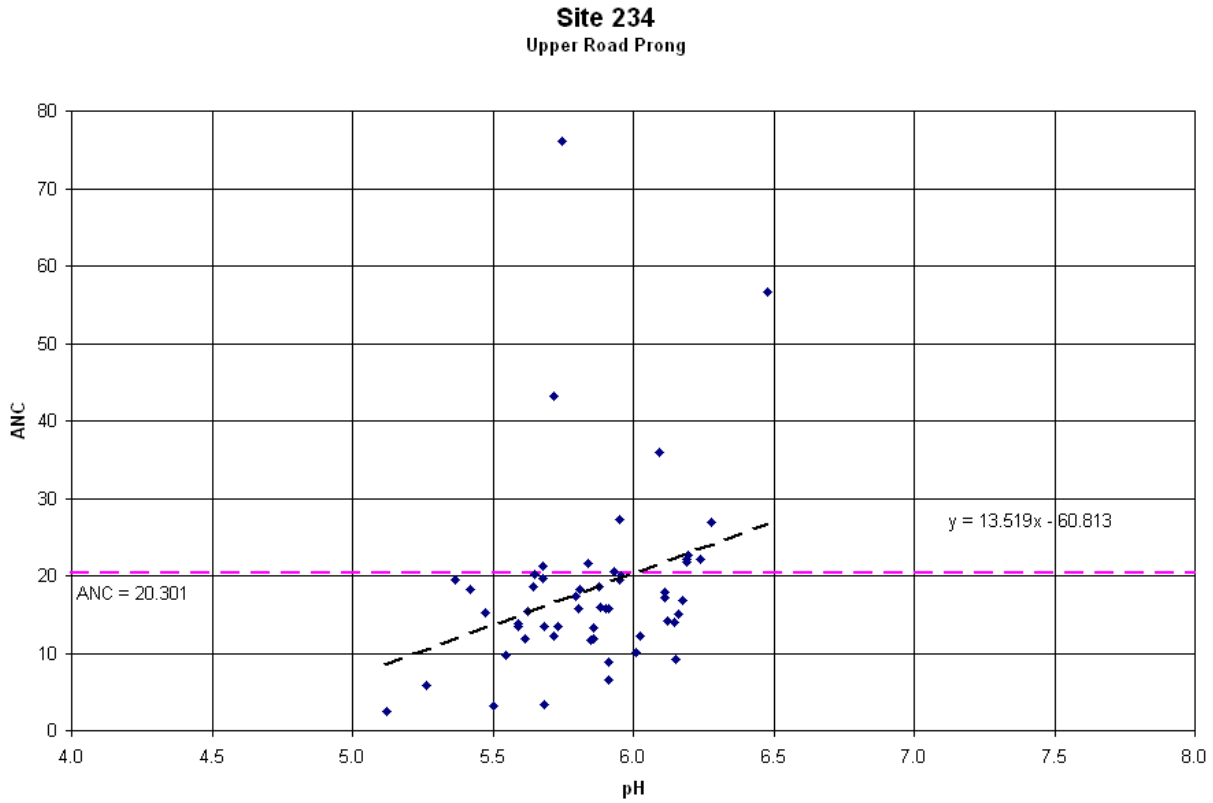


Figure C-9 pH vs ANC for Upper Road Prong

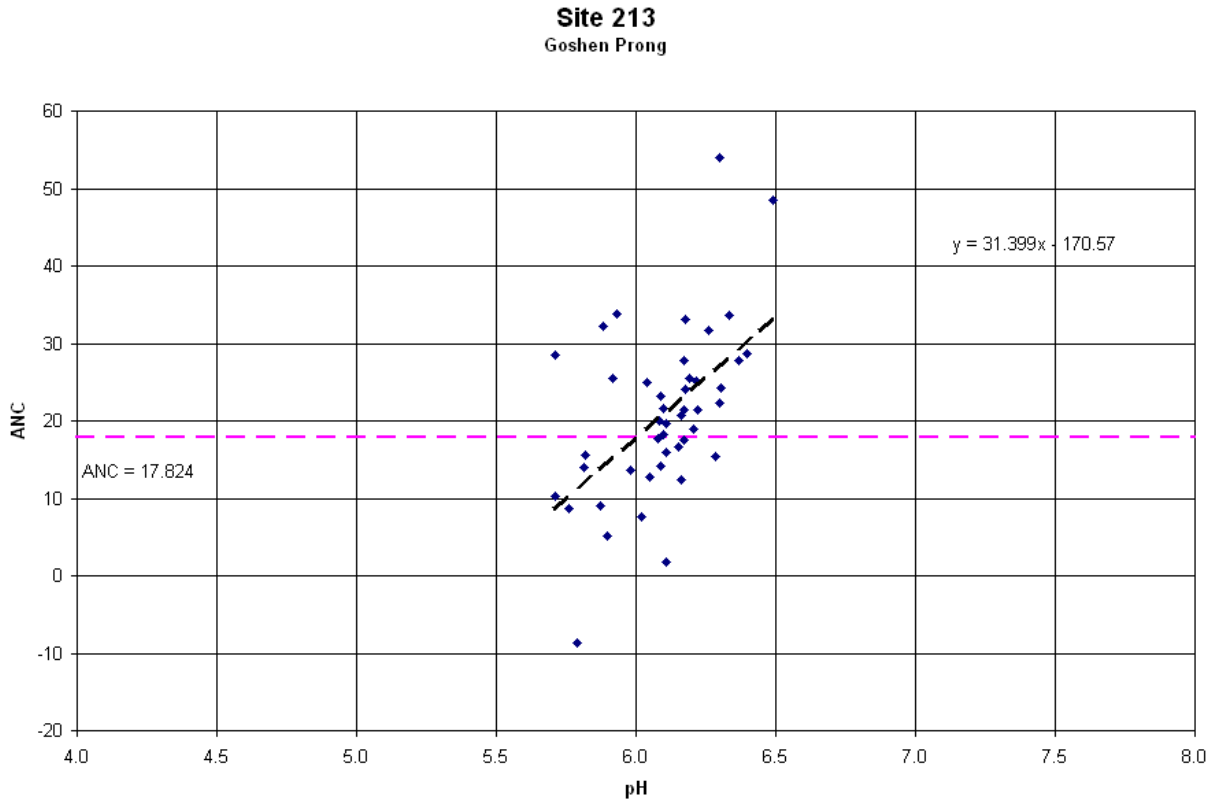


Figure C-10 pH vs ANC for Goshen Prong

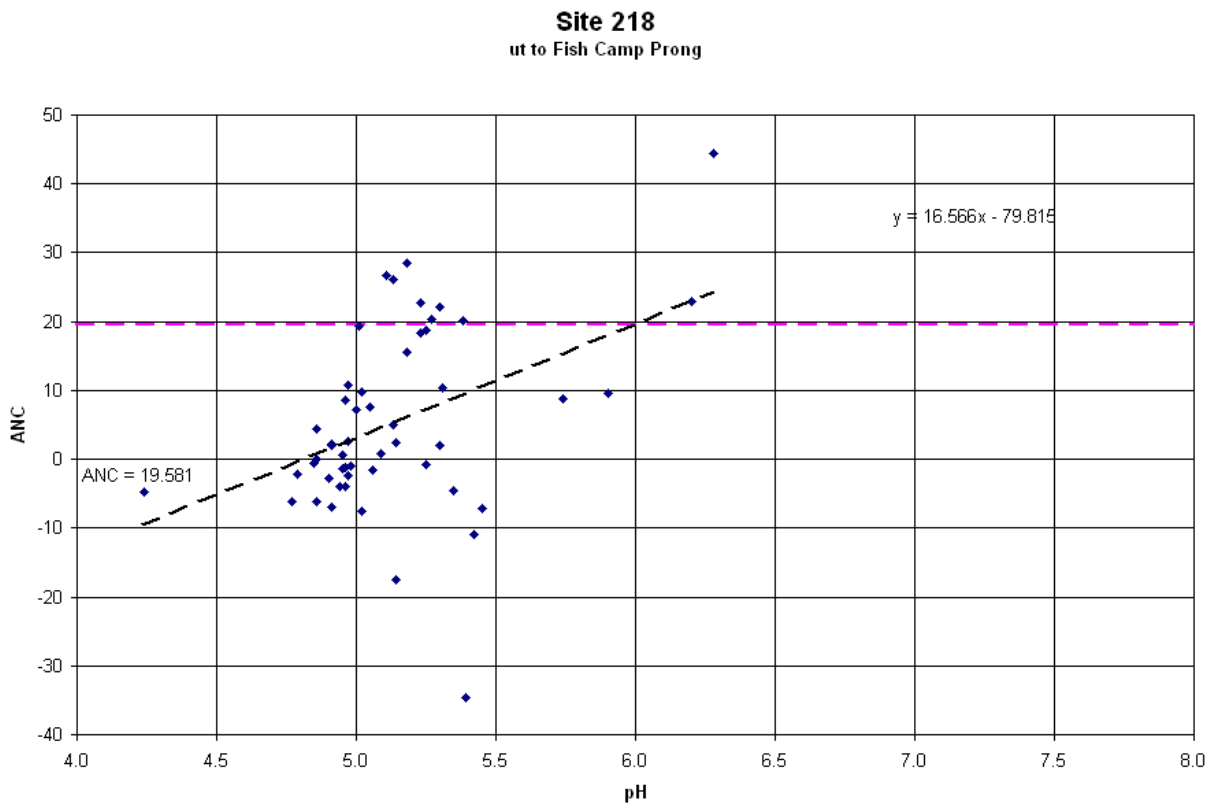


Figure C-11 pH vs ANC for ut to Fish Camp Prong

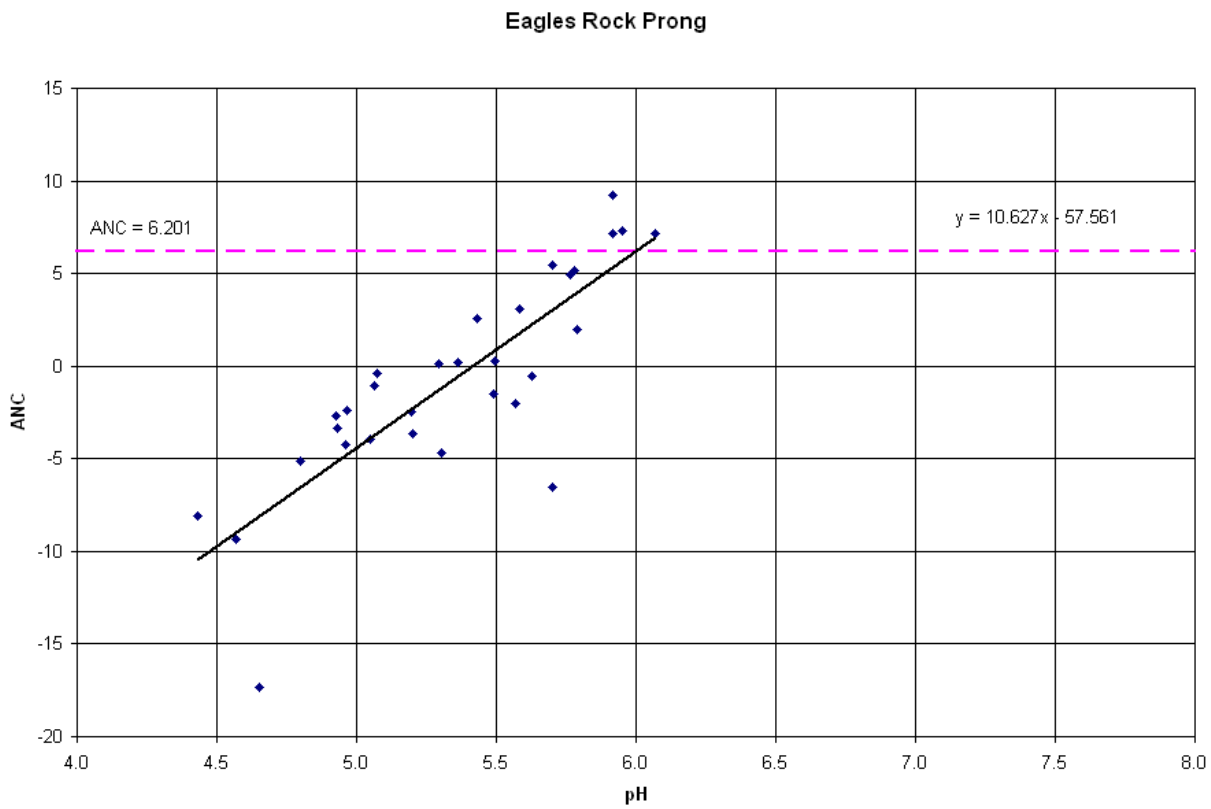


Figure C-12 pH vs ANC for Eagle Rock Prong

Table C-3. Results of SSWC Model for Lower Rock Creek

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/15	6.01	0.0000	0.0000	0.6569	0.4743	0.3805	2.2877	0.6133	2.9090	0.665	40.69	0.106	21.510	37.917	5.405	21.62	45.17
2000/05/15	5.63	1.2685	0.3290	0.5331	0.4191	0.4930	2.4029	0.5017	2.3033	0.665	124.28	0.319	34.885	119.441	17.026	68.11	(7.81)
2000/08/15	6.57	1.1693	0.3010	1.4428	0.4531	5.2535	0.7450	0.4084	0.1333	0.665	157.44	0.400	40.190	167.300	23.849	95.39	(58.38)
2000/11/15	6.56	1.0921	0.2839	1.3377	0.5134	4.2080	1.1866	0.4350	0.0000	0.665	149.16	0.380	38.866	154.532	22.029	88.11	(52.52)
2001/03/15	6.59	0.8617	0.2300	1.0789	0.3382	3.3890	0.8736	0.5417	0.2536	0.665	117.49	0.302	33.798	122.201	17.420	69.68	(33.26)
2001/05/15	6.41	1.3677	0.3310	1.2181	0.6107	5.3600	0.7680	0.4371	0.2003	0.665	164.07	0.415	41.251	174.561	24.884	99.54	(63.69)
2001/08/15	6.57	1.0611	0.2830	1.1981	0.4700	4.4140	0.9634	0.4052	0.3112	0.665	140.35	0.358	37.456	146.581	20.895	83.58	(46.54)
2001/11/12	6.56	0.9238	0.2640	1.4009	0.4735	4.9945	0.6442	0.5123	0.0000	0.665	140.85	0.360	37.536	149.522	21.314	85.26	(51.56)
2002/03/25	6.26	0.8366	0.2240	0.9582	0.2956	3.3545	0.8755	0.3162	0.0000	0.665	109.41	0.282	32.506	113.431	16.170	64.68	(18.75)
2002/05/20	6.34	1.0009	0.2510	1.4619	0.7229	4.1730	0.7277	0.3053	0.0000	0.665	152.66	0.388	39.426	162.080	23.105	92.42	(46.49)
2002/08/16	6.97	1.4027	0.3500	1.8395	0.4887	6.1780	0.7608	0.3294	0.4129	0.665	191.29	0.479	45.606	205.544	29.300	117.20	(66.84)
2002/11/18	6.67	0.8176	0.3600	1.0019	0.3656	2.5610	1.9171	0.3552	1.1699	0.665	123.34	0.317	34.734	121.692	17.347	69.39	(10.91)
2003/03/18	6.95	0.8817	0.2550	1.3536	0.3652	4.9400	0.8362	0.5176	0.2027	0.665	133.18	0.341	36.309	139.618	19.903	79.61	(38.74)
2003/05/19	6.99	0.8607	0.2690	1.4727	0.4137	3.5410	0.7445	0.6385	0.2654	0.665	139.70	0.357	37.352	147.493	21.025	84.10	(42.55)
2003/08/15	6.88	1.0579	0.2677	1.1636	0.4043	5.1325	0.7795	0.5967	0.3032	0.665	135.75	0.347	36.720	142.859	20.365	81.46	(39.51)
2003/11/13	6.41	1.2080	0.2918	1.3726	0.6877	4.4600	1.0517	0.9136	0.0000	0.665	161.57	0.410	40.851	169.327	24.138	96.55	(57.85)
2004/03/20	5.48	1.0082	0.2939	0.7130	0.3480	0.3925	1.9656	0.4017	1.6622	0.665	114.40	0.294	33.304	112.150	15.987	63.95	(7.69)
2004/05/15	5.67	1.0835	0.2572	0.7112	0.4614	1.0270	1.5648	1.6042	1.1786	0.665	117.96	0.303	33.874	118.346	16.870	67.48	(16.41)
2004/07/19	5.54	1.1571	0.1761	0.8091	0.4528	0.5340	1.2293	1.2859	1.4545	0.665	118.99	0.306	34.038	121.567	17.329	69.32	(15.29)
2004/09/26	5.69	0.8300	0.2214	0.6074	0.3714	0.7700	1.8653	0.2570	0.7335	0.665	95.55	0.247	30.288	93.433	13.319	53.28	(6.98)
2004/11/20	5.81	0.8809	0.2702	0.6261	0.4011	0.9720	2.2080	0.1365	1.2698	0.665	103.68	0.267	31.589	99.826	14.230	56.92	(4.87)
2005/01/20	5.64	0.9190	0.2307	0.8144	0.5935	0.9275	1.9973	0.4212	1.6492	0.665	115.44	0.297	33.470	113.023	16.112	64.45	(14.87)
2005/03/19	5.99	0.8971	0.2629	0.6185	0.2569	0.7325	2.0650	0.1521	1.5419	0.665	99.87	0.258	30.979	96.765	13.794	55.18	(6.75)
2005/05/21	5.86	1.0498	0.2881	0.6015	0.4066	1.4365	2.2435	0.0847	1.7968	0.665	112.65	0.290	33.024	108.673	15.491	61.97	(10.80)
2005/07/16	6.02	0.8965	0.2441	0.6882	0.3644	1.7490	2.0443	0.3659	1.5996	0.665	104.07	0.268	31.651	101.134	14.417	57.67	(8.62)
2005/09/17		0.9547	0.2473	0.6217	0.3749	0.0000	2.1374	0.3659	1.3522	0.665	104.61	0.270	31.738	101.159	14.420	57.68	(11.29)
2005/11/21	6.15	1.1248	0.3011	0.7031	0.6037	0.6600	2.2200	0.4754	2.6028	0.665	126.92	0.325	35.307	123.359	17.585	70.34	(10.53)
2006/01/21	5.83	0.9322	0.2622	0.6052	0.4647	0.6015	1.9584	0.3496	2.0906	0.665	106.30	0.274	32.008	103.889	14.810	59.24	14.50
2006/03/18	6.06	1.0378	0.2940	0.6190	0.3681	0.4705	2.0213	0.3595	2.1148	0.665	112.32	0.289	32.971	109.674	15.634	62.54	11.46
2006/05/20	5.53	1.2420	0.3097	0.4025	0.5138	-0.0635	2.5258	0.2524	1.8743	0.665	118.11	0.304	33.898	112.428	16.027	64.11	7.31
2006/07/15	5.37	0.9300	0.2439	0.6762	0.2406	1.0515	1.9056	0.3517	1.5550	0.665	102.04	0.263	31.326	99.832	14.231	56.92	11.06
2006/09/16	5.89	0.8907	0.2386	0.6196	0.4562	0.2075	2.2488	0.3191	1.6424	0.665	102.69	0.265	31.431	98.606	14.056	56.23	12.70
2006/11/20	5.48	0.9563	0.2873	0.5214	0.2506	0.1745	2.2099	0.3574	1.7881	0.665	100.44	0.259	31.071	96.562	13.765	55.06	15.43
2007/01/20	5.39	0.9603	0.2898	0.5851	0.3882	-0.1280	2.0578	0.3563	2.4825	0.665	107.14	0.276	32.142	104.178	14.851	59.40	9.32
2007/03/17	5.36	1.3256	0.3748	0.6299	0.5039	0.0345	2.3261	0.4637	3.5483	0.665	137.27	0.351	36.964	133.241	18.994	75.97	4.18
2007/05/20	6.08	1.0007	0.2948	0.6090	0.5514	0.6275	2.1211	0.3542	2.3951	0.665	114.78	0.295	33.366	111.588	15.907	63.63	4.16
2007/07/21	5.95	1.1869	0.2978	0.5863	0.3142	0.1600	2.2459	0.3184	2.5513	0.665	117.27	0.301	33.762	113.338	16.156	64.63	4.84
2007/09/15	5.22	1.0092	0.2399	0.7035	0.5242	0.2740	2.2474	0.3641	2.0962	0.665	114.10	0.294	33.257	110.123	15.698	62.79	1.79
2007/11/17	6.19	1.0316	0.3077	0.7960	0.4866	0.4700	2.3698	0.6151	1.4093	0.665	123.86	0.318	34.818	119.239	16.998	67.99	(10.78)
									AVERAGE	0.665	121.84	0.312	34.494	122.467	17.458	69.83	(15.86)

Table C-4. Results of SSWC Model for Upper Rock Creek

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/15	5.75			0.6304	0.4500	0.0550	2.5800	0.5431	3.4478	0.665	38.92	0.101	21.227	35.620	5.078	20.31	52.26
2000/05/15	5.32	1.4538	0.3411	0.7220	0.4805	0.0350	2.6506	0.4676	2.8055	0.665	144.30	0.368	38.088	137.996	19.671	78.69	(13.00)
2000/08/15	5.86	1.1442	0.2850	0.6548	0.1959	0.2395	2.7830	0.4705	1.6895	0.665	114.04	0.293	33.246	106.782	15.222	60.89	(7.18)
2000/11/15	5.84	1.1542	0.3560	0.8080	0.4528	0.4555	2.5584	0.7420	2.1768	0.665	133.61	0.342	36.378	127.825	18.222	72.89	(13.95)
2001/03/15	5.93	1.0841	0.3310	0.7818	0.5098	0.5880	2.2771	0.7243	1.9375	0.665	128.37	0.329	35.539	124.455	17.741	70.96	(16.48)
2001/05/15	5.78	1.0020	0.3380	0.6985	0.3757	0.4350	2.4994	0.7810	1.9319	0.665	117.80	0.303	33.848	112.282	16.006	64.02	(9.60)
2001/08/15	5.96	0.9729	0.2640	0.6783	0.2491	0.6580	2.2061	0.4332	1.3931	0.665	106.14	0.274	31.982	102.315	14.585	58.34	(9.70)
2001/11/12	5.97	0.8957	0.3030	0.7944	0.3249	0.8940	2.2051	0.4815	1.3776	0.665	112.49	0.290	32.998	108.743	15.501	62.01	(13.53)
2002/03/25	6.07	1.0631	0.2931	0.9531	0.6697	1.6500	2.0722	1.2572	2.0274	0.665	135.74	0.347	36.718	133.501	19.031	76.12	(8.45)
2002/05/20	5.86	1.2454	0.3290	0.7250	0.2788	0.2785	2.3539	0.3418	1.9375	0.665	127.88	0.328	35.461	123.429	17.595	70.38	(3.67)
2002/08/16	6.12	1.0721	0.2960	0.8660	0.1845	1.1480	2.5142	0.5602	1.6008	0.665	120.23	0.309	34.237	114.627	16.340	65.36	(2.26)
2002/11/18	6.00	0.5401	0.2140	0.6753	0.3542	0.7400	1.9483	0.5378	1.5326	0.665	82.98	0.215	28.277	80.333	11.451	45.81	16.56
2003/03/18	6.14	1.0230	0.3050	0.7940	0.3116	0.7780	2.2022	0.4822	1.5097	0.665	118.64	0.305	33.982	115.013	16.395	65.58	(10.69)
2003/08/15	6.52	1.2180	0.3628	0.7558	0.2448	2.3970	2.1566	0.6307	1.4812	0.665	129.76	0.332	35.762	126.712	18.063	72.25	(17.66)
2003/11/13	5.63	1.2699	0.3336	0.8708	0.4899	0.5010	2.4638	1.0420	1.5159	0.665	141.22	0.360	37.595	136.269	19.425	77.70	(22.74)
2004/03/20	5.29	1.2240	0.3786	0.5918	0.3542	0.2395	2.3093	0.3854	1.8681	0.665	127.03	0.326	35.325	122.866	17.515	70.06	(11.59)
2004/05/15	5.65	1.2334	0.2743	0.6861	0.6389	0.9240	1.6992	1.3766	2.3455	0.665	130.30	0.334	35.848	130.450	18.596	74.38	(10.80)
2004/07/19	5.52	1.1154	0.2137	0.8579	0.4445	0.4710	1.4486	1.3469	2.1198	0.665	121.92	0.313	34.507	123.275	17.573	70.29	(9.13)
2004/09/26	5.76	0.8763	0.2514	0.6311	0.1885	0.6330	2.3544	0.2804	1.0559	0.665	96.68	0.250	30.469	92.038	13.120	52.48	(2.73)
2004/11/20	5.79	0.9859	0.3048	0.6613	0.2362	0.9565	2.3501	0.3123	1.5202	0.665	109.08	0.281	32.453	104.441	14.888	59.55	(4.82)
2005/01/20	5.71	0.9847	0.2599	0.8508	0.5071	1.2615	2.2416	0.4265	1.7044	0.665	120.49	0.309	34.278	116.646	16.628	66.51	(16.34)
2005/03/19	6.03	1.0092	0.3041	0.6617	0.3746	1.1430	2.3141	0.1588	1.6573	0.665	113.74	0.293	33.198	109.346	15.587	62.35	(12.68)
2005/05/21	5.81	1.0653	0.3118	0.5835	0.2815	1.2000	2.5541	0.0858	1.9375	0.665	111.39	0.287	32.822	105.543	15.045	60.18	(7.51)
2005/07/16	5.93	1.0028	0.2810	0.6017	0.2123	1.6985	2.4302	0.3021	1.6759	0.665	104.76	0.270	31.762	99.662	14.207	56.83	(6.96)
2005/09/17			0.2771	0.4954	0.2729		2.5123	0.3744	1.9090	0.665	51.33	0.134	23.213	47.437	6.762	27.05	25.32
2005/11/21	6.02	1.3276	0.3762	0.6902	0.5540	0.6900	2.5800	0.4602	3.6506	0.665	141.39	0.361	37.622	135.570	19.326	77.30	(6.26)
2006/01/21	5.75	1.0827	0.2991	0.7020	0.4582	0.2455	2.2238	0.5123	2.2680	0.665	120.89	0.310	34.342	117.168	16.702	66.81	8.83
2006/03/18	5.92	1.1595	0.3364	0.6877	0.3321	0.2830	2.3568	0.4208	2.3300	0.665	123.95	0.318	34.831	119.407	17.022	68.09	8.21
2006/05/20	5.39	1.4566	0.3732	0.5833	0.4214	0.1200	3.1666	0.4322	2.6319	0.665	139.55	0.356	37.328	129.340	18.438	73.75	5.79
2006/07/15	6.00	0.9344	0.2680	0.6515	0.2190	0.4670	2.2003	0.3464	1.5450	0.665	102.62	0.265	31.418	98.796	14.084	56.33	11.55
2006/09/16	5.88	0.9825	0.2694	0.6222	0.3216	0.2310	2.6914	0.3212	1.7317	0.665	106.48	0.274	32.036	99.878	14.238	56.95	12.93
2006/11/20	5.50	1.0579	0.3111	0.6524	0.4585	0.1165	2.5526	0.4683	2.0869	0.665	118.48	0.305	33.958	112.631	16.056	64.22	9.47
2007/01/20	5.46	1.0933	0.3245	0.6326	0.3426	0.0375	2.4178	0.5286	2.6015	0.665	117.54	0.302	33.806	112.532	16.041	64.17	5.84
2007/03/17	5.26	1.2813	0.3840	0.5412	0.4968	-0.0045	2.6942	0.3772	3.5005	0.665	131.78	0.337	36.085	125.018	17.821	71.29	8.36
2007/05/20	5.95	1.0274	0.3320	0.6293	0.5808	0.2210	2.5541	0.3549	2.4217	0.665	120.81	0.310	34.330	114.953	16.387	65.55	2.53
2007/07/21	5.84	1.2384	0.3416	0.6097	0.3867	0.0155	2.6155	0.3031	2.1781	0.665	126.31	0.324	35.210	120.068	17.116	68.46	(3.00)
2007/09/15	6.00	1.0316	0.3015	0.7634	0.3106	0.5070	2.6045	0.3928	2.3238	0.665	117.43	0.302	33.788	111.246	15.858	63.43	3.59
2007/11/17	6.06	1.1282	0.3938	0.7621	0.7425	0.5555	2.7010	0.6243	2.4124	0.665	140.84	0.360	37.534	134.100	19.116	76.46	(8.49)
									AVERAGE	0.665	117.02	0.300	33.724	112.324	16.012	64.05	(2.05)

Table C-5. Results of SSWC Model for Inadu Creek

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/15	5.54	0.0000	0.0000	0.6555	0.5360	0.0380	2.0218	0.5385	3.2587	0.665	42.21	0.110	21.754	39.970	5.698	22.79	47.75
2000/05/15	5.37	1.3095	0.2890	0.5083	0.4449	0.1200	2.1298	0.4162	2.5457	0.665	122.62	0.315	34.619	119.551	17.042	68.17	(5.27)
2000/08/15	5.79	0.8016	0.2140	0.6072	0.2455	0.1695	1.2682	0.7172	1.2574	0.665	90.29	0.234	29.446	90.997	12.972	51.89	(2.81)
2000/11/15	5.57	1.0230	0.2660	0.7252	0.4606	0.1300	1.8254	0.8363	2.3951	0.665	116.25	0.299	33.600	114.926	16.383	65.53	(4.25)
2001/03/15	5.80	0.8537	0.2240	1.2098	0.7788	0.3005	1.5984	0.7140	1.8265	0.665	133.56	0.342	36.370	134.609	19.189	76.75	(23.46)
2001/05/15	5.73	0.9098	0.2260	0.7369	0.4821	0.2760	1.6085	0.5825	2.0751	0.665	108.37	0.279	32.339	108.043	15.402	61.61	(5.65)
2001/08/15	5.49	0.7935	0.1970	0.6203	0.2839	-0.0670	1.7462	0.4971	1.8160	0.665	90.04	0.233	29.406	88.415	12.604	50.41	2.76
2001/11/12	5.91	0.7444	0.2330	0.7342	0.4739	0.6640	1.5974	0.7527	1.7645	0.665	100.37	0.259	31.059	99.795	14.226	56.90	(4.28)
2002/03/25	5.62	0.9108	0.2200	0.5640	0.3288	0.1310	1.6042	0.6481	2.3982	0.665	96.49	0.249	30.438	95.747	13.649	54.60	17.06
2002/05/20	5.59	1.0020	0.2210	0.6560	0.2839	-0.0420	1.5955	0.4251	2.0249	0.665	103.97	0.268	31.635	103.540	14.760	59.04	8.61
2002/08/16	5.73	0.8497	0.2100	0.8073	0.2909	0.4580	1.9421	0.7183	1.9425	0.665	102.22	0.264	31.355	99.818	14.229	56.92	9.85
2002/11/17	6.04	0.6763	0.2860	0.7636	0.2975	1.3480	2.3616	0.4325	1.4961	0.665	98.10	0.253	30.696	93.411	13.316	53.26	8.71
2003/03/18	5.94	0.7875	0.2140	0.7215	0.3323	0.4480	1.5374	0.5297	1.6969	0.665	96.78	0.250	30.485	96.394	13.741	54.96	1.94
2003/05/19	6.14	0.9549	0.2700	0.7351	0.3370	0.7270	2.9986	0.6931	1.0986	0.665	110.45	0.284	32.672	101.974	14.536	58.15	(7.66)
2003/08/15	6.52	1.4109	0.3879	0.8361	0.3875	1.8940	2.1888	0.5485	1.4111	0.665	148.60	0.378	38.776	146.018	20.815	83.26	(29.42)
2003/11/13	5.17	1.2210	0.2420	0.6955	0.4606	0.1635	1.7909	0.7966	1.9387	0.665	122.87	0.315	34.659	122.034	17.396	69.58	(10.09)
									AVERAGE	0.665	105.20	0.271	31.832	103.453	14.747	58.99	0.24

Table C-6. Results of SSWC Model for Otter Creek

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/15	4.97	0.0000	0.0000	0.6215	0.6111	-0.4860	3.0907	1.0657	5.5006	0.665	42.65	0.111	21.824	37.919	5.405	21.62	72.97
2000/05/15	4.83	1.4578	0.2380	0.5451	0.4985	-0.5820	3.1248	0.5002	4.4008	0.665	128.79	0.330	35.606	119.056	16.972	67.89	14.91
2000/08/15	5.53	1.5660	0.2560	0.8347	0.3710	-0.1650	3.0614	0.6757	3.2674	0.665	145.00	0.370	38.200	135.544	19.322	77.29	(6.65)
2000/11/15	5.40	1.7785	0.3020	0.7151	0.4825	-0.0720	3.1603	1.5216	3.9451	0.665	157.04	0.399	40.126	146.788	20.925	83.70	(5.80)
2001/03/15	5.65	1.7965	0.2990	1.0743	0.5732	0.1870	3.0518	1.6939	4.0945	0.665	175.63	0.443	43.101	166.563	23.744	94.97	(17.36)
2001/05/15	5.52	1.4388	0.2541	0.6456	0.4715	0.1080	2.7163	0.4428	2.7776	0.665	132.84	0.340	36.254	125.926	17.951	71.80	(8.31)
2001/08/15	5.60	1.5470	0.2510	0.6279	0.3093	-0.0835	3.2059	0.5251	2.6090	0.665	133.07	0.341	36.291	122.684	17.489	69.95	(8.27)
2001/11/12	5.91	1.4949	0.2600	0.6944	0.4879	0.7725	2.5810	0.6052	2.3727	0.665	138.67	0.354	37.187	132.795	18.930	75.72	(16.57)
2002/03/25	5.29	1.6713	0.2790	0.6040	0.3851	-0.4970	2.9280	0.4045	3.7033	0.665	142.47	0.364	37.795	134.034	19.107	76.43	9.22
2002/05/20	5.49	0.1473	0.2151	0.7574	0.4219	-0.4025	2.9832	0.5889	3.2724	0.665	68.77	0.179	26.003	62.313	8.883	35.53	45.50
2002/08/16	5.89	1.6562	0.2660	0.8466	0.2100	0.3520	3.1901	0.5435	2.7354	0.665	146.72	0.374	38.475	136.258	19.424	77.69	(2.42)
2002/11/17	5.37	0.9368	0.2390	0.9009	0.4129	0.0650	3.1699	0.6910	2.8179	0.665	116.15	0.299	33.584	106.456	15.175	60.70	15.45
2003/03/18	5.49	1.5440	0.2801	0.7930	0.5853	0.2980	2.8843	0.4875	2.7807	0.665	149.55	0.381	38.928	141.494	20.170	80.68	(12.16)
2003/05/19	6.32	1.4558	0.2510	0.6086	0.4168	0.9155	2.5843	0.7356	2.0342	0.665	130.43	0.334	35.869	124.426	17.737	70.95	(10.43)
2003/08/15	5.57	1.3548	0.2309	0.6659	0.2498	0.0555	3.0466	0.3652	1.6399	0.665	121.95	0.313	34.512	112.883	16.092	64.37	(8.08)
2003/11/13	5.38	1.3839	0.2483	0.7388	0.6952	0.2540	2.3717	0.9019	2.4006	0.665	139.40	0.356	37.304	135.090	19.257	77.03	(12.58)
									AVERAGE	0.665	129.32	0.330	35.691	121.264	17.286	69.15	3.09

Table C-7. Results of SSWC Model for Copperhead Branch

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/15	5.63	0.0000	0.0000	0.6067	0.6318	-0.1500	2.6112	0.7562	4.5192	0.665	42.54	0.111	21.806	38.927	5.549	22.20	61.87
2000/05/15	5.12	1.5841	0.2560	0.5290	0.6862	-0.2505	2.9338	0.5311	4.0815	0.665	140.67	0.359	37.507	132.190	18.844	75.37	3.99
2000/08/15	6.04	1.4358	0.2411	1.3979	0.5888	0.0890	2.5214	0.8516	3.2178	0.665	167.33	0.423	41.773	162.778	23.204	92.82	(22.71)
2000/11/15	5.67	1.4859	0.2660	0.6843	0.5091	0.1380	2.5934	0.9182	3.6419	0.665	138.81	0.355	37.210	132.845	18.937	75.75	(1.10)
2001/03/15	5.65	1.4027	0.2500	0.6210	0.3331	0.0630	2.4725	0.7381	3.0963	0.665	126.10	0.323	35.176	120.818	17.223	68.89	(1.98)
2001/05/15	5.85	1.1603	0.2270	0.5566	0.6107	0.7060	2.4197	0.4152	1.9735	0.665	116.40	0.299	33.624	111.376	15.877	63.51	(8.64)
2001/08/15	5.75	1.3526	0.2340	0.7937	0.4535	0.0165	2.6333	0.7385	3.3889	0.665	132.87	0.340	36.259	126.545	18.039	72.16	(2.11)
2001/11/12	5.72	1.4408	0.2610	0.8954	0.8574	0.5870	2.4581	1.1816	3.1750	0.665	154.24	0.392	39.678	149.720	21.343	85.37	(17.62)
2002/03/25	5.36	1.5160	0.2510	0.6631	0.8821	-0.1780	2.4432	0.6853	3.8310	0.665	147.70	0.376	38.632	143.085	20.397	81.59	5.43
2002/05/20	5.62	0.1533	0.1880	0.9862	1.2586	-0.2075	2.4451	0.4261	3.3604	0.665	98.19	0.254	30.710	93.059	13.266	53.06	28.91
2002/08/16	6.00	1.3897	0.2350	0.8604	0.3789	0.4450	2.4677	0.6619	3.1825	0.665	135.79	0.347	36.726	130.691	18.630	74.52	5.54
2002/11/17	5.52	0.9138	0.2340	0.5757	0.4285	0.3160	2.4485	0.3669	3.4745	0.665	100.85	0.260	31.136	95.676	13.639	54.55	28.64
2003/03/18	5.71	1.4889	0.3870	0.8140	0.5005	0.5830	2.5915	0.8278	3.2414	0.665	154.34	0.392	39.694	148.733	21.202	84.81	(11.34)
2003/05/19	5.95	1.2655	0.2260	1.2664	0.4727	0.3370	2.3342	0.9891	2.3287	0.665	148.90	0.379	38.824	145.182	20.696	82.78	(19.11)
2003/08/15	6.24	1.3568	0.2412	0.6005	0.4121	0.9165	2.6635	0.6725	1.5717	0.665	124.21	0.319	34.874	117.639	16.770	67.08	(11.52)
									AVERAGE	0.665	128.60	0.329	35.575	123.284	17.574	70.30	2.55

Table C-8. Results of SSWC Model for Shutts Prong

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/18	5.20	0.0000	0.0000	0.5566	0.2807	-0.2935	4.8202	0.7030	2.4199	0.665	31.38	0.082	20.021	24.799	3.535	14.14	47.40
2000/05/20	5.78	1.0821	0.5000	0.6587	0.2373	0.7490	3.8808	0.6158	1.9542	0.665	129.86	0.333	35.778	114.866	16.374	65.50	(8.95)
2000/08/19	5.66	1.0070	0.4700	0.7303	0.2502	0.0420	3.7834	0.4999	1.7868	0.665	127.08	0.326	35.333	112.912	16.096	64.38	(9.63)
2000/11/18	5.86	1.4278	0.7000	0.5476	0.2537	0.3855	5.1562	0.7679	1.6740	0.665	159.16	0.404	40.466	132.126	18.835	75.34	(21.79)
2001/03/24	5.44	0.3076	0.5320	0.5072	0.1791	-0.0780	4.2067	0.5357	1.7261	0.665	85.77	0.222	28.723	72.684	10.361	41.44	10.77
2001/05/19	5.80	1.2985	0.5200	0.8114	0.3527	0.4715	3.9826	1.4894	2.0299	0.665	151.90	0.386	39.304	135.029	19.249	76.99	(21.52)
2001/08/18	5.70	1.0020	0.4550	0.8057	0.2725	0.1820	3.9288	0.6360	1.4167	0.665	129.45	0.332	35.712	114.148	16.272	65.09	(16.19)
2001/11/17	5.87	1.0470	0.4720	0.7036	0.2475	0.7775	3.9523	0.7615	1.7162	0.665	128.02	0.328	35.483	112.645	16.058	64.23	(12.12)
2002/03/23	5.47	1.3637	0.4600	0.5610	0.1822	-0.2485	3.9029	0.5105	2.0671	0.665	134.96	0.345	36.594	119.524	17.038	68.15	(0.05)
2002/08/17	5.71	1.4394	0.6101	0.6100	0.1677	0.3040	4.7774	0.5548	1.9840	0.665	152.85	0.389	39.456	129.503	18.461	73.84	(6.63)
2002/11/16	5.36	1.5530	0.6900	0.5193	0.1791	-0.0260	4.5523	0.4414	1.2803	0.665	161.45	0.409	40.832	139.348	19.864	79.46	(19.79)
2003/03/15	5.54	1.3306	0.4099	0.7597	0.2401	-0.0100	3.9288	0.4924	1.8705	0.665	139.31	0.356	37.290	123.454	17.598	70.39	(11.63)
2003/05/17	5.77	1.3326	0.5659	0.5490	0.2076	0.2880	3.8299	0.6233	1.1402	0.665	142.26	0.363	37.762	127.003	18.104	72.42	(21.49)
2003/08/16	5.53	1.8260	0.6860	0.4747	0.2600	0.1115	4.6507	0.8477	1.4936	0.665	174.87	0.441	42.979	151.098	21.539	86.16	(31.44)
2003/11/15	5.52	1.6628	0.6837	0.6732	0.3617	0.2700	4.0354	0.7690	2.1378	0.665	177.77	0.448	43.443	159.580	22.748	90.99	(29.36)
									AVERAGE	0.665	135.07	0.344	36.612	117.914	16.809	67.24	(10.16)

Table C-9. Results of SSWC Model for Lower Cannon Creek

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/18	5.69	0.0000	0.0000	0.6254	0.4590	-0.1380	2.1274	0.7420	2.5538	0.665	38.93	0.101	21.229	36.586	5.215	20.86	42.12
2000/05/20	5.92	0.7124	0.2080	0.5918	0.3476	0.5285	1.4861	0.5297	1.3783	0.665	87.29	0.226	28.966	86.839	12.379	49.52	0.86
2000/08/19	5.87	0.6913	0.2080	0.6491	0.2925	0.4485	1.6142	0.6268	1.1420	0.665	87.32	0.226	28.971	86.267	12.297	49.19	(1.35)
2000/11/18	5.87	0.7665	0.2801	0.5690	0.4062	0.6015	2.0808	0.7956	1.0335	0.665	96.43	0.249	30.429	93.210	13.287	53.15	(6.47)
2001/03/24	5.84	0.7495	0.2290	0.5640	0.3366	0.3375	1.6786	0.6080	1.2555	0.665	89.38	0.231	29.301	88.069	12.554	50.22	(3.05)
2001/05/19	6.01	0.6583	0.1950	0.6898	0.4090	0.4925	1.3315	0.5336	1.2642	0.665	89.35	0.231	29.296	89.710	12.788	51.15	(3.89)
2001/08/18	6.03	0.6543	0.1950	0.6415	0.4211	0.6175	1.6224	0.4747	0.7545	0.665	87.36	0.226	28.978	86.269	12.298	49.19	(7.40)
2001/11/17	5.97	1.3306	0.3680	0.6479	0.3335	0.9480	1.5763	0.6821	0.8482	0.665	133.39	0.341	36.342	134.586	19.185	76.74	(33.94)
2002/03/23	5.98	0.8236	0.2530	0.5442	0.3394	0.2990	1.6579	0.3542	1.5612	0.665	94.26	0.244	30.082	93.174	13.282	53.13	9.55
2002/05/18	5.81	1.1552	0.4500	0.5191	0.2741	0.1395	2.4586	0.4123	1.1588	0.665	124.27	0.319	34.883	119.061	16.972	67.89	(9.53)
2002/08/17	6.29	0.8607	0.2610	0.6548	0.3527	0.9990	2.0026	0.5520	0.6330	0.665	101.92	0.263	31.307	99.181	14.138	56.55	(3.83)
2002/11/16	6.05	0.7394	0.2660	0.5824	0.3925	1.0840	1.7419	0.3740	1.0658	0.665	94.15	0.243	30.064	92.635	13.205	52.82	4.54
2003/03/15	6.03	0.7565	0.2500	0.7020	0.3476	0.5150	1.6901	0.5233	1.4167	0.665	97.74	0.252	30.638	96.586	13.768	55.07	(1.18)
2003/05/17	6.05	0.6893	0.2070	0.5559	0.3183	0.6615	1.6670	0.5800	0.8457	0.665	83.75	0.217	28.400	82.377	11.743	46.97	0.80
2003/08/16	6.14	0.8771	0.2387	0.6268	0.2784	0.7375	1.6435	0.5243	0.8004	0.665	97.79	0.253	30.646	96.882	13.811	55.24	(7.96)
2003/11/15	5.72	1.0528	0.2931	0.7450	0.4919	0.6545	1.9483	0.7172	1.2580	0.665	121.63	0.312	34.461	119.716	17.066	68.26	(16.07)
									AVERAGE	0.665	95.31	0.246	30.250	93.822	13.374	53.50	(2.30)

Table C-10. Results of SSWC Model for Lower Road Prong

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/18	5.74	0.0000	0.0000	0.5251	0.4406	0.5730	2.2488	0.6421	2.5984	0.665	34.10	0.089	20.456	31.753	4.526	18.11	45.35
2000/05/20	6.15	1.2534	0.3290	0.7280	0.3699	1.6485	1.9632	0.5236	1.9015	0.665	130.74	0.335	35.918	129.072	18.399	73.60	(17.61)
2000/08/19	6.39	1.2605	0.3250	0.7068	0.2940	1.7990	2.0179	0.5286	1.8550	0.665	127.90	0.328	35.464	125.744	17.925	71.70	(16.21)
2000/11/18	6.25	1.4709	0.3650	0.6613	0.3726	1.6195	2.1926	0.6282	1.9319	0.665	141.72	0.362	37.675	138.825	19.790	79.16	(22.85)
2001/03/24	6.03	1.3637	0.3460	0.6987	0.4117	1.1525	2.1547	1.3437	2.1520	0.665	137.44	0.351	36.990	134.665	19.197	76.79	(20.00)
2001/05/19	6.27	1.4418	0.3470	0.7454	0.3793	1.1670	2.1101	0.5166	2.0528	0.665	142.62	0.364	37.819	140.385	20.012	80.05	(24.33)
2001/08/18	6.32	1.3106	0.3350	1.4695	0.6729	1.5985	2.0746	0.4811	1.7298	0.665	174.07	0.439	42.851	173.908	24.791	99.16	(46.91)
2001/11/17	6.17	1.8767	0.5399	0.7376	0.2858	2.1425	2.0674	0.7881	2.1185	0.665	177.47	0.447	43.395	177.615	25.319	101.28	(44.85)
2002/03/23	5.78	1.3236	0.3260	0.6201	0.3339	2.9570	1.9325	0.5516	2.3269	0.665	128.38	0.329	35.541	126.827	18.079	72.32	(1.43)
2002/05/18	5.42	1.4879	0.3581	0.4591	0.2588	-0.0645	2.4451	0.4662	2.1725	0.665	130.30	0.334	35.848	125.263	17.856	71.43	(2.19)
2002/11/16	6.15	1.1532	0.3150	0.9048	0.4207	1.3420	1.9824	0.3804	1.8061	0.665	133.58	0.342	36.373	131.896	18.802	75.21	(9.91)
2003/03/15	6.26	1.2354	0.3380	0.7776	0.3218	0.7420	2.0640	0.5137	2.4837	0.665	131.51	0.337	36.042	129.167	18.413	73.65	(8.31)
2003/05/17	6.23	1.1753	0.3260	0.7868	0.4027	1.3415	1.7654	0.6435	1.8879	0.665	129.99	0.333	35.798	129.663	18.484	73.93	(14.99)
2003/08/16	6.51	1.4869	0.3447	0.7093	0.3437	2.0545	1.8557	0.6506	1.5450	0.665	142.20	0.363	37.752	141.871	20.224	80.90	(25.62)
2003/11/15	6.12	1.6989	0.3735	0.7001	0.6999	1.6515	1.9258	0.7559	2.1049	0.665	163.86	0.415	41.218	164.315	23.423	93.69	(32.42)
2004/03/20	5.84	1.5733	0.1988	0.5932	0.3581	0.9970	1.8878	0.4432	2.2252	0.665	129.82	0.333	35.771	128.636	18.337	73.35	(11.05)
2004/05/16	5.91	1.4578	0.3146	0.6327	0.5603	1.5290	1.0742	0.7743	1.2078	0.665	140.48	0.359	37.477	145.895	20.797	83.19	(31.81)
2004/07/17	5.84	1.5969	0.2886	0.7487	0.1048	1.9135	1.4256	0.5786	1.4694	0.665	138.67	0.354	37.187	141.322	20.146	80.58	(26.39)
2004/09/25	5.94	1.1823	0.3127	0.6132	0.2878	1.2965	2.1893	0.3056	1.7472	0.665	118.76	0.305	34.002	115.217	16.424	65.70	(8.53)
2004/11/20	6.1	1.3967	0.3476	0.5003	0.4383	1.6135	2.0650	0.1546	2.0131	0.665	131.27	0.336	36.003	128.911	18.376	73.51	(13.48)
2005/01/24	5.92	1.4180	0.3017	0.7542	0.5364	1.5250	1.9848	0.4584	2.1216	0.665	142.10	0.363	37.736	140.789	20.070	80.28	(25.63)
2005/03/19	6.31	1.3671	0.3403	0.6153	0.4004	1.2645	2.0506	0.2078	2.0361	0.665	133.22	0.341	36.315	131.036	18.679	74.72	(20.99)
2005/05/21	6.19	1.2823	0.3216	0.4637	0.4074	2.0580	2.3890	0.1457	2.0156	0.665	121.04	0.311	34.366	116.252	16.572	66.29	(12.78)
2005/07/16	6.17	1.2673	0.3016	0.6293	0.4422	1.0040	2.1658	0.3602	2.0472	0.665	126.73	0.325	35.277	123.532	17.610	70.44	(16.59)
2005/09/17		1.3985	0.3428	0.6539	0.3445	0.0000	2.1317	0.4354	1.9338	0.665	135.24	0.346	36.638	132.552	18.895	75.58	(22.95)
2005/11/21	6.38	1.5947	0.3958	0.5987	0.5454	1.1900	2.3256	0.4676	3.2228	0.665	152.14	0.387	39.342	148.616	21.185	84.74	(18.28)
2006/01/21	5.76	1.1969	0.3285	0.5058	0.3828	0.4175	2.2195	0.3496	2.7993	0.665	118.55	0.305	33.968	114.811	16.366	65.47	15.87
2006/03/18	6.28	1.2500	0.3700	0.5644	0.4023	0.8855	1.9714	0.3595	2.8601	0.665	127.66	0.327	35.426	125.813	17.935	71.74	10.25
2006/05/21	5.96	1.3927	0.3672	0.4805	0.2326	0.5965	2.3280	0.2524	3.1236	0.665	126.56	0.325	35.250	122.260	17.428	69.71	15.10
2006/07/23	5.53	1.3811	0.3419	0.5474	0.3378	0.7335	2.4413	0.3517	2.6170	0.665	129.50	0.332	35.720	124.477	17.744	70.98	8.40
2006/09/16	6.15	1.4146	0.3411	0.5929	0.2522	1.7005	2.1979	0.3191	2.2208	0.665	130.89	0.335	35.942	127.589	18.188	72.75	2.38
2006/11/20	5.73	1.3518	0.3752	0.5244	0.4172	0.5925	2.1317	0.3574	3.0225	0.665	131.81	0.337	36.090	129.002	18.389	73.56	10.17
2007/01/20	5.9	1.3981	0.3780	0.6201	0.1959	0.6795	2.1168	0.4134	3.4348	0.665	132.85	0.340	36.256	130.183	18.558	74.23	4.71
2007/03/17	5.45	1.6045	0.3958	0.4701	0.2041	0.2540	2.3251	0.4102	4.1614	0.665	138.31	0.353	37.130	134.313	19.146	76.59	10.15
2007/05/19	6.42	1.4005	0.3718	0.6026	0.6432	1.1685	2.1134	0.3978	2.7888	0.665	143.14	0.365	37.902	140.902	20.086	80.34	(8.33)
2007/07/21	6.52	1.6378	0.3945	0.6877	0.4113	2.0820	2.4725	0.3694	2.1979	0.665	154.62	0.393	39.739	149.995	21.382	85.53	(19.85)
2007/09/15	6.47	1.8077	0.4511	0.7445	0.6361	1.5585	2.7917	0.4861	2.4874	0.665	175.98	0.444	43.157	169.325	24.137	96.55	(27.77)
2007/11/17	6.51	1.6977	0.4421	0.7549	0.4324	1.9590	2.8133	0.6289	2.7826	0.665	164.99	0.418	41.398	157.801	22.495	89.98	(18.03)
									AVERAGE	0.665	136.06	0.347	36.769	133.690	19.058	76.23	(11.78)

Table C-11. Results of SSWC Model for Upper Road Prong

			Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH		Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit		(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/05/15	5.86	1.38E-06	0.9759	0.3390	0.7648	0.2377	0.5915	1.2677	0.5995	3.3883	0.665	115.93	0.298	33.549	118.058	16.829	67.32	4.61
2000/11/15	6.11	7.762E-07	0.9889	0.3281	0.8137	0.2502	0.8975	1.3526	0.6002	3.2711	0.665	118.13	0.304	33.901	119.867	17.087	68.35	2.33
2001/03/15	5.85	1.413E-06	1.0320	0.3489	0.8298	0.2815	0.5845	1.3531	0.8101	3.4714	0.665	123.50	0.317	34.760	125.582	17.902	71.61	(0.67)
2001/05/15	6.19	6.457E-07	0.7004	0.2330	0.7510	0.3691	1.0860	0.8390	0.4634	1.6783	0.665	96.22	0.249	30.395	99.431	14.174	56.70	(4.99)
2001/08/15	5.95	1.122E-06	0.9829	0.3290	0.7988	0.2381	0.9755	1.3219	0.5474	3.2327	0.665	116.95	0.301	33.712	118.806	16.936	67.74	0.63
2001/11/14	5.95	1.122E-06	0.9358	0.3321	0.8045	0.2827	1.3615	0.9682	0.5892	2.8253	0.665	116.24	0.299	33.598	120.254	17.142	68.57	(4.57)
2002/03/28	5.91	1.23E-06	1.0731	0.3420	0.7457	0.5325	0.4425	1.3248	0.8413	3.3362	0.665	127.74	0.327	35.438	130.307	18.575	74.30	(28.37)
2002/11/17	5.68	2.089E-06	0.7545	0.2460	0.9678	0.2866	0.1650	1.5014	0.3208	2.6530	0.665	107.31	0.277	32.170	107.556	15.332	61.33	13.06
2003/05/21	6.12	7.586E-07	1.0110	0.3590	0.4802	0.3046	0.7095	1.1376	0.8700	3.4168	0.665	108.67	0.280	32.387	111.102	15.838	63.35	12.00
2003/11/11	5.62	2.399E-06	1.2829	0.3421	0.8763	0.3468	0.7740	1.2125	0.9041	3.3970	0.665	139.15	0.355	37.264	143.417	20.444	81.78	(6.64)
2004/03/20	5.68	2.089E-06	1.1126	0.4544	0.6992	0.3331	0.6740	1.2571	0.4935	3.5216	0.665	131.84	0.338	36.094	135.183	19.270	77.08	(0.88)
2004/05/16	5.65	2.239E-06	1.3402	0.3281	0.7185	0.3765	1.0070	1.8662	1.6801	2.5891	0.665	134.75	0.345	36.560	133.950	19.095	76.38	(10.18)
2004/07/17	5.65	2.239E-06	1.4039	0.3011	0.9619	0.5591	0.9330	0.8794	1.4748	3.4150	0.665	150.96	0.384	39.154	158.962	22.660	90.64	(15.58)
2004/09/25	5.47	3.388E-06	1.2478	0.3475	0.7427	0.3550	0.7630	1.2667	0.2975	3.3424	0.665	132.24	0.339	36.158	135.547	19.322	77.29	(3.01)
2004/11/20	5.36	4.365E-06	1.2180	0.2750	0.5233	0.2475	0.9565	1.3982	0.1457	3.2649	0.665	112.49	0.290	32.998	113.610	16.195	64.78	8.67
2005/01/24	5.68	2.089E-06	1.0561	0.3215	0.9807	0.4281	1.0660	1.4246	0.5616	3.2643	0.665	132.75	0.340	36.240	134.979	19.241	76.97	(10.06)
2005/03/19	5.81	1.549E-06	1.1122	0.3965	0.7689	0.3593	0.9145	1.4203	0.4205	3.0802	0.665	130.75	0.335	35.920	132.870	18.941	75.76	(10.84)
2005/05/21	6.1	7.943E-07	1.0609	0.3340	0.7335	0.3507	1.7990	1.4453	0.2156	3.3089	0.665	121.29	0.311	34.406	122.628	17.481	69.92	(2.54)
2005/07/16	5.72	1.905E-06	1.2977	0.3400	0.7266	0.5200	2.1555	1.4578	0.4620	3.5173	0.665	137.63	0.352	37.021	139.969	19.953	79.81	(10.20)
2005/09/17			1.1556	0.3511	0.7222	0.2573	0.0000	1.5298	0.4478	3.5687	0.665	124.55	0.320	34.928	125.527	17.894	71.58	(1.41)
2005/11/19	6.19	6.457E-07	1.0617	0.3533	0.7468	0.2350	1.1100	1.5374	0.4612	3.5867	0.665	120.54	0.310	34.286	121.239	17.283	69.13	1.23
2006/01/21	5.59	2.57E-06	1.1162	0.3182	0.7245	0.3601	0.6695	1.6066	0.3988	3.8254	0.665	122.60	0.315	34.616	122.961	17.528	70.11	22.23
2006/05/21	6.01	9.772E-07	1.0192	0.3745	0.7123	0.2252	0.5085	1.2826	0.4237	4.0009	0.665	118.41	0.304	33.946	120.609	17.193	68.77	25.45
2006/07/23	5.55	2.818E-06	2.1686	0.6460	0.4837	0.0000	0.4910	1.4366	0.4425	3.8837	0.665	182.42	0.459	44.187	188.958	26.936	107.74	(14.78)
2006/09/16	5.72	1.905E-06	1.1180	0.3792	0.7806	0.2319	0.6090	1.4515	0.4552	3.9494	0.665	126.87	0.325	35.299	128.516	18.320	73.28	20.39
2006/11/20	5.12	7.586E-06	1.0809	0.3691	0.6426	0.3276	0.1210	1.2322	0.4286	4.2030	0.665	120.64	0.310	34.302	123.315	17.579	70.31	26.08
2007/01/20	5.5	3.162E-06	1.0999	0.3849	0.7245	0.2799	0.1630	1.3320	0.4435	2.6015	0.665	125.23	0.321	35.037	127.571	18.185	72.74	(2.74)
2007/05/19	6.15	7.079E-07	1.1909	0.3869	0.7339	0.5912	0.4605	1.3786	0.4900	2.4217	0.665	138.30	0.353	37.128	141.271	20.138	80.55	(12.48)
2007/07/21	6.24	5.754E-07	1.2502	0.3912	0.5561	0.2921	1.1060	1.4170	0.4414	2.1781	0.665	126.24	0.324	35.198	128.078	18.258	73.03	(7.57)
2007/09/15	6.11	7.762E-07	0.9941	0.3462	0.8471	0.2107	0.8585	1.4611	0.4492	2.3238	0.665	120.32	0.309	34.251	121.498	17.320	69.28	(2.25)
2007/11/17	6.15	7.079E-07	1.0873	0.3691	0.7898	0.0000	0.6990	1.5451	0.4875	2.4124	0.665	118.98	0.306	34.037	119.545	17.041	68.16	(0.19)
										AVERAGE	0.665	125.79	0.322	35.13	128.102	18.261	73.04	(0.43)

Table C-12. Results of SSWC Model for Goshen Prong

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/19	5.71	0.0000	0.0000	0.6189	0.3800	0.5095	1.4558	0.6772	1.8910	0.665	36.63	0.096	20.861	35.726	5.093	20.37	35.50
2000/08/19	6.10	0.7004	0.2240	0.9159	0.4008	1.0815	1.4314	0.6740	1.1916	0.665	103.46	0.267	31.554	103.923	14.814	59.26	(10.89)
2000/11/19	6.11	0.7525	0.2600	0.6555	0.3816	0.9855	1.3786	0.5049	1.3838	0.665	97.21	0.251	30.554	97.670	13.923	55.69	(5.26)
2001/03/25	6.05	0.6974	0.2340	0.6661	0.3362	0.6380	1.2989	0.5563	1.3559	0.665	91.62	0.237	29.659	92.236	13.148	52.59	(4.35)
2001/05/20	6.16	0.7495	0.2440	0.7498	0.3793	0.6230	1.3656	0.6070	1.2140	0.665	99.78	0.258	30.965	100.428	14.316	57.26	(10.54)
2001/08/19	6.16	0.6042	0.2120	0.7719	0.3589	1.0325	1.3757	0.5435	1.0850	0.665	90.34	0.234	29.454	90.526	12.905	51.62	(6.28)
2001/11/18	6.04	0.6603	0.2420	0.7174	0.3077	1.2485	1.2854	0.7899	1.1389	0.665	91.93	0.238	29.709	92.626	13.204	52.82	(6.90)
2002/03/24	5.79	0.6402	0.2151	0.6371	0.3179	-0.4365	1.2922	0.4187	1.3225	0.665	85.48	0.221	28.677	85.869	12.241	48.96	11.15
2002/05/19	6.11	0.0000	0.0000	0.5260	0.2229	0.0855	1.4928	0.5563	2.1471	0.665	28.57	0.075	19.571	27.711	3.950	15.80	53.16
2002/08/17	6.37	0.7124	0.2340	0.8464	0.3382	1.3900	1.4357	0.7750	1.0038	0.665	100.26	0.259	31.042	100.553	14.334	57.34	(0.64)
2002/11/17	6.02	0.6122	0.2353	0.6799	0.3476	0.3840	1.3608	0.6484	1.4905	0.665	88.37	0.229	29.139	88.551	12.623	50.49	11.42
2003/03/16	5.98	0.6322	0.2760	0.7806	0.3089	0.6795	2.6002	0.4651	1.6275	0.665	96.11	0.248	30.378	90.201	12.858	51.43	4.72
2003/05/18	6.28	0.5972	0.2151	0.4076	0.3996	0.7675	1.2014	0.7084	1.1371	0.665	75.44	0.196	27.070	75.839	10.811	43.24	7.65
2003/08/17	6.30	0.8945	0.2242	0.7751	0.4535	2.6955	1.2446	0.8370	0.9554	0.665	108.39	0.279	32.342	110.181	15.706	62.83	(13.88)
2003/11/16	5.92	1.0989	0.2620	0.8066	0.6557	1.2735	1.4554	0.6105	1.4564	0.665	128.24	0.329	35.518	129.949	18.524	74.10	(19.78)
									AVERAGE	0.665	88.12	0.228	29.100	88.132	12.563	50.25	3.01

Table C-13. Results of SSWC Model for ut to Fish Camp Prong

		Basic cations (mg/L)----------				Anions (mg/L)----------				Runoff	Calculated equations ----------						
Date	pH	Ca	Mg	Na	K	Alk	SO4	Cl	NO3aj	Q	BC	F	USO4o	Bco	ANClimit	CL	Excess loads
YYYY/MM/DD	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	m/yr	ueq/L		ueq/L	ueq/L	ueq/L	meq/m2/yr	meq/m2/yr
2000/03/15	5.02	0.0000	0.0000	0.7259	0.5302	-0.3765	2.1312	0.6233	4.5899	0.665	45.12	0.118	22.219	42.513	6.060	24.24	60.58
2000/05/15	4.86	0.8807	0.2801	0.5821	0.4614	-0.3080	2.2339	0.5162	4.0350	0.665	104.11	0.269	31.658	100.113	14.271	57.09	21.78
2000/08/15	5.25	1.3366	0.3321	0.8250	0.7030	0.9400	3.0250	0.8285	3.6828	0.665	147.88	0.377	38.661	138.705	19.773	79.09	(4.00)
2000/11/15	5.06	0.8627	0.2870	0.7217	0.5720	-0.0765	2.2320	0.7991	4.0691	0.665	112.68	0.290	33.029	108.773	15.506	62.02	17.21
2001/03/15	4.85	0.8777	0.3140	0.6587	0.5165	-0.0290	2.1494	0.9165	4.8472	0.665	111.49	0.287	32.838	108.062	15.404	61.62	24.07
2001/05/15	4.86	0.8777	0.3321	0.6015	0.5282	-0.0025	1.6286	0.6265	5.3413	0.665	110.79	0.285	32.726	110.447	15.744	62.98	28.01
2001/08/15	4.86	0.5922	0.2420	0.9083	0.6314	0.2190	2.4965	1.0331	3.7467	0.665	105.11	0.271	31.818	99.637	14.203	56.81	17.07
2001/11/16	5.39	0.8456	0.3650	1.3439	1.0455	-1.7325	2.2483	1.3111	3.1632	0.665	157.41	0.400	40.186	154.751	22.060	88.24	(20.61)
2002/03/26	5.14	0.8507	0.3030	0.4984	0.9735	-0.8710	2.0189	0.9728	4.0443	0.665	113.96	0.293	33.234	111.372	15.876	63.50	25.80
2002/05/21	5.42	0.9338	0.3050	0.8013	0.3730	-0.5490	1.7506	0.8101	4.2879	0.665	116.08	0.299	33.573	115.215	16.424	65.70	26.23
2002/08/20	5.45	1.5340	0.3590	0.8085	0.7847	-0.3590	2.7115	0.6421	5.1460	0.665	161.32	0.409	40.811	154.908	22.082	88.33	12.80
2002/11/15	5.00	0.6813	0.2920	1.0389	0.5759	0.3600	2.1168	0.8562	5.1435	0.665	117.93	0.303	33.869	114.829	16.369	65.48	35.62
2003/03/17	5.09	0.9889	0.3630	0.7857	0.4391	0.0420	2.2474	0.7601	5.0282	0.665	124.62	0.320	34.939	120.821	17.223	68.89	23.74
2003/05/21	4.96	0.7184	0.2579	0.3694	0.4664	-0.1995	2.4216	0.7229	3.2804	0.665	85.07	0.220	28.611	80.258	11.441	45.76	28.12
									AVERAGE	0.665	115.26	0.296	33.441	111.457	15.888	63.55	21.17

APPENDIX D

Development of Load Duration Curves For pH-Impaired Streams in Great Smoky Mountains National Park

A flow duration curve is a cumulative frequency graph, constructed from historic flow data at a particular location, that represents the percentage of time a particular flow rate is equaled or exceeded. When a water quality target (or criteria) concentration is applied to the flow duration curve, the resulting load duration curve (LDC) represents the allowable pollutant loading in a waterbody over the entire range of flow. Pollutant monitoring data, plotted on the LDC, provides a visual depiction of stream water quality as well as the frequency and magnitude of any exceedances. Load duration curve intervals can be grouped into several broad categories or zones, in order to provide additional insight about conditions and patterns associated with the impairment. For example, the duration curve could be divided into five zones: high flows (exceeded 0-10% of the time), moist conditions (10-40%), median or mid-range flows (40-60%), dry conditions (60-90%), and low flows (90-100%). Impairments observed in the low flow zone typically indicate the influence of point sources, while those further left on the LDC (representing zones of higher flow) generally reflect potential nonpoint source contributions (Stiles, 2003).

D.1 Development of Flow Duration Curves

Flow duration curves are developed for a waterbody from daily discharges of flow over a period of record. In general, there is a higher level of confidence that curves derived from data over a long period of record correctly represent the entire range of flow. The preferred method of flow duration curve computation uses daily mean data from USGS continuous-record stations located on the waterbody of interest. For ungaged streams, alternative methods must be used to estimate daily mean flow. These include: 1) regression equations (using drainage area as the independent variable) developed from continuous record stations in the same ecoregion; 2) drainage area extrapolation of data from a nearby continuous-record station of similar size and topography; and 3) calculation of daily mean flow using a dynamic computer model, such as the Loading Simulation Program C++ (LSPC).

Flow duration curves for pH-impaired waterbodies in the Great Smoky Mountains National Park were derived from LSPC hydrologic simulations based on parameters derived from calibration at USGS Station No. 03461200, located on Cosby Creek near Cosby, Tennessee, in the Pigeon River watershed (see Appendix E for details of calibration). For example, a sample flow-duration curve was constructed using simulated daily mean flow for Road Prong below the barrier cascade for the period from 10/1/95 through 9/30/05 and dividing by the drainage area. This flow duration curve is shown in Figure D-1 and represents the cumulative distribution of daily discharges arranged to show percentage of time specific flows were exceeded during the period of record (the highest daily mean flow during this period is exceeded 0% of the time and the lowest daily mean flow is equaled or exceeded 100% of the time). This flow duration curve could be applied to all impaired waterbodies because it was developed on a “per area” basis.

D.2 Development of Target Load Duration Curve for ANC

A target ANC load duration curve was developed from the sample flow duration curve developed in Section D.1. The site-specific target ANC concentration was applied to each of the ranked flows used to generate the flow duration curve and the results were plotted. (The default minimum ANC concentration of 50 μeq/L was used when a site-specific target was not available.) The ANC target load corresponding to each ranked daily mean flow is:

$$\text{Target Load}_{\text{site-specific}} = (\text{Target ANC})_{\text{site-specific}} \times (Q/A) \times (\text{UCF})$$

where: Q = daily mean flow
A = drainage area
UCF = the required unit conversion factor

The sample target ANC load duration curve, using the default minimum concentration of 50 μeq/L, is presented in Figures D-2 and D-3. Figure D-2 is presented in semi-log scale format while Figure D-3 is presented in non-log scale format. Because the calculated ANC of any subwatershed can be negative and negative values cannot be plotted on a log or semi-log scale format, the non-log scale format will be used for ANC load duration curves in this TMDL.

D.3 Development of Load Duration Curves for ANC

Sampling was conducted at several sites in GSMNP subwatersheds by National Park Service. ANC load duration curves were developed from target load duration curves developed using the method described in Section D.2 and water quality monitoring data collected by National Park Service. Load duration curves were developed using the following procedure (Lower Road Prong is used as an example):

1. Daily ANC loads were calculated for each of the water quality samples collected at the Lower Road Prong monitoring station by multiplying the measured ANC by the daily mean flow for the sampling date and the required unit conversion factor. ANC load calculations for the GSMNP subwatersheds are summarized in Tables D-1 thru D-12.

   Note: In order to be consistent for all analyses, the derived daily mean flow was used to compute sampling data loads, even if measured ("instantaneous") flow data was available for some sampling dates.

   Example – 3/24/01 sampling event:
   Modeled Flow = 5.31 cfs
   Measured ANC = 23.05 μeq/L
   Calculated ANC Load = 143.4 meq/acre/day

2. Using the flow duration curve developed in Figure D-1, the "percent of days the flow was exceeded" (PDFE) was determined for each sampling event.

Example – 3/24/01 sampling event:
Modeled Flow = 5.31 cfs
PDFE from flow duration curve for Road Prong subwatershed corresponding to 5.31 cfs = 65.8%

3. Each sample load was then plotted on the target load duration curve developed in Section D.2 according to the PDFE. The resulting curve is presented in Figure D-11.

   Load duration curves for ANC for other impaired waterbodies were derived in a similar manner and are shown in Figures D-4 through D-15.

D.4 Development of WLAs & LAs

As previously discussed, a TMDL can be expressed as the sum of all point source loads (WLAs), nonpoint source loads (LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty concerning the relationship between effluent limitations and water quality:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

For waterbodies with no active point sources, there is no WLA. As stated in Section 7.2, an implicit MOS was utilized. Therefore, the LA for nonpoint sources is equal to the TMDL.

TMDLs, WLAs, & LAs for impaired waterbodies in the GSMNP are summarized in Table D-13. The TMDL equations in Table D-13 are equivalent to the target load duration curves presented in Figures D-4 through D-15.

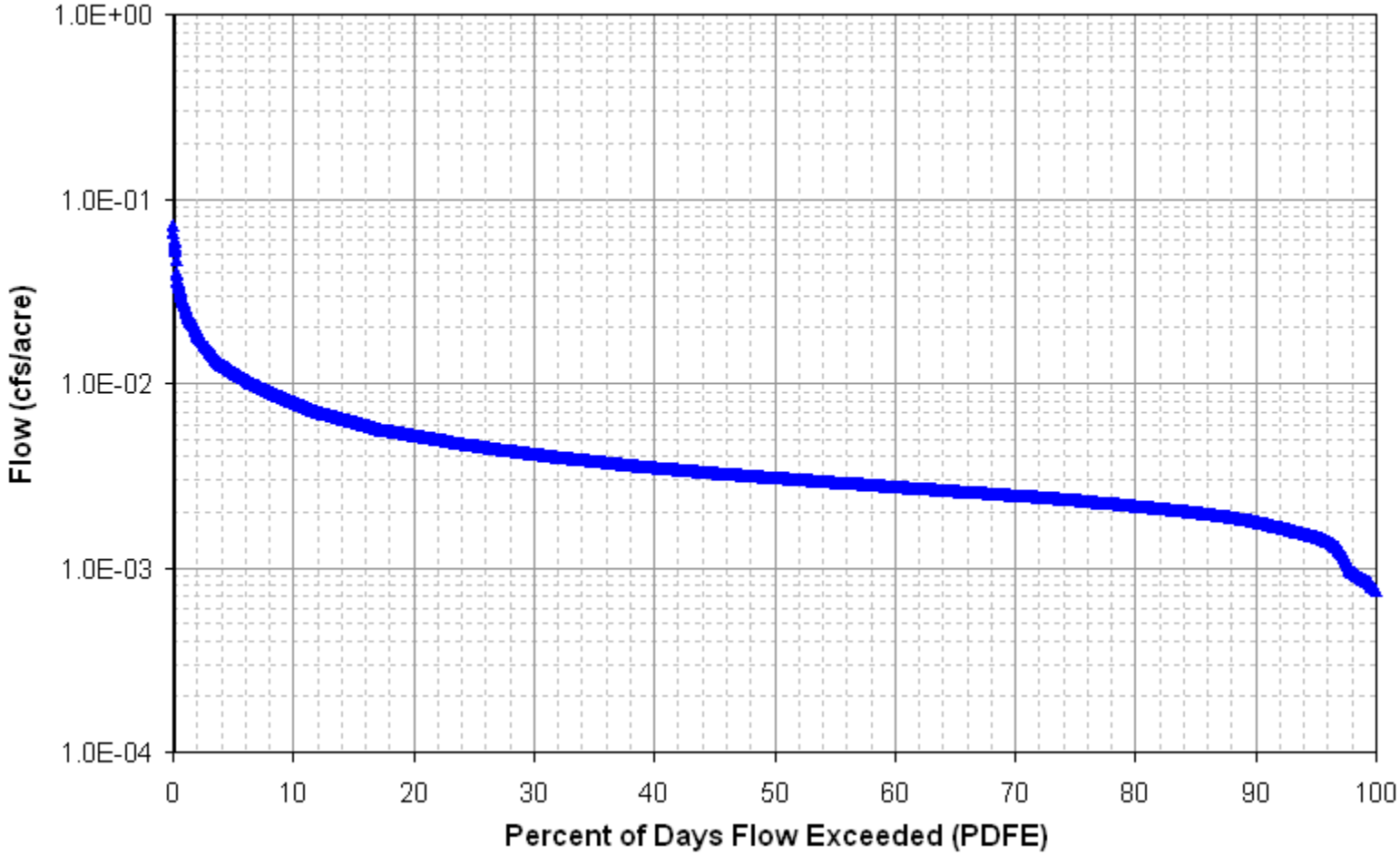


Figure D-1 Sample Flow Duration Curve

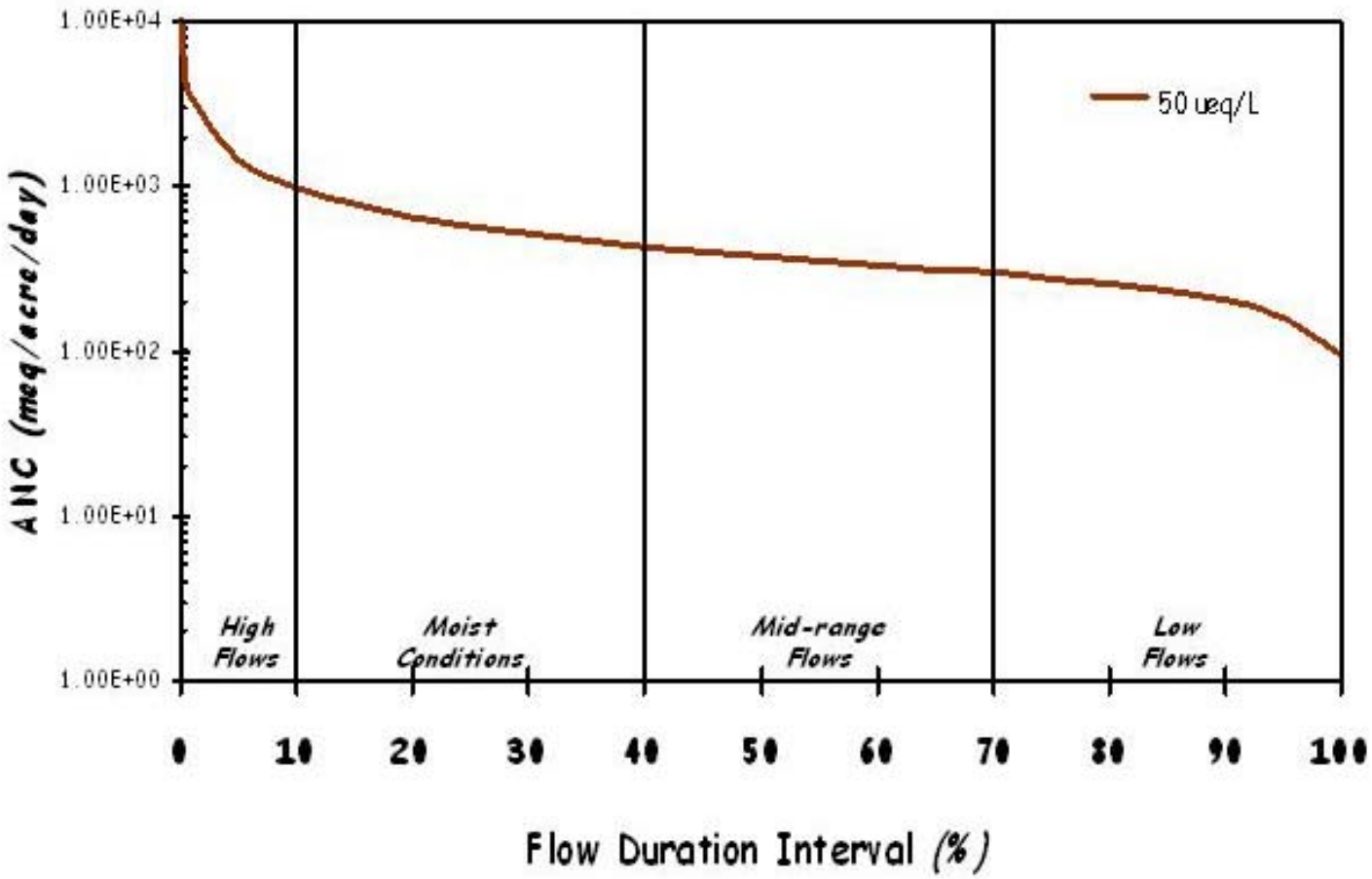


Figure D-2 Sample Target Net Alkalinity Load Duration Curve (semi-log-scale) (using default minimum ANC concentration)

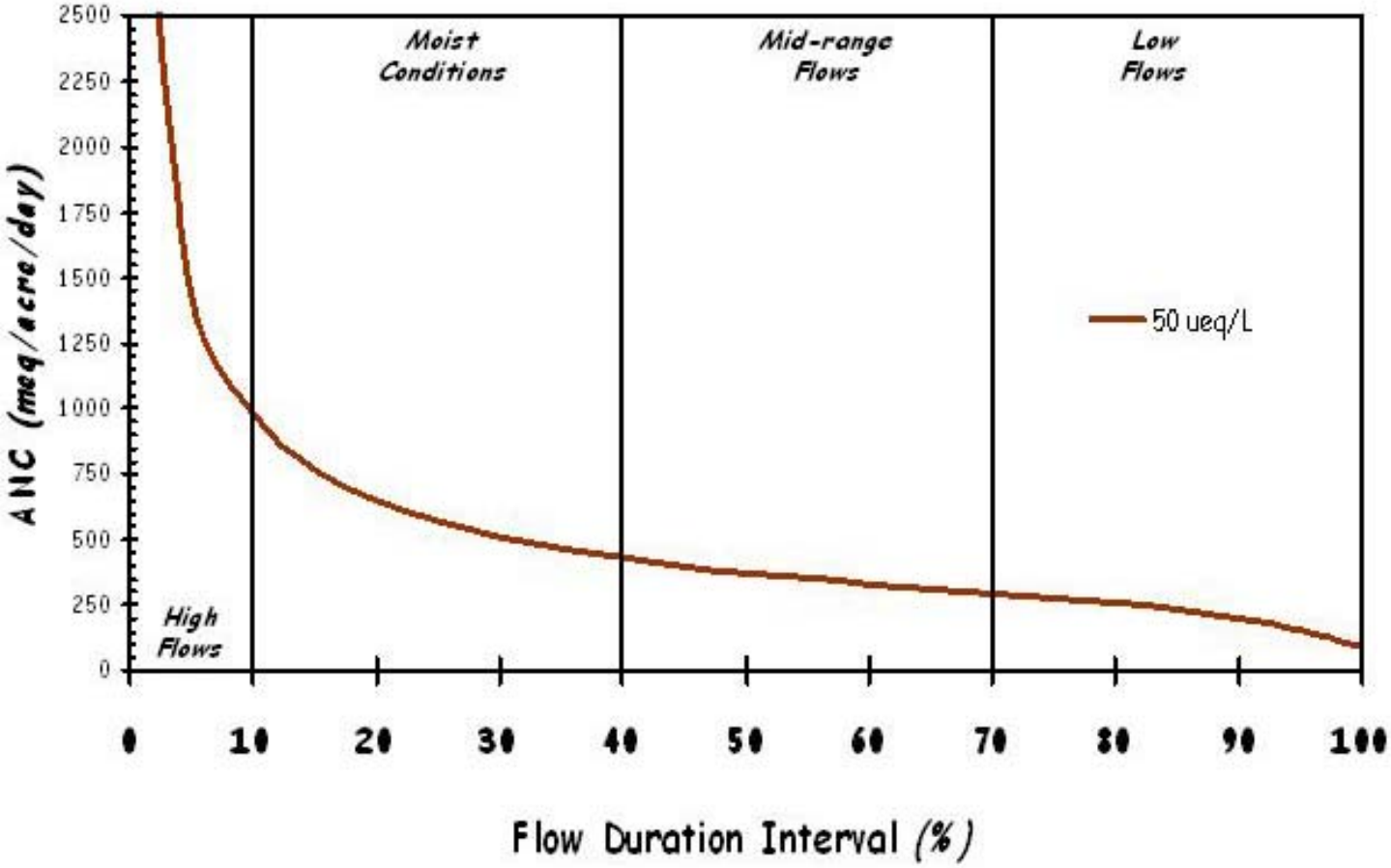


Figure D-3 Sample Target ANC Load Duration Curve (non-log scale) (using default minimum ANC concentration)

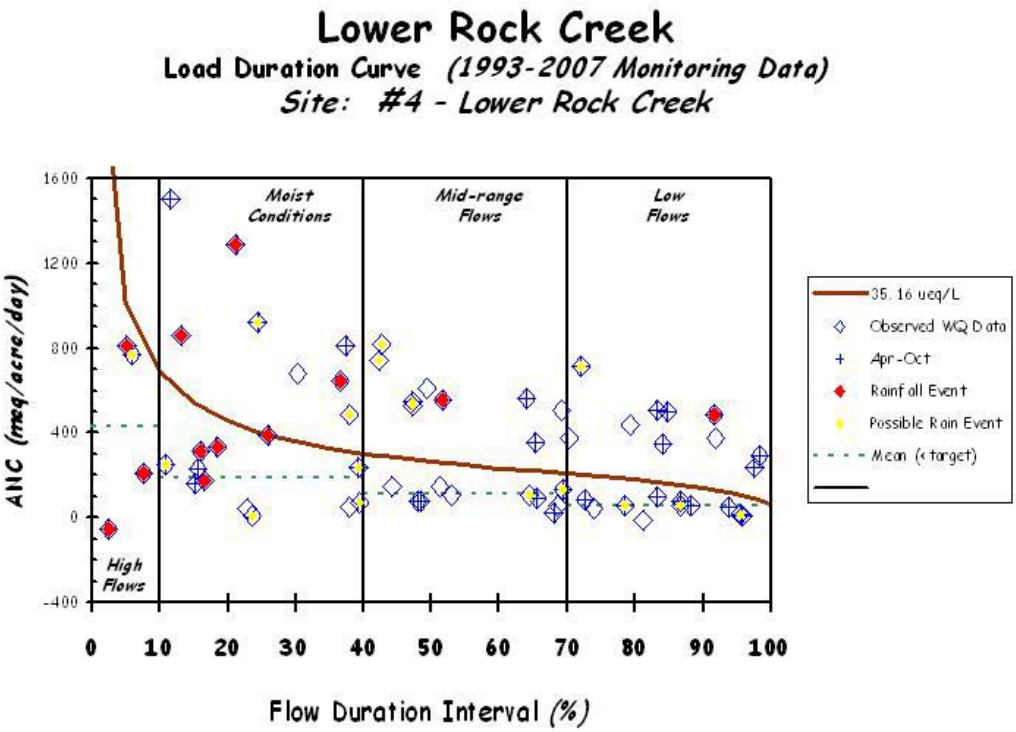


Figure D-4 ANC Load Duration Curve for Lower Rock Creek

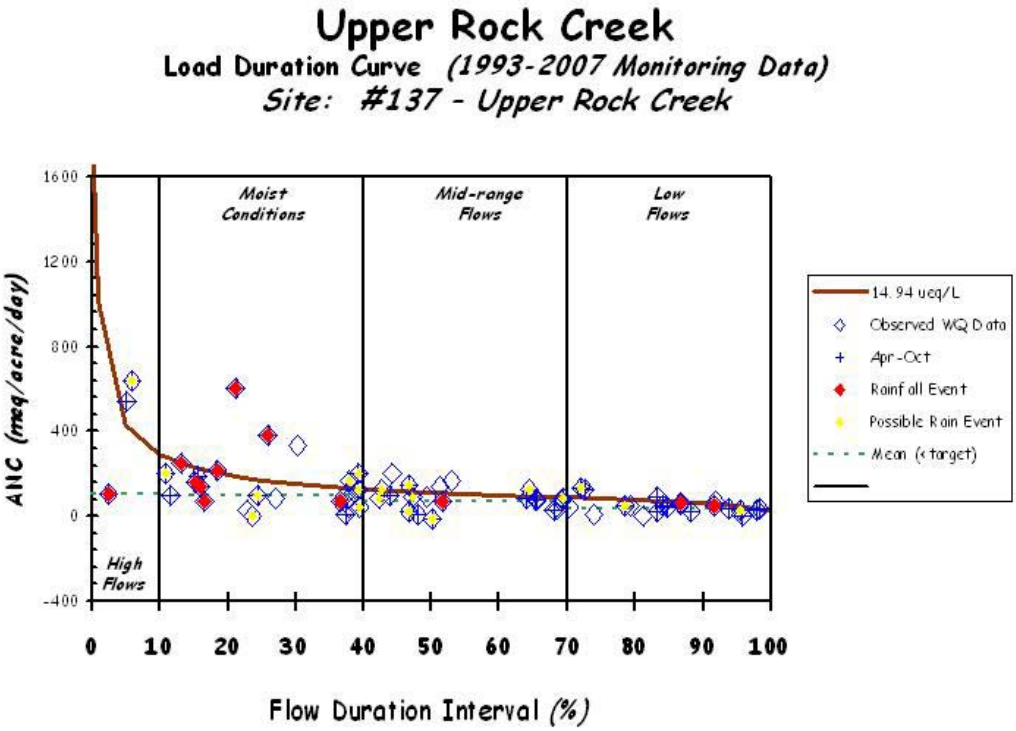


Figure D-5 ANC Load Duration Curve for Upper Rock Creek

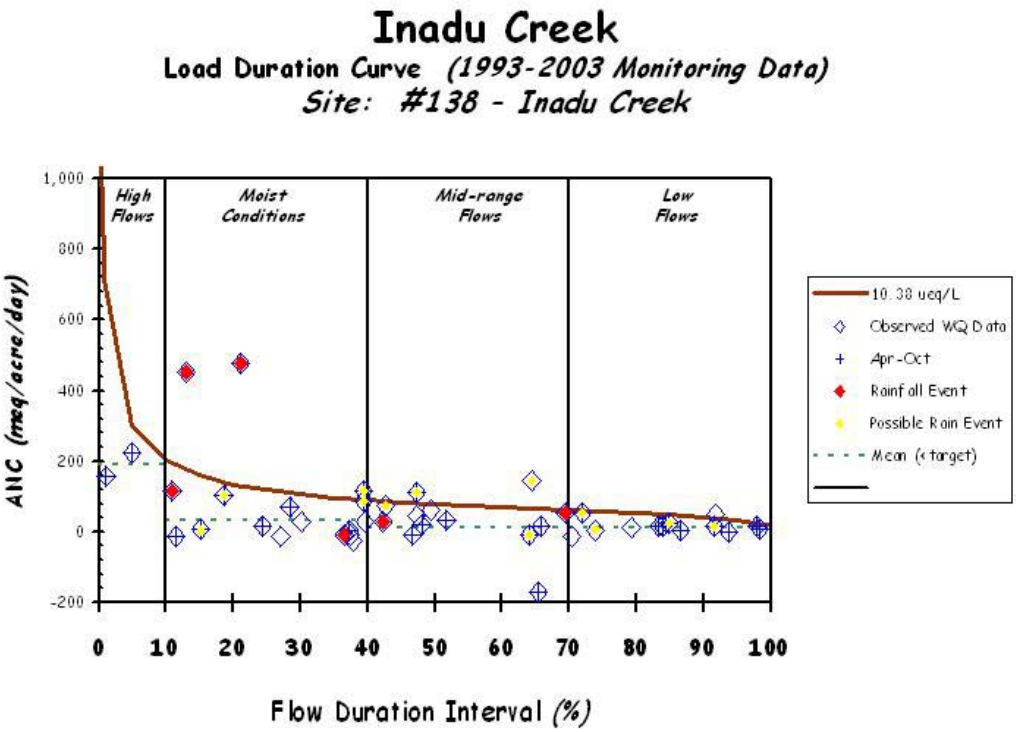


Figure D-6 ANC Load Duration Curve for Inadu Creek

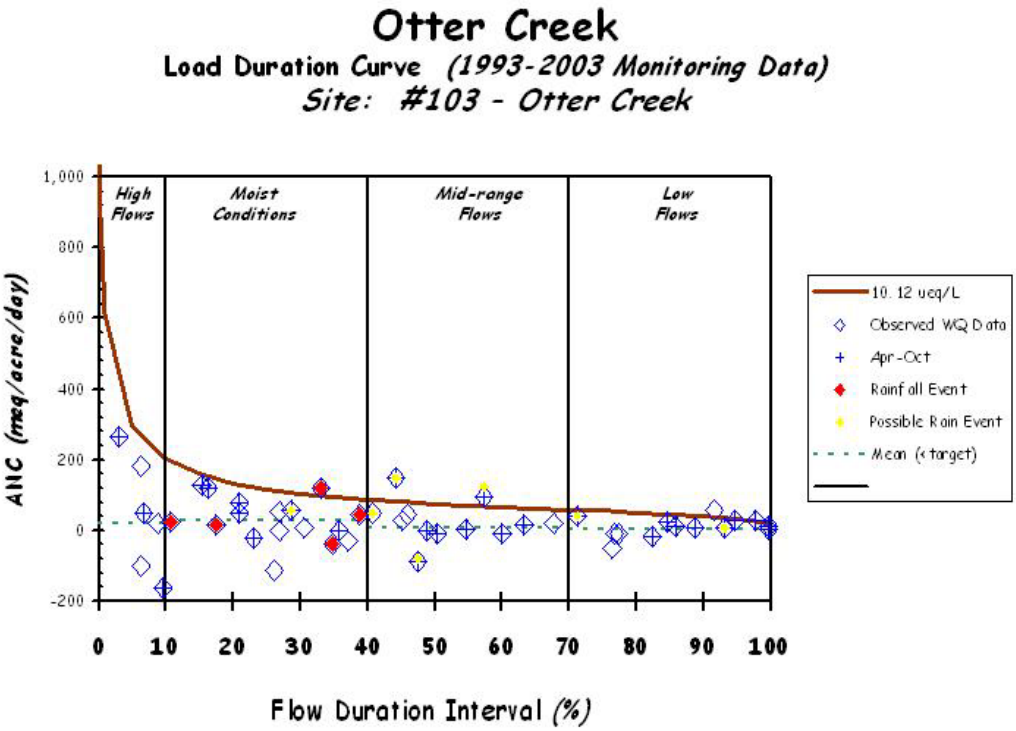


Figure D-7 ANC Load Duration Curve for Otter Creek

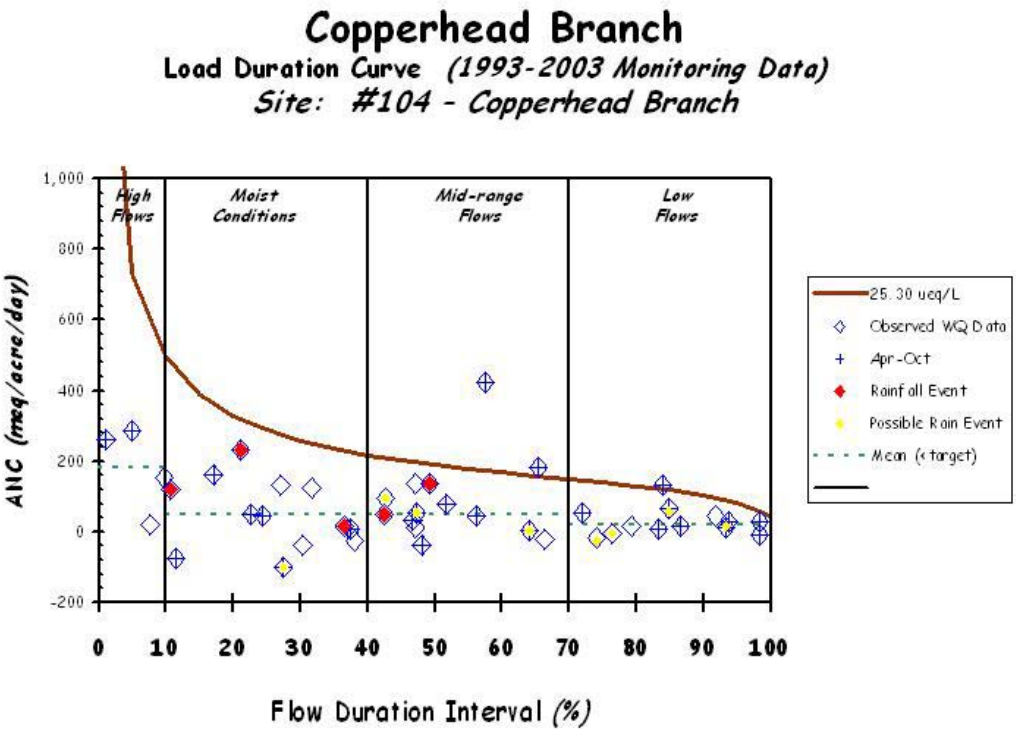


Figure D-8 ANC Load Duration Curve for Copperhead Branch

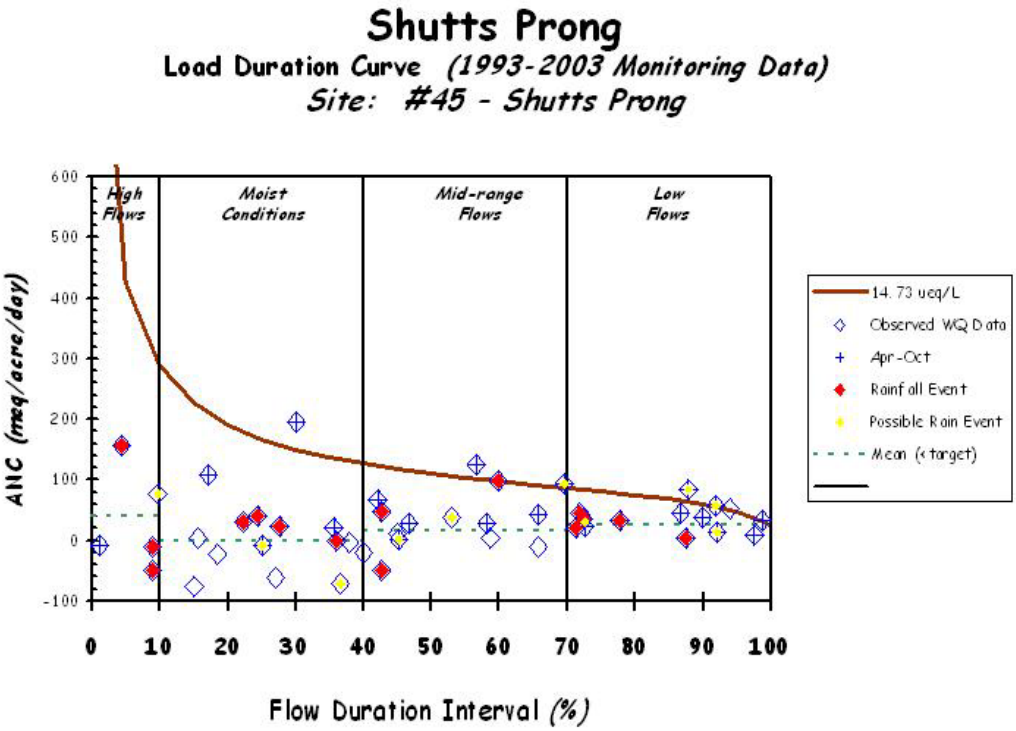


Figure D-9 ANC Load Duration Curve for Shutts Prong

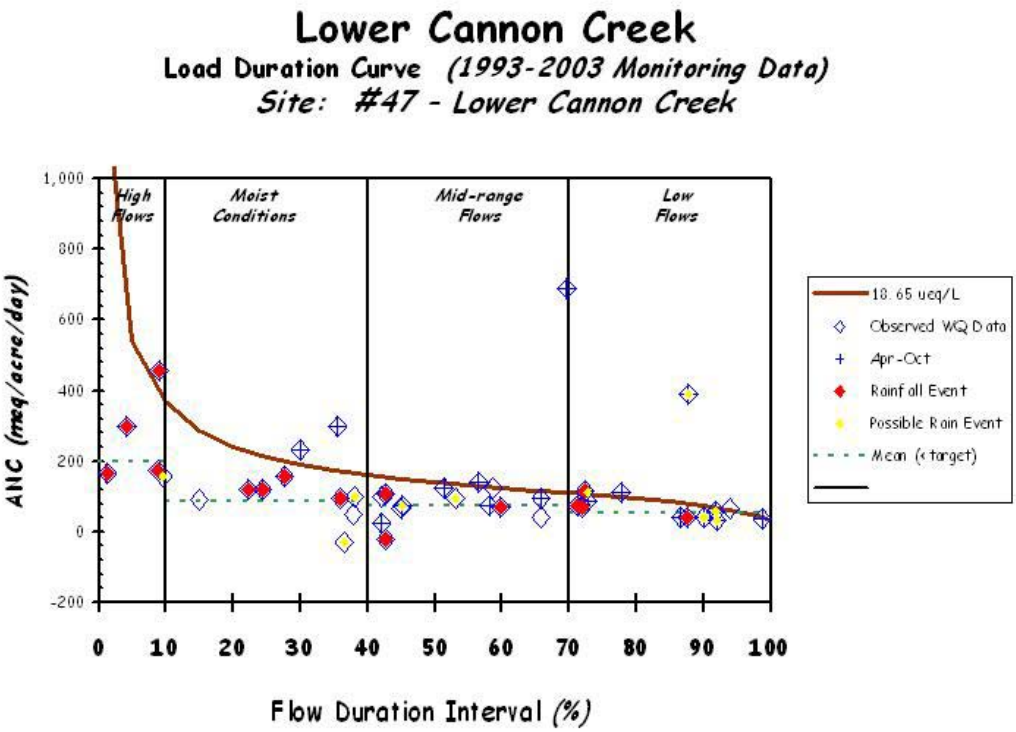


Figure D-10 ANC Load Duration Curve for Cannon Creek

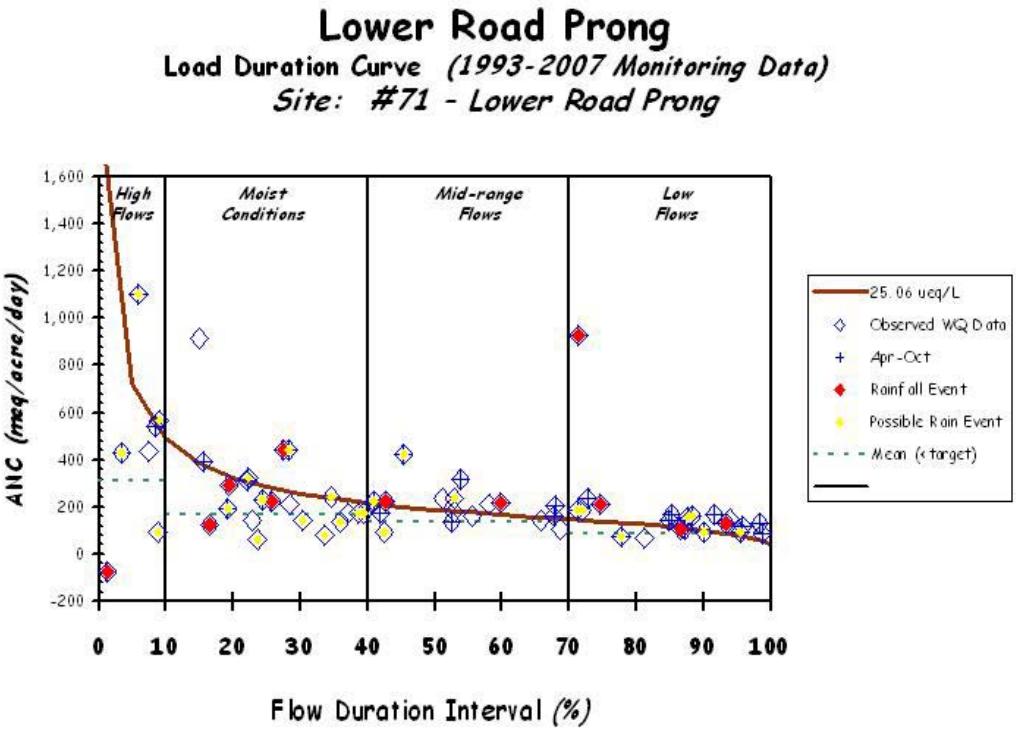


Figure D-11 ANC Load Duration Curve for Lower Road Prong

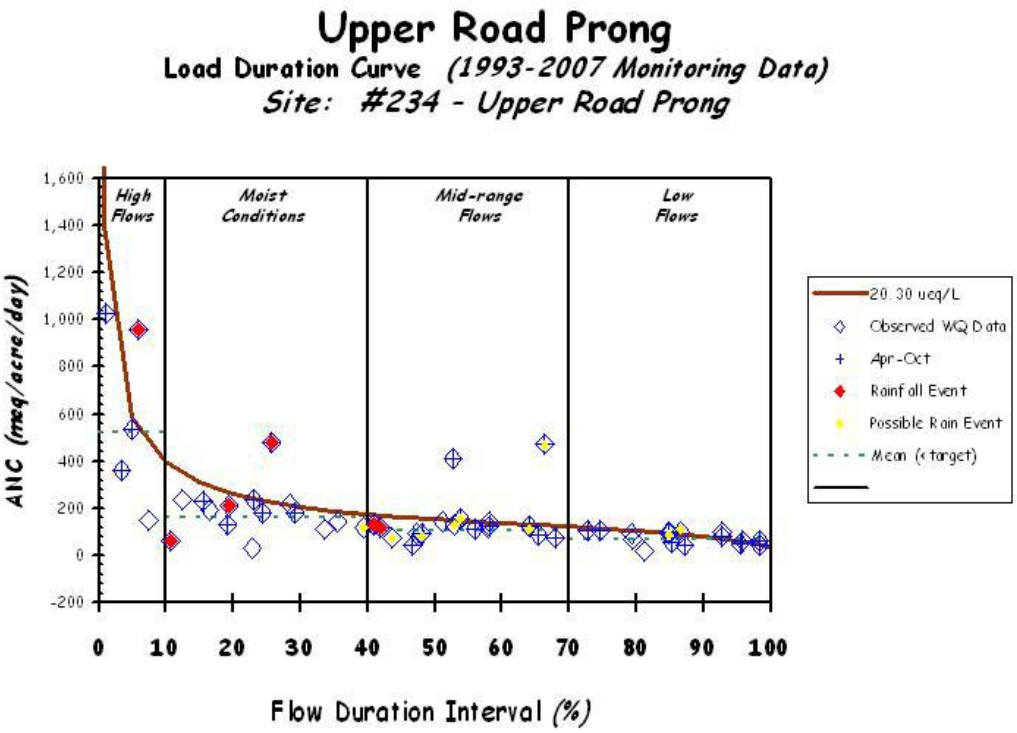


Figure D-12 ANC Load Duration Curve for Upper Road Prong

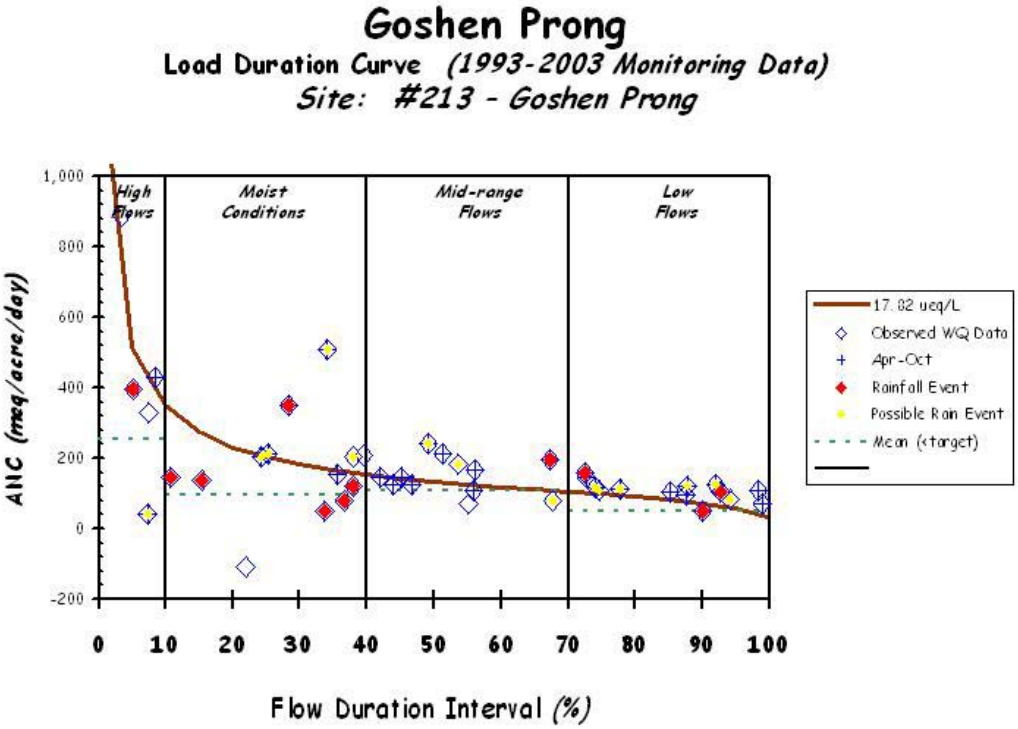


Figure D-13 ANC Load Duration Curve for Goshen Prong

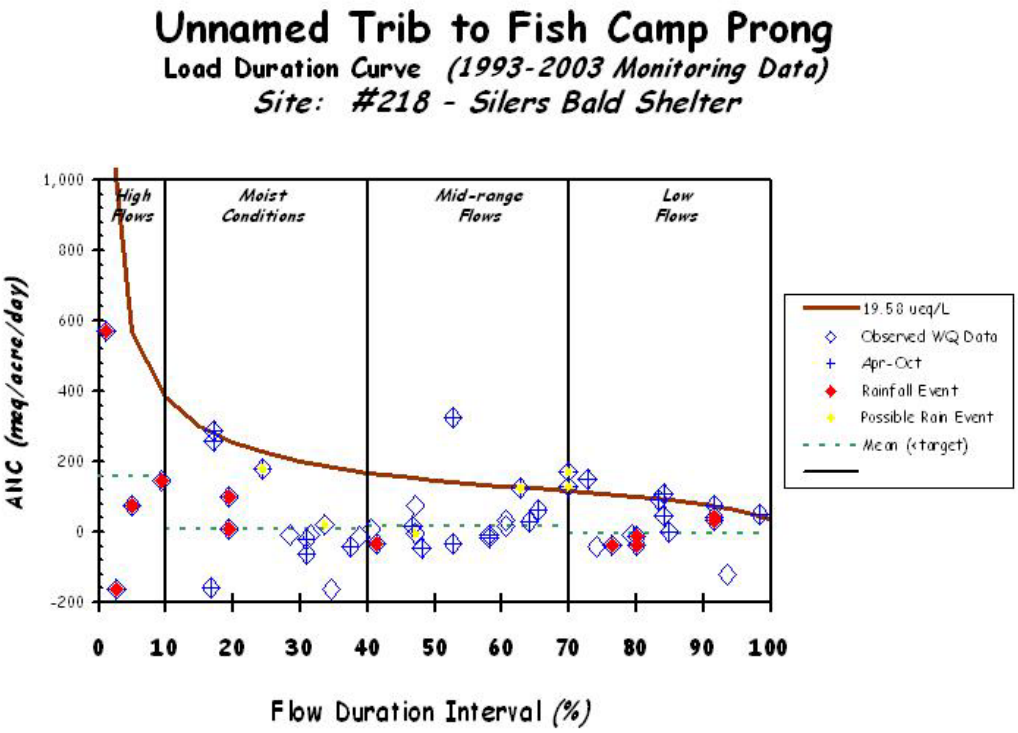


Figure D-14 ANC Load Duration Curve for UT to Fish Camp Prong

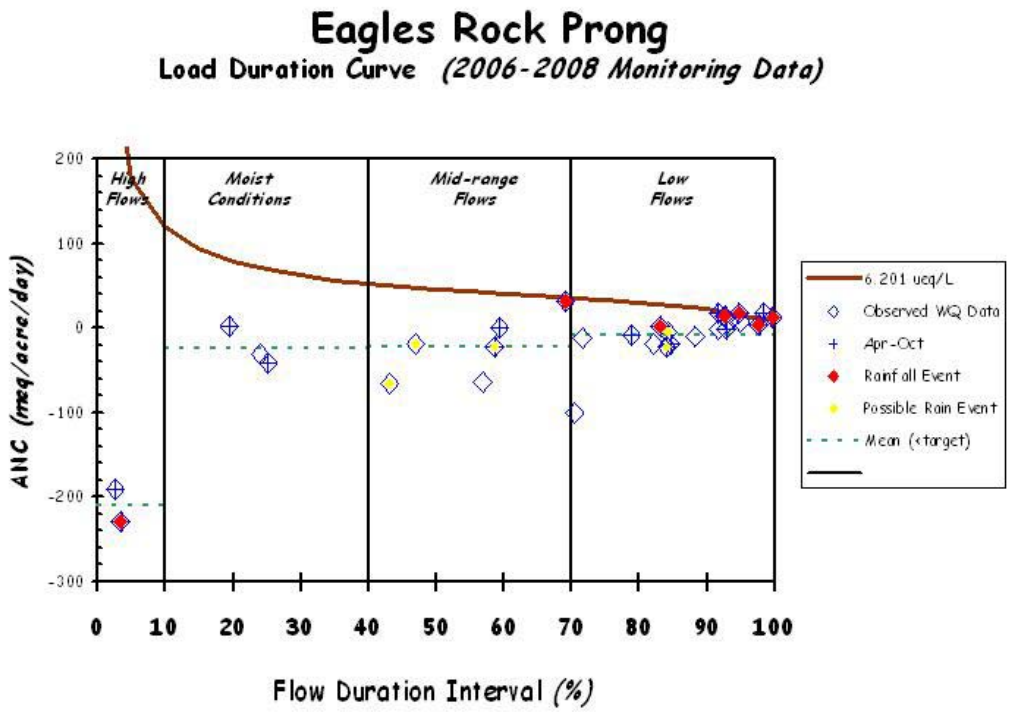


Figure D-15 ANC Load Duration Curve for Eagles Rock Prong

Table D-1. Load Calculations for Lower Rock Creek (Site #4)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/23/93	0.827	97.7	103.11	240.0
10/23/93	0.827	97.7	101.59	236.5
5/23/94	2.72	48.4	10.16	77.8
8/20/94	8.30	7.6	8.82	206.2
2/25/95	2.68	49.4	80.60	609.2
3/26/95	2.13	69.3	84.91	508.1
4/15/95	1.69	84.1	73.33	349.9
5/12/95	6.67	10.9	13.46	252.8
7/21/95	1.22	93.9	13.99	48.2
8/15/95	2.03	72.8	15.27	87.3
10/13/95	4.77	18.6	25.04	336.3
12/17/95	3.15	38.0	55.00	487.5
2/27/96	2.24	64.5	17.15	108.4
5/15/96	10.21	5.1	28.28	813.4
8/15/96	5.43	15.2	10.61	162.3
10/24/96	3.07	39.4	27.28	236.1
3/16/97	3.15	38.0	5.55	49.2
5/18/97	2.21	65.7	14.93	93.0
8/15/97	1.59	86.8	17.16	77.0
10/17/97	2.12	69.5	21.92	130.8
3/13/98	2.09	70.5	63.75	375.9
5/15/98	2.61	51.8	75.67	556.3
8/17/98	1.35	91.7	127.92	485.8
10/15/98	0.782	98.4	133.59	294.1
3/21/99	3.22	36.7	71.39	647.3
5/15/99	4.09	24.4	80.20	923.4
8/15/99	2.22	65.5	56.32	351.9
10/15/99	3.18	37.4	90.13	808.1
3/15/00	2.00	74.0	7.61	42.8
5/15/00	2.73	48.1	9.86	75.8
8/15/00	1.72	83.4	105.07	508.8
11/15/00	1.85	79.4	84.16	437.4
3/15/01	2.76	47.4	67.78	525.9
5/15/01	1.66	84.9	107.20	501.8
8/15/01	2.25	64.1	88.28	559.7
11/12/01	1.34	92.0	99.89	376.0

Table D-1 (cont'd). Load Calculations for Lower Rock Creek (Site #4)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/25/02	3.61	30.3	67.09	682.5
5/20/02	6.38	11.6	83.46	1498.2
8/16/02	2.05	72.1	123.56	714.2
11/18/02	5.94	13.1	51.22	857.2
3/18/03	2.93	42.8	98.80	814.9
5/19/03	2.76	47.4	70.82	549.9
8/15/03	4.47	21.1	102.65	1292.1
11/13/03	2.94	42.4	89.20	738.9
3/20/04	3.07	39.5	7.85	68.0
5/15/04	1.72	83.4	20.54	99.4
7/19/04	1.87	78.6	10.68	56.2
9/25/04	5.37	15.6	15.40	233.0
11/20/04	2.63	51.3	19.44	143.7
1/20/05	2.87	44.3	18.55	150.1
3/19/05	2.57	53.0	14.65	106.1
5/21/05	9.48	6.0	28.73	766.7
7/16/05	3.97	25.9	34.98	391.1
11/19/05	1.60	86.8	13.20	59.3
1/21/06	5.13	16.6	12.03	173.8
3/18/06	2.14	68.7	9.41	56.7
5/20/06	15.19	2.5	-1.27	-54.2
7/15/06	5.27	16.1	21.03	311.8
9/16/06	2.15	68.1	4.15	25.2
11/20/06	4.27	22.9	3.49	41.9
1/20/07	1.78	81.3	-2.56	-12.9
3/17/07	4.16	23.7	0.69	8.1
5/20/07	1.52	88.3	12.55	53.8
7/21/07	1.02	96.0	3.20	9.1
9/15/07	1.06	95.6	5.48	16.3

Note: Target ANC Concentration for Lower Rock Creek was 35.158 μeq/L.

Table D-2. Load Calculations for Upper Rock Creek (Site #137)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/24/93	0.808	98.1	12.35	28.1
2/20/94	3.84	27.1	7.83	84.7
3/19/94	3.17	37.5	9.00	80.5
3/19/94	3.17	37.5	11.61	103.8
5/22/94	2.89	43.9	11.84	96.2
5/22/94	2.89	43.9	11.84	96.2
8/15/94	2.78	46.8	19.04	149.2
8/15/94	2.78	46.8	3.06	24.0
2/25/95	2.68	49.4	12.42	93.9
3/26/95	2.13	69.3	11.37	68.0
4/15/95	1.69	84.1	10.98	52.4
5/12/95	6.67	10.9	10.93	205.3
7/21/95	1.22	93.9	10.70	36.8
8/15/95	2.03	72.8	21.45	122.7
10/13/95	4.77	18.6	16.11	216.4
12/17/95	3.15	38.0	18.96	168.0
2/27/96	2.24	64.5	19.42	122.7
5/15/96	10.21	5.1	18.77	539.6
8/15/96	5.43	15.2	10.36	158.5
10/24/96	3.07	39.4	14.60	126.4
10/24/96	3.07	39.4	14.60	126.4
10/24/96	3.07	39.4	23.19	200.7
3/16/97	3.15	38.0	4.67	41.4
5/18/97	2.21	65.7	12.40	77.3
8/15/97	1.59	86.8	12.85	57.7
10/17/97	2.12	69.5	14.05	83.8
3/13/98	2.09	70.5	7.24	42.7
5/15/98	2.61	51.8	9.17	67.4
8/17/98	1.35	91.7	13.31	50.5
10/15/98	0.782	98.4	17.14	37.7
3/21/99	3.22	36.7	8.02	72.7
5/15/99	4.09	24.4	8.42	96.9
8/15/99	2.22	65.5	12.05	75.3
10/15/99	3.18	37.4	0.90	8.1
3/15/00	2.00	74.0	1.10	6.2
5/15/00	2.73	48.1	0.70	5.4
8/15/00	1.72	83.4	4.79	23.2
11/15/00	1.85	79.4	9.11	47.3

Table D-2 (cont'd). Load Calculations for Upper Rock Creek (Site #137)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/15/01	2.76	47.4	11.76	91.2
5/15/01	1.66	84.9	8.70	40.7
8/15/01	2.25	64.1	13.16	83.4
11/12/01	1.34	92.0	17.88	67.3
3/25/02	3.61	30.3	33.00	335.7
5/20/02	6.38	11.6	5.57	100.0
8/16/02	2.05	72.1	22.96	132.7
11/18/02	5.94	13.1	14.80	247.7
3/18/03	2.93	42.8	15.56	128.3
5/20/03	2.66	50.1	-1.88	-14.1
8/15/03	4.47	21.1	47.94	603.5
11/13/03	2.94	42.4	10.02	83.0
3/20/04	3.07	39.5	4.79	41.5
5/15/04	1.72	83.4	18.48	89.4
7/19/04	1.87	78.6	9.42	49.5
9/25/04	5.37	15.6	12.66	191.5
11/20/04	2.63	51.3	19.13	141.4
1/20/05	2.87	44.3	25.23	204.2
3/19/05	2.57	53.0	22.86	165.7
5/21/05	9.48	6.0	24.00	640.4
7/16/05	3.97	25.9	33.97	379.8
11/19/05	1.60	86.8	13.80	62.0
1/21/06	5.13	16.6	4.91	71.0
3/18/06	2.14	68.7	5.66	34.1
5/20/06	15.19	2.5	2.40	102.8
7/15/06	5.27	16.1	9.34	138.4
9/16/06	2.15	68.1	4.62	28.0
11/20/06	4.27	22.9	2.33	27.9
1/20/07	1.78	81.3	0.75	3.8
3/17/07	4.16	23.7	-0.09	-1.0
5/20/07	1.52	88.3	4.42	19.0
7/21/07	1.02	96.0	0.31	0.9
9/15/07	1.06	95.6	10.14	30.2

Note: Target ANC Concentration for Upper Rock Creek was 14.938 μeq/L.

Table D-3. Load Calculations for Inadu Creek (Site #138)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/24/93	0.701	98.1	7.23	16.5
2/20/94	3.33	27.1	-1.09	-11.8
3/19/94	2.75	37.5	-0.98	-8.8
5/15/94	19.94	1.2	2.44	158.0
8/15/94	2.41	46.8	-1.24	-9.7
10/15/94	3.25	28.6	6.67	70.3
2/25/95	2.33	49.5	7.94	60.0
3/15/95	2.66	39.6	3.41	29.5
4/15/95	1.47	84.1	3.02	14.4
5/12/95	5.77	11.0	6.10	114.5
7/21/95	1.06	93.9	-0.77	-2.7
8/23/95	2.66	39.5	10.00	86.4
8/23/95	2.66	39.5	10.00	86.4
10/13/95	4.14	18.6	7.81	104.9
2/27/96	1.94	64.5	23.12	146.1
5/15/96	8.87	5.1	7.82	225.3
8/15/96	4.71	15.2	0.39	5.9
10/24/96	2.66	39.5	13.52	117.0
3/16/97	2.73	38.0	-2.98	-26.4
5/18/97	1.92	65.8	2.70	16.8
8/15/97	1.38	86.8	0.92	4.1
10/17/97	1.84	69.5	9.17	54.7
3/13/98	1.81	70.5	-2.11	-12.5
5/15/98	2.26	51.8	4.33	31.8
8/17/98	1.17	91.7	4.47	17.0
10/15/98	0.678	98.4	3.00	6.6
3/21/99	2.79	36.7	-1.13	-10.2
5/15/99	3.54	24.4	1.47	16.9
8/15/99	1.92	65.5	-27.77	-173.5
10/15/99	2.76	37.4	0.20	1.8
3/15/00	1.73	74.0	0.76	4.3
5/15/00	2.37	48.1	2.40	18.5
8/15/00	1.49	83.4	3.39	16.4
11/15/00	1.60	79.4	2.60	13.5
3/15/01	2.39	47.4	6.01	46.7
5/15/01	1.44	84.9	5.52	25.8
8/15/01	1.95	64.1	-1.34	-8.5
11/12/01	1.16	92.0	13.28	50.0

Table D-3 (cont'd). Load Calculations for Inadu Creek (Site #138)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/25/02	3.13	30.3	2.62	26.6
5/20/02	5.52	11.6	-0.84	-15.1
8/16/02	1.78	72.1	9.16	52.9
11/18/02	5.15	13.1	26.96	451.0
3/18/03	2.54	42.7	8.96	73.9
5/19/03	2.39	47.4	14.54	112.9
8/15/03	3.87	21.1	37.88	476.5
11/13/03	2.55	42.4	3.27	27.1

Note: Target ANC Concentration for Inadu Creek was 10.376 μeq/L.

Table D-4. Load Calculations for Otter Creek (Site #103)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/15/93	0.437	99.9	6.64	12.1
10/15/93	0.437	99.9	6.64	12.1
10/15/93	0.437	99.9	1.91	3.5
2/15/94	6.21	6.4	6.98	180.6
2/15/94	6.21	6.4	-3.94	-101.9
2/15/94	6.21	6.4	-3.94	-101.9
3/15/94	2.64	27.0	0.04	0.4
5/15/94	9.24	3.0	6.92	266.3
8/15/94	1.82	49.0	-0.21	-1.6
2/19/95	5.10	8.9	0.86	18.3
3/25/95	1.45	67.9	3.08	18.5
3/25/95	1.45	67.9	3.08	18.5
4/15/95	1.11	84.8	5.09	23.5
5/23/95	3.07	21.0	6.27	80.1
5/23/95	3.07	21.0	3.75	47.9
7/21/95	0.777	94.8	8.55	27.7
8/20/95	2.33	33.1	12.41	120.3
9/15/95	3.71	15.4	8.19	126.6
10/12/95	3.56	16.3	8.20	121.4
10/12/95	3.56	16.3	8.20	121.4
11/19/95	2.64	27.0	4.72	51.8
12/15/95	1.89	46.1	5.70	44.9
3/15/96	2.44	30.7	0.93	9.5
5/15/96	6.03	6.7	2.02	50.8

Table D-4 (cont'd). Load Calculations for Otter Creek (Site #103)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
8/19/96	2.53	28.8	5.62	59.4
10/17/96	1.64	57.4	14.16	96.5
3/16/97	2.17	37.1	-3.11	-28.2
5/15/97	1.69	54.7	0.67	4.7
8/15/97	1.01	88.9	1.47	6.2
3/14/98	1.26	77.5	-2.01	-10.6
5/15/98	1.79	50.4	-1.19	-8.9
8/15/98	0.861	93.2	1.89	6.8
10/15/98	0.578	97.9	12.00	28.9
3/21/99	2.26	34.9	-4.14	-39.0
5/15/99	2.90	23.1	-1.87	-22.6
8/15/99	1.53	63.3	2.36	15.0
10/15/99	2.23	35.8	-0.23	-2.1
3/15/00	1.29	76.4	-9.72	-52.3
5/15/00	1.86	47.6	-11.64	-89.9
8/15/00	1.16	82.5	-3.30	-16.0
11/15/00	1.28	76.8	-1.44	-7.7
3/15/01	1.92	45.3	3.74	29.9
5/15/01	1.08	86.0	2.16	9.7
8/15/01	1.58	60.2	-1.67	-11.0
11/12/01	0.909	91.8	15.45	58.5
3/25/02	2.68	26.2	-9.94	-110.9
5/20/02	4.88	9.7	-8.05	-163.6
8/16/02	1.38	71.2	7.04	40.6
11/17/02	4.63	10.7	1.30	25.1
3/18/03	2.05	40.8	5.96	50.9
5/19/03	1.94	44.4	18.31	147.7
8/15/03	3.37	17.6	1.11	15.6
11/13/03	2.11	39.0	5.08	44.6

Note: Target ANC Concentration for Otter Creek was 10.121 μeq/L.

Table D-5. Load Calculations for Copperhead Branch (Site #104)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/15/93	0.175	98.5	-4.25	-9.3
2/15/94	1.839	7.7	0.85	19.7
5/15/94	5.165	1.2	4.01	260.7
8/15/94	0.623	46.8	4.21	33.0
2/19/95	1.587	9.8	7.57	151.3
3/25/95	0.491	66.4	-3.74	-23.1
4/15/95	0.379	84.1	27.56	131.4
5/23/95	0.959	22.8	3.93	47.4
7/21/95	0.273	93.9	7.87	27.1
8/20/95	0.601	49.3	17.82	134.8
9/15/95	1.119	17.2	11.43	160.9
10/12/95	1.146	16.6	161.56	2329.9
11/19/95	0.858	27.2	12.18	131.5
12/15/95	0.619	47.2	17.63	137.3
3/15/96	0.786	31.7	12.35	122.3
5/15/96	2.312	5.0	9.86	286.9
8/19/96	0.852	27.5	-9.46	-101.5
10/17/96	0.544	57.6	61.43	420.5
3/16/97	0.703	38.1	-2.88	-25.5
5/15/97	0.553	56.2	6.74	46.9
8/15/97	0.356	86.8	3.17	14.2
3/14/98	0.432	76.5	-0.70	-3.8
5/15/98	0.584	51.8	10.81	79.5
8/15/98	0.280	93.5	3.77	13.3
10/15/98	0.175	98.5	13.73	30.2
3/21/99	0.721	36.6	1.96	17.8
5/15/99	0.912	24.5	3.81	43.7
8/15/99	0.496	65.5	29.00	181.1
10/15/99	0.711	37.5	0.80	7.2
3/15/00	0.446	74.1	-3.00	-16.9
5/15/00	0.610	48.1	-5.01	-38.5
8/15/00	0.384	83.4	1.78	8.6
11/15/00	0.412	79.4	2.76	14.3
3/15/01	0.618	47.3	1.26	9.8
5/15/01	0.371	85.0	14.12	66.0
8/15/01	0.503	64.2	0.33	2.1
11/12/01	0.299	92.0	11.74	44.2

Table D-5 (cont'd). Load Calculations for Copperhead Branch (Site #104)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/25/02	0.805	30.4	-3.56	-36.1
5/20/02	1.419	11.5	-4.15	-74.1
8/16/02	0.459	72.1	8.90	51.4
11/17/02	1.498	10.8	6.32	119.1
3/18/03	0.655	42.8	11.66	96.1
5/19/03	0.616	47.4	6.74	52.3
8/15/03	0.996	21.2	18.33	229.8
11/13/03	0.657	42.5	5.79	47.9

Note: Target ANC Concentration for Copperhead Creek was 25.304 μeq/L.

Table D-6. Load Calculations for Shutts Prong (Site #45)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/23/93	0.950	97.7	4.23	9.8
1/15/94	5.48	18.6	-1.59	-21.4
2/20/94	4.41	27.1	-5.77	-62.4
3/21/94	3.51	40.0	-2.29	-19.7
5/15/94	26.43	1.2	-0.12	-7.6
8/15/94	3.20	46.8	3.48	27.3
12/11/94	6.15	15.7	0.34	5.2
1/22/95	3.27	45.1	1.46	11.7
2/19/95	8.19	9.7	3.82	76.6
2/19/95	8.19	9.7	3.82	76.6
3/19/95	2.75	58.8	0.50	3.4
4/9/95	1.83	86.8	10.12	45.4
5/20/95	12.64	4.3	5.07	157.0
6/18/95	3.27	45.3	0.27	2.2
7/16/95	1.54	92.0	15.51	58.4
8/15/95	2.33	72.8	4.09	23.4
9/15/95	5.76	17.1	7.69	108.6
10/22/95	4.16	30.1	19.16	195.4
3/17/96	4.97	22.4	2.44	29.7
5/19/96	3.76	35.7	2.34	21.6
8/18/96	4.62	25.2	-0.77	-8.8
10/22/96	2.83	56.6	18.06	125.2
3/16/97	3.61	38.0	-0.48	-4.3
5/18/97	2.54	65.8	7.00	43.6

Table D-6 (cont'd). Load Calculations for Shutts Prong (Site #45)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
8/16/97	1.77	87.9	19.45	84.5
10/21/97	2.43	69.7	15.72	93.6
3/21/98	8.61	8.9	-2.34	-49.3
5/18/98	2.77	58.2	4.32	29.3
8/18/98	1.53	92.1	3.46	13.0
10/17/98	0.869	98.9	15.74	33.5
3/21/99	3.70	36.7	-7.92	-71.8
5/15/99	4.69	24.5	3.50	40.3
8/21/99	2.17	77.8	6.05	32.2
10/16/99	3.40	42.2	8.06	67.2
3/18/00	3.36	42.8	-5.87	-48.4
5/20/00	2.71	59.9	14.98	99.7
8/19/00	1.79	87.6	0.84	3.7
11/18/00	2.36	72.0	7.71	44.6
3/24/01	2.54	65.8	-1.56	-9.7
5/19/01	1.65	90.1	9.43	38.1
8/18/01	2.38	71.3	3.64	21.2
11/17/01	1.40	94.0	15.55	53.4
3/23/02	6.29	15.0	-4.97	-76.6
8/17/02	2.34	72.5	6.08	34.9
11/16/02	8.56	9.0	-0.52	-10.9
3/15/03	3.73	36.0	-0.20	-1.8
5/17/03	3.37	42.7	5.76	47.5
8/16/03	4.36	27.7	2.23	23.9
11/15/03	2.95	53.1	5.40	39.1

Note: Target ANC Concentration for Shutts Prong was 14.732 μeq/L.

Table D-7. Load Calculations for Cannon Creek (Site #47)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
12/15/94	4.09	42.2	11.65	97.0
1/22/95	3.94	45.0	8.04	64.5
2/19/95	9.86	9.7	7.94	159.4
3/19/95	3.30	58.8	18.64	125.4
4/9/95	2.20	86.8	8.69	39.0
5/20/95	15.22	4.3	9.67	299.6
6/18/95	3.93	45.3	9.18	73.5

Table D-7 (cont'd). Load Calculations for Cannon Creek (Site #47)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
7/16/95	1.85	92.0	15.47	58.3
8/15/95	2.81	72.8	14.82	84.7
9/9/95	3.63	51.4	16.54	122.2
10/22/95	5.01	30.1	22.66	231.1
12/17/95	4.35	38.1	11.42	101.2
3/17/96	5.98	22.3	9.96	121.3
5/19/96	4.52	35.7	32.24	296.9
10/22/96	3.40	56.6	20.36	141.1
3/16/97	4.35	38.0	5.60	49.7
5/18/97	3.06	65.8	15.25	95.0
8/16/97	2.13	87.9	90.03	391.3
10/21/97	2.93	69.7	115.45	687.9
3/21/98	10.37	8.9	8.16	172.3
5/18/98	3.34	58.2	11.05	75.1
8/18/98	1.84	92.1	9.19	34.4
10/17/98	1.05	98.9	17.94	38.2
3/21/99	4.45	36.7	-3.35	-30.4
5/15/99	5.65	24.4	10.37	119.3
8/21/99	2.62	77.8	20.58	109.6
10/16/99	4.09	42.2	2.88	24.0
3/18/00	4.05	42.8	-2.76	-22.8
5/20/00	3.27	59.9	10.57	70.3
8/19/00	2.15	87.6	8.97	39.3
11/18/00	2.84	72.0	12.03	69.6
3/24/01	3.05	65.8	6.75	42.0
5/19/01	1.98	90.1	9.85	39.8
8/18/01	2.87	71.3	12.35	72.1
11/17/01	1.69	94.0	18.96	65.1
3/23/02	7.57	15.0	5.98	92.2
5/18/02	29.04	1.3	2.79	165.0
8/17/02	2.82	72.5	19.98	114.7
11/16/02	10.31	9.0	21.68	455.1
3/15/03	4.49	36.0	10.30	94.2
5/17/03	4.05	42.7	13.23	109.2
8/16/03	5.25	27.7	14.75	157.8
11/15/03	3.55	53.1	13.09	94.7

Note: Target ANC Concentration for Lower Cannon Creek was 18.65 μeq/L.

Table D-8. Load Calculations for Lower Road Prong (Site #71)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/15/93	1.88	98.4	59.80	131.7
2/15/94	19.87	7.6	18.65	434.2
2/15/94	19.87	7.6	18.65	434.2
3/15/94	9.01	28.5	19.76	208.6
12/10/94	10.37	22.4	26.82	326.0
1/21/95	7.68	37.2	19.15	172.4
2/22/95	8.65	30.4	13.96	141.5
3/18/95	5.98	55.6	23.21	162.5
4/8/95	3.96	85.4	36.71	170.2
5/21/95	18.41	8.5	25.16	542.7
6/17/95	7.23	41.0	26.70	226.1
7/15/95	3.24	91.7	44.72	169.7
8/15/95	4.88	72.8	41.57	237.8
9/10/95	6.11	54.0	44.12	315.7
10/21/95	9.03	28.4	42.00	444.4
12/16/95	7.99	34.7	25.95	242.8
3/16/96	11.26	19.4	21.91	289.1
8/17/96	10.42	22.1	25.53	311.9
10/19/96	6.81	45.4	52.79	421.4
10/19/96	6.81	45.4	53.28	425.3
3/15/97	8.15	33.7	8.19	78.2
5/19/97	5.18	67.9	26.16	158.7
8/17/97	3.64	88.5	37.18	158.7
10/18/97	4.98	71.4	159.34	929.6
3/21/98	18.06	8.9	4.37	92.4
5/16/98	6.21	52.6	18.91	137.7
8/15/98	3.01	93.5	37.58	132.3
10/17/98	1.82	98.9	41.44	88.3
3/20/99	7.46	38.8	20.12	175.8
5/15/99	9.83	24.4	19.73	227.3
8/21/99	4.55	77.8	13.54	72.1
10/16/99	7.11	42.1	20.89	174.2
3/18/00	7.04	42.6	11.46	94.6
5/20/00	5.68	59.9	32.97	219.3
8/19/00	3.74	87.6	35.98	157.7
11/18/00	4.94	72.0	32.39	187.5
3/24/01	5.31	65.8	23.05	143.4
5/19/01	3.45	90.1	23.34	94.3

Table D-8 (cont'd). Load Calculations for Lower Road Prong (Site #71)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
8/18/01	4.98	71.3	31.97	186.7
11/17/01	2.93	94.0	42.85	147.3
3/23/02	13.19	15.0	59.14	914.0
5/18/02	50.39	1.3	-1.29	-76.2
11/16/02	17.92	9.0	26.84	563.8
3/15/03	7.81	36.0	14.84	135.8
5/17/03	7.04	42.7	26.83	221.4
8/16/03	9.14	27.6	41.09	440.1
11/15/03	6.18	53.0	33.03	239.1
3/20/04	7.39	39.5	19.94	172.6
5/16/04	4.00	84.9	30.58	143.4
7/17/04	4.74	74.8	38.27	212.6
9/25/04	12.91	15.6	25.93	392.4
11/20/04	6.31	51.3	32.27	238.6
1/24/05	5.81	58.1	30.50	207.5
3/19/05	6.19	53.0	25.29	183.3
5/21/05	22.79	6.0	41.16	1099.4
7/16/05	9.55	25.9	20.08	224.6
11/19/05	3.84	86.8	23.80	107.0
1/21/06	12.33	16.6	8.35	120.6
3/18/06	5.14	68.7	17.71	106.7
5/21/06	30.48	3.5	11.93	426.2
7/23/06	11.31	19.2	14.67	194.4
9/16/06	5.17	68.1	34.01	206.0
11/20/06	10.26	22.9	11.85	142.5
1/20/07	4.28	81.3	13.59	68.2
3/17/07	10.01	23.7	5.08	59.6
5/19/07	3.78	87.3	23.37	103.5
7/21/07	2.44	96.0	41.64	119.2
9/15/07	2.54	95.6	31.17	92.8

Note: Target ANC Concentration for Lower Road Prong was 25.056 μeq/L.

Table D-9. Load Calculations for Upper Road Prong (Site #234)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/15/93	1.88	98.4	26.82	59.1
2/15/94	19.87	7.6	6.49	151.1
3/15/94	9.01	28.5	20.60	217.4
5/15/94	55.18	1.2	15.92	1029.4
8/15/94	6.69	46.8	5.83	45.7
3/22/95	5.83	57.9	16.88	115.3
4/8/95	3.96	85.4	12.25	56.8
6/17/95	7.23	41.0	14.99	126.9
7/18/95	3.10	92.8	22.60	82.0
8/15/95	4.88	72.8	18.29	104.6
9/10/95	6.11	54.0	21.60	154.6
10/17/95	10.19	23.1	19.97	238.4
3/16/96	11.26	19.4	15.77	208.1
5/15/96	24.51	5.1	18.62	534.7
8/20/96	8.86	29.2	17.40	180.6
10/15/96	6.20	52.8	56.68	411.8
3/15/97	8.15	33.7	11.86	113.3
5/15/97	5.95	56.1	15.80	110.2
10/15/97	5.27	66.5	76.08	469.6
3/15/98	4.41	79.6	13.39	69.2
5/18/98	5.80	58.2	18.22	123.8
10/15/98	1.88	98.5	19.67	43.3
3/15/99	14.55	12.6	13.79	235.1
5/15/99	9.83	24.4	15.69	180.7
8/15/99	5.33	65.5	13.36	83.5
5/15/00	6.56	48.1	11.83	91.0
11/15/00	4.44	79.3	17.95	93.3
3/15/01	6.62	47.4	11.69	90.7
5/15/01	4.00	84.9	21.72	101.7
8/15/01	5.41	64.1	19.51	123.7
11/14/01	3.11	92.8	27.23	99.1
3/28/02	6.95	43.7	8.85	72.1
11/17/02	16.13	10.8	3.30	62.4
5/21/03	7.13	42.0	14.19	118.6
11/11/03	7.87	35.6	15.48	142.9
3/20/04	7.39	39.5	13.48	116.7
5/16/04	4.00	84.9	20.14	94.4
7/17/04	4.74	74.8	18.66	103.7

Table D-9 (cont'd). Load Calculations for Upper Road Prong (Site #234)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
9/25/04	12.91	15.6	15.26	230.9
11/20/04	6.31	51.3	19.55	144.5
1/24/05	5.81	58.1	21.32	145.0
3/19/05	6.19	53.0	18.29	132.6
5/21/05	22.79	6.0	35.98	960.9
7/16/05	9.55	25.9	43.11	482.3
11/19/05	3.84	86.8	22.20	99.8
1/21/06	12.33	16.6	13.39	193.4
5/21/06	30.48	3.5	10.17	363.1
7/23/06	11.31	19.2	9.82	130.2
9/16/06	5.17	68.1	12.18	73.8
11/20/06	10.26	22.9	2.42	29.1
1/20/07	4.28	81.3	3.26	16.3
5/19/07	3.78	87.3	9.21	40.8
7/21/07	2.44	96.0	22.12	63.3
9/15/07	2.54	95.6	17.17	51.1

Note: Target ANC Concentration for Upper Road Prong was 20.301 μeq/L.

Table D-10. Load Calculations for Goshen Prong (Site #213)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/15/93	1.62	98.5	48.53	106.8
2/15/94	17.09	7.6	14.12	328.4
5/15/94	47.56	1.2	21.43	1387.3
8/15/94	5.76	46.8	16.01	125.4
1/15/95	25.89	3.5	25.15	886.4
2/18/95	20.76	5.3	13.99	395.5
3/15/95	6.35	39.6	24.21	209.1
4/8/95	3.41	85.4	22.31	103.4
5/21/95	15.83	8.5	19.94	429.5
5/21/95	15.83	8.5	19.94	429.5
6/18/95	5.88	45.2	18.30	146.5
7/16/95	2.77	92.0	33.69	126.8
8/15/95	4.20	72.8	25.42	145.4
9/9/95	5.43	51.4	28.72	212.2

Table D-10 (cont'd). Load Calculations for Goshen Prong (Site #213)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
10/21/95	7.77	28.4	33.17	351.0
12/17/95	6.51	38.0	23.19	205.5
5/19/96	6.77	35.7	16.59	152.9
8/18/96	8.32	25.2	18.85	213.5
10/20/96	5.56	49.3	31.67	239.7
3/15/97	7.01	33.7	5.20	49.6
5/15/97	5.12	56.1	24.10	168.0
8/16/97	3.19	87.9	27.78	120.7
10/19/97	4.49	67.4	32.20	196.7
3/22/98	11.16	15.4	9.00	136.8
5/17/98	5.13	55.9	15.49	108.2
8/16/98	2.67	92.8	28.42	103.2
10/18/98	1.55	99.1	33.88	71.3
3/21/99	6.66	36.7	8.69	78.8
5/15/99	8.46	24.4	17.77	204.5
8/21/99	3.91	77.8	21.36	113.8
10/16/99	6.12	42.1	17.50	145.9
3/19/00	5.17	55.3	10.19	71.7
8/19/00	3.22	87.6	21.63	94.8
11/19/00	4.09	74.7	19.71	109.7
3/25/01	4.47	67.7	12.76	77.6
5/20/01	2.96	90.2	12.46	50.2
8/19/01	4.13	74.2	20.65	116.1
11/18/01	2.48	94.2	24.97	84.3
3/24/02	8.97	22.1	-8.73	-106.6
5/19/02	17.40	7.4	1.71	40.5
8/17/02	4.22	72.5	27.80	159.6
11/17/02	13.88	10.8	7.68	145.1
3/16/03	6.50	38.1	13.59	120.3
5/18/03	5.96	44.0	15.35	124.6
8/17/03	6.95	34.1	53.91	509.9
11/16/03	5.28	53.6	25.47	183.2

Note: Target ANC Concentration for Goshen Prong was 17.824 μeq/L.

Table D-11. Load Calculations for UT to Fish Camp Prong (Site #218)

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/15/94	0.946	28.6	-0.72	-7.6
5/15/94	5.83	1.2	8.76	569.7
8/15/94	0.704	46.9	1.99	15.6
3/20/95	0.592	60.6	2.33	15.4
3/20/95	0.592	60.6	4.92	32.5
4/7/95	0.426	84.2	22.84	108.6
4/7/95	0.426	84.2	9.56	45.4
5/14/95	3.69	2.7	-3.95	-162.4
7/15/95	0.340	91.7	20.19	76.6
8/15/95	0.512	72.9	26.67	152.3
8/15/95	0.512	72.9	26.18	149.5
9/15/95	1.26	17.2	20.30	285.8
9/15/95	1.26	17.2	18.41	259.1
10/15/95	1.18	19.4	7.51	99.0
10/15/95	1.18	19.4	0.58	7.6
12/15/95	0.699	47.2	9.68	75.4
3/15/96	0.889	31.6	-0.95	-9.4
5/15/96	2.61	5.0	2.56	74.6
10/15/96	0.651	52.7	-4.72	-34.3
10/15/96	0.651	52.7	44.44	322.5
3/15/97	0.855	33.7	2.05	19.5
3/15/97	0.855	33.7	2.13	20.3
5/20/97	0.578	62.9	19.27	124.2
8/4/97	0.459	80.2	-6.94	-35.5
8/4/97	0.459	80.2	-2.68	-13.7
10/22/97	0.533	69.9	22.05	131.0
10/22/97	0.533	69.9	28.57	169.7
4/7/98	0.897	31.0	-2.14	-21.4
4/7/98	0.897	31.0	-6.09	-60.9
5/18/98	0.609	58.2	-1.14	-7.7
5/18/98	0.609	58.2	-2.35	-16.0
8/17/98	0.341	91.7	8.66	32.9
8/17/98	0.341	91.7	10.85	41.2
10/15/98	0.197	98.5	22.66	49.9
3/22/99	0.781	39.0	-1.40	-12.2
5/15/99	1.03	24.5	15.53	178.2
8/15/99	0.560	65.5	10.30	64.3
10/15/99	0.803	37.5	-4.57	-40.9

Table D-11 (cont'd). Load Calculations for UT to Fish Camp Prong (Site #218)

Sample Date	Flow	PDFE	Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/15/00	0.504	74.1	-7.53	-42.3
5/15/00	0.689	48.1	-6.16	-47.3
8/15/00	0.434	83.4	18.80	91.0
11/15/00	0.466	79.4	-1.53	-7.9
3/15/01	0.698	47.3	-0.58	-4.5
5/15/01	0.419	85.0	-0.05	-0.2
8/15/01	0.568	64.2	4.38	27.7
11/16/01	0.315	93.6	-34.65	-121.5
3/26/02	0.839	34.6	-17.42	-163.0
5/21/02	1.28	16.8	-10.98	-157.0
8/20/02	0.488	76.4	-7.18	-39.1
11/15/02	1.84	9.4	7.20	147.4
3/17/03	0.763	40.6	0.84	7.1
5/21/03	0.754	41.5	-3.99	-33.5

Note: Target ANC Concentration for UT to Fish Camp Prong was 19.581 μeq/L.

Table D-12. Load Calculations for Eagles Rock Prong

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
3/8/06	5.91	71.7	-2.05	-11.6
3/22/06	8.03	47.0	-2.47	-19.0
4/23/06	42.29	2.7	-4.71	-190.1
5/31/06	36.58	3.5	-6.56	-229.3
6/20/06	6.12	69.2	5.44	31.8
6/27/06	11.71	25.2	-3.67	-41.0
8/4/06	6.93	58.7	-3.34	-22.1
9/8/06	6.87	59.5	0.14	0.9
9/30/06	13.53	19.5	0.17	2.1
11/14/06	11.97	24.1	-2.70	-30.9
12/1/06	8.44	43.2	-8.10	-65.3
1/2/07	6.01	70.5	-17.33	-99.5
2/2/07	4.69	84.4	-1.09	-4.9
2/28/07	4.09	88.3	-2.38	-9.3
3/3/07	7.07	56.9	-9.36	-63.2
3/14/07	3.49	91.7	-0.40	-1.3
3/23/07	4.92	82.3	-3.93	-18.5

Table D-12 (cont'd). Load Calculations for Eagles Rock Prong

Sample Date	Flow	PDFE	ANC Concentration	ANC Load
	[cfs]	[%]	[μeq/L]	[meq/acre/day]
4/13/07	4.72	84.1	-5.11	-23.0
4/25/07	4.64	84.7	-4.24	-18.8
4/29/07	5.26	78.9	-1.53	-7.7
5/30/07	3.47	91.8	5.15	17.1
6/15/07	3.15	92.8	4.92	14.8
7/3/07	3.11	93.0	-0.55	-1.6
7/31/07	4.83	83.2	0.30	1.4
8/28/07	2.14	97.8	1.95	4.0
9/14/07	2.59	94.9	7.30	18.1
10/14/07	1.98	98.5	9.22	17.4
10/23/07	1.77	99.8	7.12	12.1
11/4/07	1.76	99.9	7.17	12.0
1/15/08	2.55	95.1	3.12	7.6
2/14/08	2.99	93.3	2.58	7.4

Note: Target ANC Concentration for Eagles Rock Prong was 6.201 μeq/L.

Table D-13. TMDLs, WLAs[a], & LAs expressed as daily loads for Impaired Waterbodies in the Great Smoky Mountains National Park

Impaired Waterbody Name	Impaired Waterbody ID	TMDL	LAs	Minimum Concentration[b]
		[meq/acre/day]	[meq/acre/day]	[μeq/L]
Rock Creek	TN06010106004 – 0500	99.0 x Q	99.0 x Q	35.158
Inadu Creek	TN06010106004 – 0610	33.7 x Q	33.7 x Q	10.376
Otter Creek	TN06010106004 – 0810	42.2 x Q	42.2 x Q	10.121
Copperhead Branch	TN06010106004 – 0820	318.5 x Q	318.5 x Q	25.304
Buck Fork	TN06010107007 – 0700	65.1 x Q	65.1 x Q	50
Eagle Rocks Prong	TN06010107007 – 0900	5.9 x Q	5.9 x Q	6.201
Shutts Prong	TN06010107007 – 1120	36.1 x Q	36.1 x Q	14.732
Lowes Creek	TN06010107007 – 1130	170.9 x Q	170.9 x Q	50
Cannon Creek	TN06010107007 – 1140	38.0 x Q	38.0 x Q	18.65
Road Prong	TN06010107010 – 1100	29.4 x Q	29.4 x Q	25.056
Goshen Prong	TN06010201032 – 0510	24.3 x Q	24.3 x Q	17.824
Unnamed Trib to Fish Camp Prong	TN06010201032 – 0530	218.3 x Q	218.3 x Q	19.581

Notes: Q = Mean Daily Flow (cfs).

a. There are currently no point sources in the Great Smoky Mountains National Park; therefore, there is no required load reduction for point sources (WLA). Any future point sources must meet instream water quality standards at the point of discharge as specified in their NPDES permit.

b. The TMDL is also expressed in terms of minimum allowable water column concentration because TDEC recognizes that these values provide information that potentially will be more useful regarding TMDL implementation efforts than the values that are expressed in terms of an allowable load.

APPENDIX E

Hydrodynamic Modeling Methodology

E.1 Model Selection

The Loading Simulation Program C++ (LSPC) was selected for TMDL analyses of pH-impaired waters in the Great Smoky Mountains National Park. LSPC is a watershed model capable of performing flow routing through stream reaches. LSPC is a dynamic watershed model based on the Hydrologic Simulation Program – Fortran (HSPF).

E.2 Model Set Up

The Great Smoky Mountains National Park watershed was delineated into subwatersheds in order to facilitate model hydrologic calibration. Boundaries were constructed so that subwatershed "pour points" coincided with HUC-12 delineations, impaired waterbodies, and water quality monitoring stations. Watershed delineation was based on the NHD stream coverage and Digital Elevation Model (DEM) data. This discretization facilitates simulation of daily flows at water quality monitoring stations.

Several computer-based tools were utilized to generate input data for the LSPC model. The Watershed Characterization System (WCS), a geographic information system (GIS) tool, was used to display, analyze, and compile available information to support hydrology model simulations for the subwatersheds within the Great Smoky Mountains National Park. This information includes land use categories, point source dischargers, soil types and characteristics, population data (human and livestock), and stream characteristics.

An important factor influencing model results is the precipitation data contained in the meteorological data file used in the simulation. Weather data from the Knoxville and Asheville, NC meteorological stations were available for the time period from January 1980 through December 2006. Precipitation data for a more limited time period was available from two stations in the GSMNP itself: Clingman's Dome and Cove Mountain. A precipitation file was constructed using data from the Clingman's Dome station, when available, and the Cove Mountain station. Precipitation data from Knoxville and Asheville were used to fill in data gaps in the record from the GSMNP stations. Meteorological data for a selected 15-year period were used for all simulations. The first year of this period was used for model stabilization with simulation data from the subsequent 14-year period (10/1/93 – 9/30/07) used for TMDL analysis.

E.3 Model Calibration

Hydrologic calibration of the watershed model involves comparison of simulated streamflow to historic streamflow data from U.S. Geological Survey (USGS) stream gaging station for a similar period of time. A USGS continuous record station located in the Pigeon River Watershed with a sufficiently long and recent historical record was selected as a basis of the hydrology calibration. The USGS station was selected based on similarity of drainage area, Level IV ecoregion, land use, and topography. The calibration involved comparison of simulated and observed hydrographs until statistical stream volumes and flows were within acceptable ranges as reported in the literature (Lumb, et al., 1994).

Initial values for hydrologic variables were taken from an EPA developed default data set. During the calibration process, model parameters were adjusted within reasonable constraints until acceptable agreement was achieved between simulated and observed streamflow. Model parameters adjusted include: evapotranspiration, infiltration, upper and lower zone storage, groundwater storage, recession, losses to the deep groundwater system, and interflow discharge.

The results of the hydrologic calibration for Cosby Creek near Cosby, Tennessee, USGS Station 03461200, are shown in Table E-1 and Figures E-1 and E-2.

Table E-1 Hydrologic Calibration Summary: Cosby Creek, USGS 03461200

		10.32032144	
Simulation Name:	USGS03461200	**Simulation Period:**	
		Watershed Area (ac):	6607.12
Period for Flow Analysis			
Begin Date:	**10/01/80**	**Baseflow PERCENTILE:**	2.5
End Date:	**09/30/87**	*Usually 1%-5%*	
Total Simulated In-stream Flow:	**212.68**	Total Observed In-stream Flow:	**220.77**
Total of highest 10% flows:	**82.45**	Total of Observed highest 10% flows:	**84.61**
Total of lowest 50% flows:	**40.42**	Total of Observed Lowest 50% flows:	**44.68**
Simulated Summer Flow Volume (months 7-9):	**25.32**	Observed Summer Flow Volume (7-9):	**35.59**
Simulated Fall Flow Volume (months 10-12):	**42.14**	Observed Fall Flow Volume (10-12):	**37.91**
Simulated Winter Flow Volume (months 1-3):	**82.79**	Observed Winter Flow Volume (1-3):	**78.74**
Simulated Spring Flow Volume (months 4-6):	**62.43**	Observed Spring Flow Volume (4-6):	**68.53**
Total Simulated Storm Volume:	**176.34**	Total Observed Storm Volume:	**185.93**
Simulated Summer Storm Volume (7-9):	**16.32**	Observed Summer Storm Volume (7-9):	**26.91**
Errors (Simulated-Observed)		*Recommended Criteria*	Last run
Error in total volume:	**-3.66**	10	
Error in 50% lowest flows:	**-9.53**	10	
Error in 10% highest flows:	**-2.55**	15	
Seasonal volume error - Summer:	**-28.85**	30	
Seasonal volume error - Fall:	**11.15**	30	
Seasonal volume error - Winter:	**5.15**	30	
Seasonal volume error - Spring:	**-8.90**	30	
Error in storm volumes:	**-5.15**	20	
Error in summer storm volumes:	**-39.35**	50	

Criteria for Median Monthly Flow Comparisons	
Lower Bound (Percentile):	25
Upper Bound (Percentile):	75

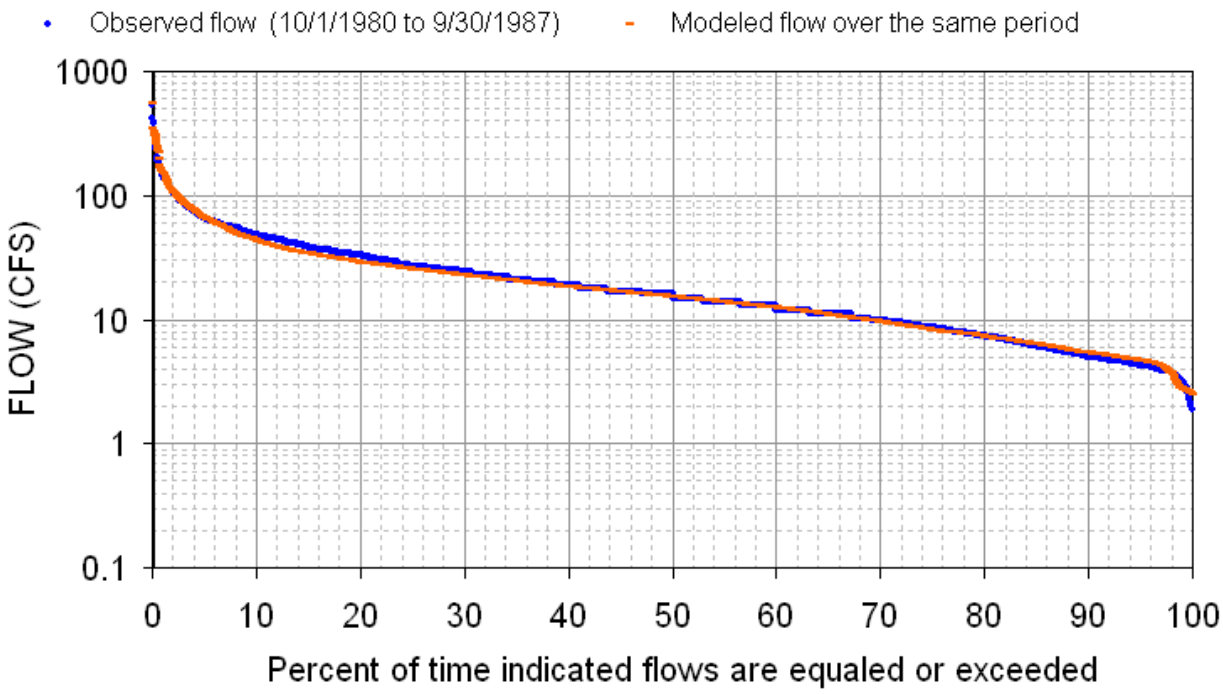


Figure E-1. Hydrologic Calibration: Cosby Creek, USGS 03461200

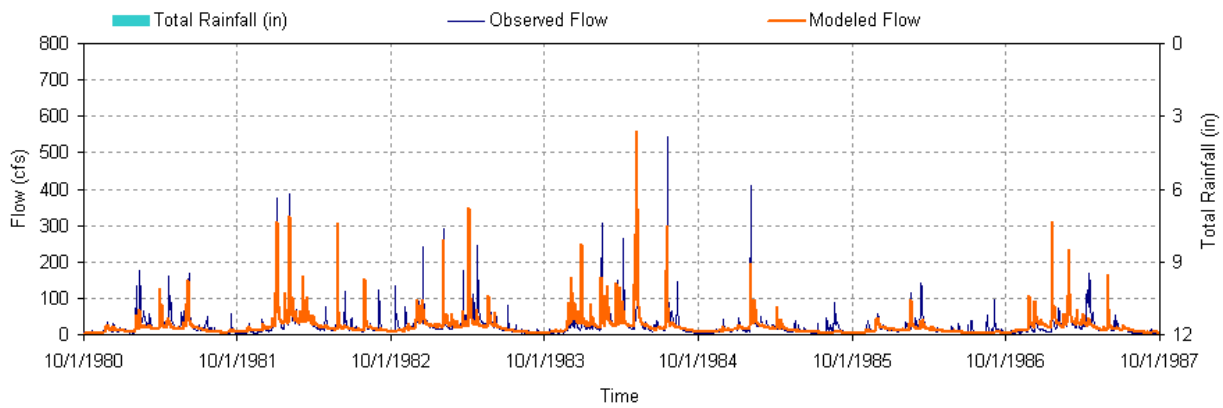


Figure E-2. 7-Year Hydrologic Comparison: Cosby Creek, USGS 03461200

APPENDIX F

Public Notice Announcement

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF WATER POLLUTION CONTROL

PUBLIC NOTICE OF AVAILABILITY OF PROPOSED TOTAL MAXIMUM DAILY LOAD (TMDL) FOR pH IN THE GREAT SMOKY MOUNTAINS NATIONAL PARK

PIGEON RIVER WATERSHED (HUC 06010106)
LOWER FRENCH BROAD RIVER WATERSHED (HUC 06010107)
FORT LOUDOUN LAKE WATERSHED (HUC 06010201)

Announcement is hereby given of the availability of Tennessee's proposed Total Maximum Daily Load (TMDL) for low pH in the Great Smoky Mountains National Park, located in eastern Tennessee. Section 303(d) of the Clean Water Act requires states to develop TMDLs for waters on their impaired waters list. TMDLs must determine the allowable pollutant load that the water can assimilate, allocate that load among the various point and nonpoint sources, include a margin of safety, and address seasonality.

A number of waterbodies in the Great Smoky Mountains National Park are listed on Tennessee's Final 2008 303(d) list as not supporting designated use classifications due, in part, to atmospheric deposition. The TMDL utilizes Tennessee's general water quality criteria, net alkalinity (as $CaCO_3$), continuous flow data from a USGS discharge monitoring station located in proximity to the watershed, site specific water quality monitoring data, a calibrated hydrologic model, load duration curves, and an appropriate Margin of Safety (MOS) to establish allowable loadings of net alkalinity (as $CaCO_3$) which will result in the attainment of water quality standards for pH.

The proposed Great Smoky Mountains pH TMDL may be downloaded from the Department of Environment and Conservation website:

http://www.state.tn.us/environment/wpc/tmdl/

Technical questions regarding this TMDL should be directed to the following members of the Division of Water Pollution Control staff:

Vicki S. Steed, P.E., Watershed Management Section
Telephone: 615-532-0707

Sherry H. Wang, Ph.D., Watershed Management Section
Telephone: 615-532-0656

Persons wishing to comment on the proposed TMDLs are invited to submit their comments in writing no later than June 21, 2010 to:

Division of Water Pollution Control
Watershed Management Section
7th Floor, L & C Annex
401 Church Street
Nashville, TN 37243-1534

All comments received prior to that date will be considered when revising the TMDL for final submittal to the U.S. Environmental Protection Agency.

The TMDL and supporting information are on file at the Division of Water Pollution Control, 6th Floor, L & C Annex, 401 Church Street, Nashville, Tennessee. They may be inspected during normal office hours. Copies of the information on file are available on request.