GEOLOGICAL SURVEY OF ALABAMA

Berry H. (Nick) Tew, Jr.
State Geologist

ECOSYSTEMS INVESTIGATIONS PROGRAM

Patrick E. O'Neil
Director

CANE CREEK CANYON NATURE PRESERVE AQUATIC MACROFAUNA SURVEY

OPEN-FILE REPORT 1118

By

Stuart W. McGregor, Patrick E. O'Neil, and E. Anne Wynn

With field assistance from Cal C. Johnson, Thomas E. Shepard, and J. Brett Smith, and geochemical analyses by Mirza A. Beg, Robert E. Meintzer, and Rick L. Wagner

Prepared in cooperation with
Alabama Division of Wildlife and Freshwater Fisheries

Tuscaloosa, Alabama
2011

CONTENTS

FIGURES

TABLES

CANE CREEK CANYON NATURE PRESERVE
AQUATIC MACROFAUNA SURVEY

By
Stuart W. McGregor, Patrick E. O'Neil, and E. Anne Wynn

ABSTRACT

Sampling for crayfishes, fishes, and snails at selected stations in Cane Creek Canyon Nature Preserve, Colbert County, Alabama (Tennessee River drainage) yielded 3 species of crayfishes in a single family, 19 species of fishes in 7 families, and 3 species of snails in 3 families. All species documented are common throughout their respective ranges and all but one are of Lowest Conservation Concern in Alabama. The Sooty Elimia, *Elimia* sp. cf. *paupercula*, is of Moderate Conservation Concern in Alabama. None are federally listed. Limited water- and sediment-quality analyses at three stations found a slightly elevated concentration of mercury in shallow bed sediment at one station, lead levels above the calculated chronic aquatic-life criteria at all stations, and elevated chloride and sulfate levels and low dissolved oxygen concentration at low water stage at one station. Comparison of land use/land cover changes between 1992 and 2006 suggests a fairly stable environment, with a modest reduction in overall forest percentage in each subwatershed within the project area.

INTRODUCTION

Cane Creek Canyon Nature Preserve (Preserve) is an 800-plus acre natural area located in the Little Mountain District of the Highland Rim Physiographic Section (Tennessee River drainage) in Colbert County, Alabama (Sapp and Emplaincourt, 1975). The Preserve is a protected scenic area that serves as a sanctuary for native plants and animals and as an outdoor laboratory for research projects. It contains about 15 miles of hiking trails, primitive camping sites, picnic areas, and several miles of wadeable streams. A Conservation Easement for the property exists between the landowners and the Nature Conservancy of Alabama. Much of the headwaters of Cane Creek and its headwater tributaries, which flow over steep cliffs in the Hartselle Sandstone and eventually onto the valley floor in the Tennessee Valley District, are protected by the Preserve. The rugged nature of the property provides special microhabitats and microclimates, and for that reason an unusually diverse forest community exists there, with more than 100 species of native trees documented, and several other rare species of plants as well. However, not all reaches of the headwaters are protected and ongoing clearcutting, poultry production, farming, and other human activities threaten the biological integrity of the system.

No systematic inventory of the aquatic macrofauna of the Preserve has been performed to date and its unique setting in a relatively remote, protected series of canyons and hollows suggests that it may harbor rare aquatic species as well. The Tennessee Valley Authority (TVA) and Geological Survey of Alabama (GSA) have documented 30 fish species and one crayfish species in two collections in Cane Creek at Alabama Highway 247 a few miles downstream of the Preserve in an agricultural landscape on the valley floor. Recent cursory collections of crayfishes using hand nets during February and November 2010 at several locations in streams within the Preserve boundary yielded several individuals, but the landowner indicated that during the spring and summer large numbers of crayfish can be seen on the stream bed, and that a bog area perched on a hillside contains crayfish burrows. During November 2010 that bog was visited but the ground was very hard due to a prolonged period of low rainfall and was impossible to excavate by hand. An abundant population of freshwater snails was also observed during those visits. Hellbenders (*Cryptobranchus alleganiensis*) have also been observed in Cane Creek in the Preserve, but not in the past 20 years or so. The landowners indicate they have never seen mussels or other bivalves on the property.

The objective of this project was to inventory the aquatic macrofauna of springs, streams, bogs, and other aquatic habitats on Preserve property targeting fishes, crayfishes, and snails, and to conduct limited water- and sediment-quality assessments at selected stations. Information gathered during this study represents the first comprehensive assessment of the aquatic macrofauna and water quality in this section of a relatively undisturbed watershed. Aquatic biological community condition was evaluated by calculating an Index of Biotic Integrity (IBI) of the fish assemblage at representative locations within the Preserve. That information will provide a basis from which future sampling efforts can monitor stream conditions and provide a tool for better management of the water resources within the Preserve. The Alabama Department of Conservation and Natural Resources (ADCNR) supported the project with Section 6 funds.

ACKNOWLEDGMENTS

We gratefully acknowledge the enthusiastic support and field assistance of the owners of the Preserve, Faye and Jim Lacefield of Tuscumbia, Alabama. Josh Ford of Killen, Alabama, Allison Evans of Tuscaloosa, Alabama, Ron Cicerello of the Kentucky Nature Preserves Commission (retired), Guenter Schuster of Eastern Kentucky University (retired), and Jeff Garner of ADCNR assisted in the field and their contributions are much appreciated. Charles

Rose of the Shoals Environmental Alliance, Sheffield, Alabama, graciously provided limited water-quality data previously gathered in Waterfall Creek for the Alabama Water Watch program. Guenter Schuster identified the crayfish and Jeff Garner identified the snails collected.

STUDY AREA

Cane Creek and its associated headwater tributaries rise in a series of canyons and hollows nestled among Hawk Pride, Wheeler, and Wagnon Mountains (north to south) at about 880 feet above mean sea level (ft.-msl) in Colbert County, Alabama (fig. 1). Cane Creek proper flows generally northwest for about 20 miles to its confluence with the Tennessee River at about Tennessee River Mile 244 and an elevation of about 440 ft-msl, for an average fall of about 22 ft/mile.

The watershed of the Preserve encompasses about 6.0 square miles (mi^2) including the main channel of Cane Creek and several tributaries (fig. 1, table 1). Lower Delony Hollow and Devil's Hollow, the lowermost tributaries in the study area, arise on or between Hawk Pride and Wheeler Mountains and enter Cane Creek from the right descending bank, while the remainder of the study area lies between Wheeler and Wagnon Mountains. The stream in Lower Delony Hollow, unnamed on topographic maps, is colloquially known as Sinking Creek in Lower Delony Hollow, and the drainage area where we sampled (LD1), near its confluence with Cane Creek, is about 0.39 mi^2. The stream in Devil's Hollow, also unnamed on topographic maps, is colloquially known as Devil's Hollow Creek and drains about 0.62 mi^2 where we sampled (DH1). A spring, unnamed on topographic maps but known as Big Spring, emerges from the foot of a bluff on the left descending bank of Devil's Hollow Creek near its confluence with Cane Creek. Further upstream on the right descending bank is another tributary unnamed on topographic maps known as Waterfall Creek due to the presence of a near 60-feet high waterfall. The lower station (WC1) was located near the confluence with Cane Creek and drains 1.13 mi^2, and the upper station (WC2), upstream of the falls, drains 0.47 mi^2. Only one tributary entering Cane Creek from the left descending bank in the Preserve was sampled during this study. That hollow and its associated stream are also unnamed on topographic maps but it is referred to as Cucumber Tree Hollow. The station was sampled at station CT1, near its confluence with Cane Creek, and has a drainage area of 0.44 mi^2. However, due to a greater presence of limestone in the underlying geology in that region of the Preserve, the stream there disappears into underground solution channels and was reduced to isolated pools during our visit. The main

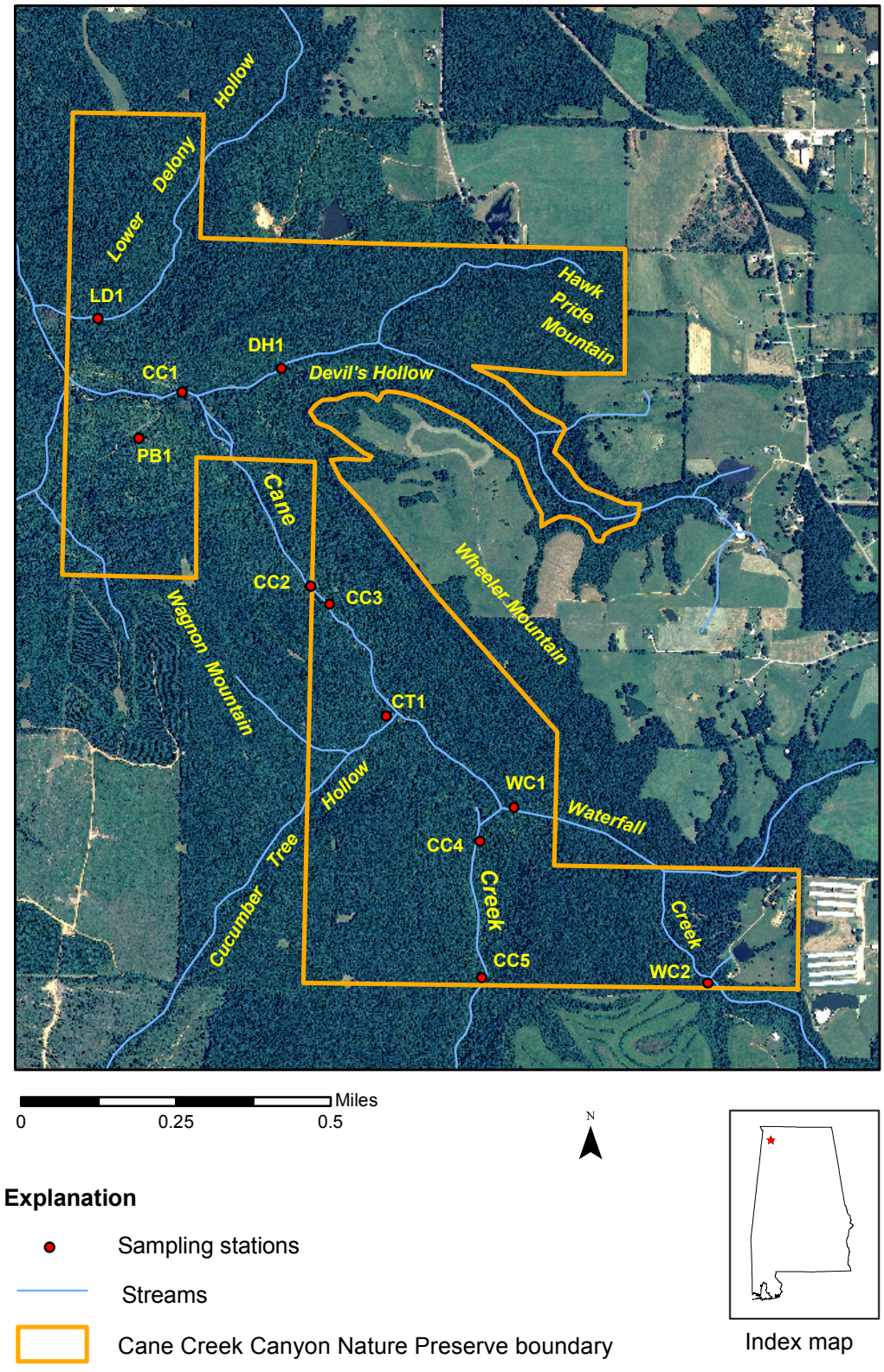


Figure 1. Aerial photograph of Cane Creek Canyon Preserve showing sampling stations and Preserve boundaries, Colbert County, Alabama.

Table 1-Summary information for sampling stations in
Cane Creek Canyon Nature Preserve, Colbert County, Alabama, 2010-11.

Locality	Station designation	Drainage area (mi^2)	Map coordinates	Township, Range, and section
Unnamed tributary in Lower Delony Hollow	LD1	0.39	N 34.6389° W 87.8194°	sec. 8, T. 5 S., R. 12 W.
Cane Creek downstream of the confluence of Devil's Hollow Creek	CC1	5.52	N 34.6372° W 87.8148°	sec. 8, T. 5 S., R. 12 W.
Unnamed tributary in Cucumber Tree Hollow	CT1	0.44	N 34.6278° W 87.8076°	sec. 16, T. 5 S., R. 12 W.
Unnamed tributary in Devil's Hollow and adjacent spring near confluence with Cane Creek	DH1	0.62	N 34.6379° W 87.8120°	sec. 8, T. 5 S., R. 12 W.
Cane Creek at Blue Hole	CC2	4.65	N 34.6316° W 87.8103°	sec. 8, T. 5 S., R. 12 W.
Cane Creek at Laurel Pool	CC3	4.61	N 34.6310° W 87.8099°	sec. 16, T. 5 S., R. 12 W.
Waterfall Creek near confluence with Cane Creek	WC1	1.13	N 34.6251° W 87.8033°	sec. 16, T. 5 S., R. 12 W.
Waterfall Creek near headwaters upstream of waterfall	WC2	0.47	N 34.6200° W 87.7964°	sec. 16, T. 5 S., R. 12 W.
Cane Creek at Linden Meadow Picnic Area and Cane Creek Cascades	CC4	2.78	N 34.6241° W 87.8045°	sec. 16, T. 5 S., R. 12 W.
Cane Creek at Upper Cane Creek Bridge	CC5	2.63	N 34.6201° W 87.8044°	sec. 16, T. 5 S., R. 12 W.
Perched bog opposite mouth of Devils Hollow	PB1	NA	N 34.6359° W 87.8168°	sec. 8, T. 5 S., R. 12 W.

channel stations sampled (CC1-CC5) were scattered from near the lower to near the upper boundaries of the Preserve and were selected based on accessibility and to allow us to sample as many available habitats in the Preserve as possible. Their respective drainage areas can be found in table 1. The perched bog opposite the mouth of Devil's Hollow where crayfish burrows were excavated (PB1) was an isolated terrestrial location with shallow groundwater and no drainage area was calculated.

METHODS

Sampling efforts were concentrated at selected stations on the Preserve representative of available aquatic habitats. Crayfishes were actively collected by hand when observed on the streambed and when excavating burrows, by using kick nets around instream structure and undercut banks, and with seines and a backpack shocker when sampling fishes. They were also collected passively with baited minnow traps. Fishes were collected with seines and a backpack shocker, sometimes supplemented with hand nets. Snails were collected by hand or in nets and seines when encountered incidental to pursuing other taxa, or by hand collecting debris from the streambed and rinsing it in a pan to free specimens. Collection data were recorded on field sheets and later stored in Excel spreadsheets and are managed within a geographic information system (GIS).

Representative crayfish of a size suitable for accurate identification were preserved in a 70 percent ethanol solution, transported to the GSA laboratory, and after a period of 3-10 days transferred to a fresh 70 percent ethanol solution. Crayfishes were identified by Dr. Guenter Schuster of Eastern Kentucky University (retired). Upon identification the specimens were returned to GSA and stored in museum quality glass jars and will eventually be deposited in the University of Alabama Decapod Crustacean collection. The crayfish data will be added to a database detailing all known crayfish records from Alabama, which will in turn be delivered to the ADCNR Heritage Database. Fishes were identified on site and returned to the stream where they were collected. Snails were identified by Jeff Garner of ADCNR and will be deposited in the Aquatic Invertebrate Collection of the North Carolina State Museum of Natural Sciences in Raleigh.

Chemical analyses of water samples were conducted in accordance with U.S. Environmental Protection Agency (USEPA 1973, 1983, 1988, 1990, 1991), Fishman and Friedman (1989), Greenberg and others (1992), and Wershaw and others (1987). Water samples

were collected in accordance with the Standard Operating Procedures and Quality Assurance Manual of Alabama Department of Environmental Management (December 1986) and the Quality Assurance-Quality Control Plan for GSA (O'Neil and Meintzer, 1995).

The following parameters were measured *in situ* for each sample. Dissolved oxygen (DO) was measured in milligrams per liter (mg/L) using a Yellow Springs Instruments (YSI) Model 58 dissolved-oxygen meter. Hydrogen-ion concentration, specific conductance (measured in micro Siemens per centimeter [μS/cm]), and temperature were measured with a Horiba Water Checker Model U-10. Total residual chlorine was measured colorimetrically with a HACH Model CN-70 chlorine test kit. A collected sample was inoculated with a standard reagent powder pillow, allowed to stand for 3 to 6 minutes for the reaction to occur, then compared against a stream blank in the standardized color-comparison wheel.

An integrated grab sample of water was collected at each station, and the following raw and filtered (0.45μm) individual samples were transported (in Nasco whirl-pak sterilized bags or polyethylene bottles) to the GSA geochemical laboratory for analysis: two 18-oz raw water bags for analysis of total suspended solids (TSS), one 4-oz filtered-chilled bag (4°C) for anions and alkalinity, one 4-oz filtered-acidified (pH <2.0 with sulfuric acid) bag for total dissolved phosphorus and ammonia analysis, one filtered-acidified (pH <2.0 with nitric acid) sample in a white polyethylene bottle for analysis of metals, one raw acidified sample (pH <2 with sulfuric acid) in an amber glass bottle for total organic carbon (TOC) analysis, one raw sample in a small clear plastic bottle for mercury analysis, and one raw-acidified 4-oz bag (pH<2.0 with sulfuric acid) for analysis of chemical oxygen demand (COD) and total Kjeldahl nitrogen (TKN).

Integrated samples of organic bed sediment were collected at two stations (WC1 and CC5) to analyze possible contaminants sequestered there. The samples were prepared for chemical analysis according to procedures described in Fishman and Friedman (1989) and USEPA (1999b) according to the methods for parameters to be determined. Subsequently, chemical analyses of the sediment samples were conducted in accordance with U.S. Environmental Protection Agency (USEPA 1983, 1993, 1994, 1999a, 1999b), Fishman and Friedman (1989), Crock and others (1987), and McLean (1982). Sediment samples were collected in accordance with the Quality Assurance-Quality Control Plan for GSA (O'Neil and Meintzer, 1995).

RESULTS AND DISCUSSION

CRAYFISH

Four sampling efforts using different methods were employed during different seasons to obtain a representative cross section of the crayfish fauna: on February 16, 2010, kick net collections were made at four stations; from January 8-15, 2011, an aggregate total of 17 minnow traps baited with commercial cat food were deployed among six stations for a total of 119 trap nights; on May 11 and 12 and again on September 8, 2011, crayfish were collected incidental to fish sampling with the aid of a backpack shocker, seines, and hand nets; and on May 12, 2011, burrows were dug by hand at a bog perched on a hillside opposite the mouth of Devil's Hollow (table 2). The crayfish fauna encountered was comprised of 95 specimens among three species, all in the family Cambaridae. All three species are common and widespread within their native ranges and all were considered Provisional Lowest Conservation Concern species by Smith and others (2011).

The Ambiguous Crayfish, *Cambarus striatus*, known to occupy lotic habitats and primary and secondary burrows, was commonly found in both trap and kick samples and by digging burrows, and was found at all but one station sampled, for a total of 54 specimens (57 percent). It is frequently encountered across Alabama except for the extreme southwest counties in the Southern Pine Hills, Alluvial Deltaic Plain, and Coastal Lowlands.

The Reticulate Crayfish, *Orconectes erichsonianus*, known to occupy lotic habitats, was collected at the most downstream station in Cane Creek proper (CC1) incidental to fish sampling while using a backpack shocker and seine, and was represented by three specimens (3 percent). Three specimens of this species were also found in Cane Creek downstream of the Preserve by GSA and TVA personnel during unrelated fish IBI sampling in 2005, perhaps reflecting a preference for slightly larger streams than found in the extreme headwaters of the Preserve. It is commonly encountered in the Black Warrior, Cahaba, Coosa, and Tallapoosa River systems and Tennessee River drainage of northern Alabama.

The Powerful Crayfish, *Orconectes validus*, known to occupy lotic habitats, was collected in both trap and kick samples among most stations sampled, and was represented by 38 specimens (40 percent). It is commonly encountered in the Black Warrior and Tombigbee River systems and Tennessee River drainage of northern Alabama.

Table 2-Summary information for crayfish species collected in
Cane Creek Canyon Nature Preserve, Colbert County, Alabama, 2010-11.

Species, common name	Provisional Conservation status[1]	Number of specimens collected[2]											
Family Cambaridae		LD1	CC1	CT1	DH1	CC2	CC3	WC1	WC2	CC4	CC5	PB1	Totals
Cambarus striatus, Ambiguous Crayfish	PP5	5	2	3	2	4		6	4	17	9	2	54
Orconectes erichsonianus, Reticulate Crayfish	PP5		3										3
Orconectes validus, Powerful Crayfish	PP5	2	2		3		11	2	8	9	1		38
Totals		7	7	3	5	4	11	8	12	26	10	2	95

[1]-Conservation status follows Smith and others (2011); PP5=Provisional Lowest Conservation Priority.

[2]-Numbers represent aggregate totals for all methods and efforts expended at each station.

FISHES

A cumulative total of 19 species of fishes in 7 families and one individual of a hybrid sunfish were collected among eight stations sampled in the Preserve (table 3). Three stations were in the main channel of Cane Creek and were distributed among the lower, middle, and upper reaches of the Preserve and six collections were made among five stations in four tributaries. No fishes were collected at two tributary stations. No federally listed species were encountered and every species collected was of Lowest Conservation Concern in Alabama (Mirarchi, 2004).

A cumulative total of 1,235 individuals was collected, numerically dominated by the Largescale Stoneroller, *Campostoma oligolepis* (24 percent), the Creek Chub, *Semotilus atromaculatus* (17 percent), the Blackfin Darter, *Etheostoma nigripinne* (12 percent), and the Green Sunfish, *Lepomis cyanellus* (11 percent). Only the Green Sunfish was found at every station sampled and was the only species found at one station, Waterfall Creek upstream of the falls (WC2). The Green Sunfish is very tolerant of disturbed stream conditions and is highly competitive with other fish species in small headwater streams. In all likelihood the falls represent a barrier to fish migration and the individuals found upstream of the falls are likely escapees from upstream farm ponds. When that unique habitat is excluded, the Rosyside Dace, Creek Chub, and Blackfin Darter were present at every station sampled including main channel and tributary stations. The fish species found in the Preserve are all common and widespread, and each is typical of the setting in which it was found, headwater tributaries of the Tennessee River.

Three fish assemblage samples were made in the main channel of Cane Creek (stations CC1, CC3, and CC4) to evaluate stream biological condition using the index of biotic integrity (IBI) technique. All three stations rated Fair with regard to biological condition, a result that is not uncommon for headwater streams in the Tennessee Valley moderately impacted by small farms. The IBI scores and catch statistics reflect a natural longitudinal gradient of upstream to downstream changes in the fish assemblage, with the downstream station supporting a more diverse and abundant fauna linked with a more persistent flow of water, greater variety of habitat types, and more space to physically support fishes. We do not see any significant impacts to the fish assemblages as determined using the IBI. On two previous occasions (May 1996 and June 2005) GSA assisted TVA with fish IBI sampling in Cane Creek approximately 5

Table 3. Summary information for fish species collected in Cane Creek Canyon Nature Preserve, Colbert County, Alabama, 2011.

				Sampling station								
		Total		CC1	CC3	CC4	CT1	DH1	LD1	WC1	WC1	WC2
Family species	common name	No.	Percent	12-May-11	11-May-11	11-May-11	8-Sep-11	8-Sep-11	8-Sep-11	11-May-11	8-Sep-11	8-Sep-11
Cyprinidae - minnows and carps												
Campostoma oligolepis	Largescale Stoneroller	292	23.64	226	63	--		--		3	--	--
Clinostomus funduloides	Rosyside Dace	123	9.96	22	17	41		9		20	14	--
Luxilus chrysocephalus	Striped Shiner	114	9.23	79	17	--		5		8	5	--
Lythrurus fasciolaris	Scarlet Shiner	26	2.11	21	1	--		--		1	3	--
Pimephales notatus	Bluntnose Minnow	4	0.32	4	--	--	**No**	--	**No**	--	--	--
Semotilus atromaculatus	Creek Chub	204	16.52	32	31	46		35		26	34	--
Catostomidae - suckers												
Minytrema melanops	Spotted Sucker	2	0.16	2	--	--		--		--	--	--
Moxostoma erythrurum	Golden Redhorse	3	0.24	--	--	--	**Fish**	3	**Fish**	--	--	--
Ictaluridae - North American catfishes												
Ameiurus natalis	Yellow Bullhead	1	0.08	1	--	--		--		--	--	--
Fundulidae - topminnows												
Fundulus olivaceus	Blackspotted Ttopminnow	11	0.89	11	--	--		--		--	--	--
Cottidae - sculpins												
Cottus carolinae	Banded Sculpin	8	0.65	7	--	--		1		--	--	--
Centrarchidae - sunfishes												
Lepomis cyanellus	Green Sunfish	134	10.85	8	13	2		8		27	11	65
Lepomis macrochirus	Bluegill	94	7.61	31	--	--		58		--	5	--
Lepomis megalotis	Longear Sunfish	3	0.24	2	--	--		1		--	--	--
Micropterus punctulatus	Spotted Bass	1	0.08	--	--	--		1		--	--	--
Micropterus salmoides	Largemouth Bass	4	0.32	4	--	--		--		--	--	--
	hybrid centrarchid	1	0.08	--	--	--		--		--	1	--
Percidae - darters												
Etheostoma caeruleum	Rainbow Darter	50	4.05	50	--	--		--		--	--	--
Etheostoma duryi	Black Darter	10	0.81	8	1	--		--		--	1	--
Etheostoma nigripinne	Blackfin Darter	150	12.15	24	48	13		26		24	15	--
	Total species	19	--	17	8	4	0	10	0	7	9	1
	Total individuals	1235	--	532	191	102	0	147	0	109	89	65
	IBI scores	--	--	40	34	32	--	--	--	--	--	--

stream miles downstream of the Preserve in an agricultural setting on the Tennessee Valley floor (table 4). Those collections yielded a very diverse and abundant fauna, represented by 30 species and one hybrid sunfish. Again, none of those species were uncommon and all were species of Lowest Conservation Concern in Alabama. The larger drainage area and correspondingly greater availability and diversity of habitats at this downstream Cane Creek site, along with its proximity to the upper reaches of the embayment of the Tennessee River, account for the greater species list at that station, many of which are typical of larger streams and impoundments.

SNAILS

Snails were encountered at five stations, sometimes incidental to sampling for other taxa (table 5). An aggregate total of 339 individuals were collected, but only three species among three families were represented. Collections were made on February 16, 2010 at DH1 and CC3 incidental to collecting crayfishes; on May 11, 2011 at CC3 incidental to collecting fishes; and on October 14, 2011 at CC1, DH1, CC3, WC1, and CC5, targeting snails.

The Sooty Elimia, *Elimia* sp. cf. *paupercula* (Pleuroceridae), was the dominant species, with 323 of the 339 specimens collected (95 percent) and was found at all stations where snails were found except the most downstream station (CC1). It is a species of Moderate Conservation Concern in Alabama and is endemic to headwaters and springs in the Tennessee River Valley. It is distributed across north Alabama and is frequently encountered in its preferred habitat (Mirarchi, 2004). Some degree of clinal variation in that species is noted within stream systems and among different subwatersheds, and it may represent a species complex (Jeff Garner, ADCNR, pers. comm., 2011).

Both of the other species collected are common and widespread within their ranges and are considered species of Lowest Conservation Concern in Alabama (Mirarchi, 2004). The Tadpole Physa, *Physella gyrina* (Physidae), is a very common and widespread species, occurring in a variety of habitats, including large rivers, streams, and ponds. It was found at two stations in the Preserve, both in the main channel of Cane Creek (CC1 and CC3). It was represented by 12 individuals (4 percent)

The Bugle Sprite, *Micromenutus dilatatus* (Planorbidae), is likely found throughout Alabama and occurs in rivers and streams, often on woody debris, submerged clumps of bryophytes, and tree roots. Four individuals (1 percent) were found at one station in the Preserve (CC1) among leaf litter and woody debris in a pool.

Table 4-Summary information for fish species collected during TVA/GSA IBI efforts in 1996 and 2005, Cane Creek at Alabama Highway 247, Colbert County, Alabama.

Species	Conservation status[1]	5/27/1996	6/16/2005
Dorosoma cepedianum, Gizzard Shad	P5	2	--
Campostoma oligolepis, Largescale Stoneroller	P5	28	88
Cyprinella spiloptera, Spotfin Shiner	P5	45	42
Luxilus chrysocephalus, Striped Shiner	P5	127	210
Lythrurus fasciolaris, Scarlet Shiner	P5	125	28
Notemigonus crysoleucas, Golden Shiner	P5	2	--
Notropis boops, Bigeye Shiner	P5	237	26
Notropis volucellus, Mimic Shiner	P5	--	2
Pimephales notatus, Bluntnose Minnow	P5	35	2
Semotilus atromaculatus, Creek Chub	P5	1	1
Hypentelium nigricans, Northern Hog Sucker	P5	2	7
Moxostoma duquesnei, Black Redhorse	P5	2	7
Fundulus olivaceus, Blackspotted Topminnow	P5	25	16
Labidesthes sicculus, Brook Silverside	P5	3	2
Cottus carolinae, Banded Sculpin	P5	36	73
Ambloplites rupestris, Rock Bass	P5	4	1
Lepomis cyanellus, Green Sunfish	P5	3	2
Lepomis gulosus, Warmouth	P5	1	--
Lepomis macrochirus, Bluegill	P5	18	5
Lepomis megalotis, Longear Sunfish	P5	56	20
Lepomis microlophus, Redear Sunfish	P5	3	--
Micropterus dolomieui, Smallmouth Bass	P5	1	--
Micropterus salmoides, Largemouth Bass	P5	1	1
Etheostoma caeruleum, Rainbow Darter	P5	27	41
Etheostoma duryi, Black Darter	P5	11	11
Etheostoma kennicotti, Stripetail Darter	P5	--	2
Etheostoma nigripinne, Blackfin Darter	P5	--	4
Etheostoma nigrum, Johnny Darter	P5	1	1
Etheostoma tennessee, Tennessee Darter	P5	1	--
Percina caprodes, Logperch	P5	1	2
hybrid centrarchid	--	--	1

[1]-Conservation status follows Mirarchi (2004); P5=Lowest Conservation Priority.

Table 5-Summary information for snail species collected in
Cane Creek Canyon Nature Preserve, Colbert County, Alabama, 2010-11.

Species	Conservation status[1]	Number of specimens collected[2]					
		CC1	DH1	CC3	WC1	CC5	Total
Family Pleuroceridae							
Elimia sp. cf. *paupercula*, Sooty Elimia	P3	--	92	162	39	30	323
Family Physidae							
Physella gyrina, Tadpole Physa	P5	8	--	4	--	--	12
Planorbidae							
Micromenutus dilatatus, Bugle Sprite	P5	4	--	--	--	--	4
Total	--	12	92	166	39	30	339

[1]Conservation status follows Mirarchi (2004); P3=Moderate Conservation Priority, P5=Lowest Conservation Priority.

[2]Totals are cumulative for each site among all collection efforts.

WATER QUALITY

Water samples and stream discharge data were collected from three stations in the Preserve on June 22, 2011 and again on August 24, 2011 (Appendix A). The lowermost sampling station (CC1) was near the downstream (northern) boundary of the Preserve. The station in Waterfall Creek (WC1) was at a footbridge near its confluence with Cane Creek. This station was selected to capture potential runoff from poultry houses and other activities on private properties located in the extreme headwaters off Preserve property. The third station (CC5) was located on Cane Creek upstream of the confluence with Waterfall Creek near the upper (southern) boundary of the Preserve. Samples of organic matter in shallow stream reaches were also collected at WC1 and CC5 at the time of the August water-quality sampling effort to ascertain possible toxins sequestered there (Appendix B).

Subsequent to the tornado outbreak on April 27, 2011, during which the property sustained some tree loss, there was a prolonged period of little to no rainfall. However, on the day before water-quality sampling on June 22 the landowners indicated that about 1.1 inches of rain had fallen on the property and early in the morning of the sampling day there was a brief but intense thunderstorm that yielded an additional 0.5 inch of rain. An ongoing timber clearcut on property upstream of the Preserve contributes sediment to the stream after rain events and during the water sample collection on June 22 station CC5 was very turbid, but the plume of sediment had not reached the lower station (CC1), and the water there was still relatively clear. At the time of the August collection another prolonged period of little to no rainfall had occurred and Cane Creek and lower Waterfall Creek (WC1) had almost imperceptible flows. However, the landowner observed that the flow in Waterfall Creek upstream of the falls (WC2) was significantly higher than the day before, despite the lack of rainfall, and later learned that a farm pond upstream was being drained and the creek ran unusually high for several days. However, the water sample and discharge measurement taken at WC1 that day were taken before the high water arrived at that point.

The alkalinity of a solution is defined as its capacity to react with and neutralize acid. The principal components of alkalinity are the dissolved carbon dioxide species carbonic acid, bicarbonate, and carbonate. Bicarbonate measurements were lowest at station WC1 (52 and 68 mg/L) and most elevated at station CC1 (78 and 90 mg/L) while pH was lowest at station CC1 (6.5 and 6.8) and highest at station CC5 (7.2 and 7.8).

Chlorine is the most abundant of the halogens, and its compounds, comprised of chlorine and the common metallic elements, alkali metals, and alkaline earth metals, are readily soluble in water (Hem, 1989). The chloride form of chlorine is the only oxidation state of significance in water exposed to the atmosphere. The other oxidation states of chlorine are not found in significant quantities in natural waters, and their presence would be the result of contamination from a chlorinated water source. Chloride is present in rock types in concentrations lower than the other major constituents of natural water. As such, chloride concentrations are generally very low in natural fresh waters, and their presence in quantity may indicate contamination. Chloride was lowest at station CC1 (1.85 and 2.21 mg/L) and highest at station WC1 (3.12 and 9.36 mg/L).

Sulfate is widely distributed in both igneous and sedimentary rocks as metallic sulfides. Sulfide minerals in contact with water undergo weathering to yield sulfate ions. This process may produce considerable quantities of hydrogen ions leading to high acidic conditions in streams. Air pollution is a significant source of sulfate with ambient rain water containing from 1.0 to 10 mg/L of sulfate. Concentrations of sulfate in the 5 mg/L range can indicate anthropogenic sources of pollution in a watershed. Sulfate was lowest at station CC5 (3.24 and 3.16 mg/L) and highest at station WC1 (5.35 and 8.96 mg/L).

The cycling of nitrogen through the atmosphere, hydrosphere, and lithosphere involves complex biological and chemical processes. Nitrogen in water occurs as nitrite (NO_2^-) and nitrate (NO_3^-) anions, as ammonium (NH_4^+) cations, and as organic solutes. Nitrate is stable in water over a variety of conditions, particularly in groundwater, and is readily transported over long distances. Excessive nitrate concentrations (>10 mg/L NO_3 as N) may cause a condition known as methemoglobinemia in small children. Upon contact with sunlight, excess nitrate can contribute to nuisance algal blooms in surface waters. Nitrate was lowest at station CC1 (0.112 and 0.175 mg/L) and highest at station WC1 (0.439 and 1.08 mg/L).

In natural waters unaffected by pollution in the southeast, trace metals occur in low concentrations, generally <1.0 μg/L. Elevated trace metal concentrations may indicate the presence of a pollution source or a nearby ore deposit. The drinking water maximum contaminant level (MCL) for cadmium is 5.0 μg/L, the MCL for leachate from sanitary landfills is 10 μg/L, whereas the chronic and acute criteria for protection of aquatic life are 0.15 μg/L and

1.03 μg/L, respectively, calculated using a hardness of 50 mg/L. Cadmium was below detection limit (0.09 μg/L) for all samples except one taken at station CC1 in June (0.1 μg/L).

The drinking water MCL for chromium (III) is 100 μg/L, the landfill leachate MCL is 50 μg/L, while the chronic and acute aquatic-life criteria are 42 μg/L and 323 μg/L, respectively, for a hardness of 50 mg/L. Chromium was below the detection limit (0.8 μg/L) in all samples.

Lead is widely distributed throughout the world due to the combustion of leaded gasoline in the 20th century. The drinking water MCL for lead is 15 μg/L, the landfill leachate criterion is 15 μg/L, while the chronic and acute aquatic-life criteria are 1.17 μg/L and 30 μg/L, respectively, for a hardness of 50 mg/L. Lead was above the detection limit (0.9 μg/L) in all samples collected in the Cane Creek system and was lowest at station CC5 (4.3 and 5.1 μg/L) and highest at station CC1 (21.1 and 15.0 μg/L). All lead measurements exceeded the calculated chronic aquatic-life criterion for this metal constituent.

Concentrations of mercury in filtered natural waters are very low, rarely exceeding a few tenths of a microgram per liter (Hem, 1989). The freshwater chronic and acute aquatic-life criteria are 0.012 and 2.4 μg/L, respectively. All samples were below the mercury detection limit (0.01 μg/L).

The water quality data suggest a modest impairment in Waterfall Branch relative to the other stations sampled, due to slightly elevated chloride and sulfate values encountered. A low DO reading (2.7 mg/L) during low flow on August 24 reinforces this conclusion.

The elevated concentration of mercury in shallow bed sediment at station CC5 (0.187 mg/L) on August 24 is slightly above the minimum guideline for the protection of aquatic life (0.15 mg/L) and merits watching (Canadian Council of Ministers of the Environment, 2002).

Over a period of about two years Charles Rose of the Shoals Environmental Alliance, in cooperation with Alabama Water Watch, made monthly water-quality measurements at station WC2. These measurements offer a glimpse of water quality trends at that location over time. With his permission we have included that data (Appendix C). Again, none of the parameters suggest substantially impaired water quality.

LAND USE/LAND COVER

Land use/land cover was analyzed in the project area using the National Land Cover Database from 2006 (Fry and others, 2011) and U.S. Department of Agriculture National Agriculture Inventory Project aerial imagery (2010). The watershed of the Preserve drains about

6.0 square miles. Appendix D displays the percentages of each land use/land cover component of the Cane Creek watershed (CC1) and other sampling station subwatersheds.

About 70 percent of the watershed of station CC1 is covered by forest (Appendix D). Around 14 percent is classified as shrub/grassland. After close examination of the aerial imagery, it appears that many of these shrub/grassland patches in the watershed are transitional areas which have been harvested for timber recently. About 2.5 percent of the watershed has been developed (road infrastructure, houses, etc.), and 13 percent is used for agricultural production, such as pasture land or poultry houses.

SUMMARY

While the Preserve's relatively intact setting hosts a unique and unusually diverse terrestrial community, the aquatic macrofauna encountered during this study was comprised of generally common and widespread species. The owners of the Preserve indicate that off-site land use practices, such as clear cutting timber, cattle operations, farm pond operations and the occasional drainage of those ponds, and the catastrophic failure of a large farm pond and the resulting intense scouring of Devil's Hollow over the past 30 years or so, have led to filling of Cane Creek and some tributaries with sediment, likely affecting the aquatic fauna to some extent. One obvious example noted earlier is the disappearance of Hellbenders, a large salamander, over the past 20 years. They are residents of spaces under large slab rocks, a unique habitat now less common due to increasing volumes of instream gravel and sand effectively filling in those spaces. It is unknown if other native species have been extirpated by this phenomenon.

Runoff associated with the operation of poultry houses in the Waterfall Creek system appears to have moderately affected water quality in this stream and further downstream in Cane Creek through the years, though no substantial impairments were seen in the water or shallow bed sediment samples collected during this study. While the acute effects of toxins lethal to aquatic life in a short period of time are readily discernable, the less obvious effects of chronic, long term exposure to contaminants must be taken into account as well.

As noted earlier, a private pond in the Waterfall Creek drainage upstream of the Preserve was being drained during our August sample and the stream ran relatively high for several days. During our subsequent fish collection in September we noticed large mats of green algae cast up on the banks of that stream, which the landowner indicated were not normally found there and likely would have come from that pond. While no noticeable accumulation of algae was

observed instream during our sampling period, it is likely that introductions of foreign materials from offsite sources and further changes to the natural setting of the Preserve could have detrimental effects to water quality in the system at times.

Based upon the results of this survey, the documented effects to the biological integrity of the Preserve property from offsite activities in the recent past, and the continuing presence of potential threats, we make the following recommendations:

- This one-year assessment should be expanded to include a quantified threats analysis survey;
- Individuals and organizations familiar with the mechanisms for identifying specific threats to natural resources should be approached to help identify and mitigate specific problems;
- A plan for long-term monitoring of Preserve resources by such means as IBIs, pebble counts, habitat assessments, etc. should be developed and implemented to document habitat conditions and population trends that might reveal detrimental conditions; upon identification of these threats mitigation measures should be implemented.
- Water and sediment quality should continue to be monitored; if values recorded begin to consistently surpass recognized aquatic life criteria then an effort should be made to determine and mitigate the source(s).
- Riparian borders in the Preserve and on associated streams should be established and maintained to stabilize banks, minimized sediment loading, and provide shade to discourage or prevent nuisance algal blooms.

LITERATURE CITED

Canadian Council of Ministers of the Environment, 2002, Canadian Sediment Quality Guidelines for the protection of aquatic life, http://www.elaw.org/system/files/sediment.

Crock, J. C., Briggs, P. H., Jackson, L. L., and Lichte, F. E., 1987, analytical methods for the analysis of stream sediments and rocks from wilderness study areas: U.S. Geological Survey, Open-file Report 87-84, 35 p.

Fishman, M. J., and Friedman, L. C., eds., 1989, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 5, Chapter A1, 545 p.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., 2011, Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, vol. 77, no. 9, p. 858-864.

Greenberg, A. E., Clesceri, L. S., and Eaton, A. D., eds., 1992, Standard methods for the examination of water and wastewater: Washington, D.C., American Public Health Association.

Hem, J. D., 1989, Study and interpretation of the chemical characteristics of natural water, third edition: U.S. Geological Survey Water-Supply Paper 2254, 263 p.

McLean, E. O., 1982, Soil pH and lime requirements, in Page, A. L., Miller, R.H., and Keeney, D. R., eds., Methods of Soil Analysis, Part 2, 2nd ed.: Madison, Wisconsin, American Society of Agronomy and Soil Science Society of America, 1159 p.

Mirarchi, R. E., ed., 2004, Alabama wildlife: Volume 1: A checklist of vertebrates and selected invertebrates: aquatic mollusks, fishes, amphibians, reptiles, birds, and mammals: Tuscaloosa, Alabama, The University of Alabama Press, 209 p.

O'Neil, P. E., and Meintzer, R. E., 1995, Lower Cahaba River water quality assessment/quality assurance/quality plans for the collection and analysis of water quality and aquatic biological samples: Alabama Geological Survey Open-File Report, 50 p.

Sapp, C. D., and Emplaincourt, Jacques, 1975, Physiographic regions of Alabama: Geological Survey of Alabama Special Map 168.

Smith, J. B., Schuster, G. A., Taylor, C. A., Wynn, E. A., and McGregor, S. W., 2011, A preliminary report on the distribution and conservation status of the Alabama crayfish fauna: Geological Survey of Alabama Open-file report 1102, 180 p.

United States Department of Agriculture (USDA) Farm Service Agency - Aerial Photography Field Office (APFO), 2010, National Agricultural Inventory Project (NAIP) Digital Ortho Photo Images, Salt Lake City, Utah, USA.

U. S. Environmental Protection Agency, 1973, Biological field and laboratory methods for measuring the quality of surface waters and effluents: Cincinnati, Ohio, United States Environmental Protection Agency, Office of Research and Development, EPA/670/4-73-001.

___1983, Methods for chemical analysis of water and wastes (revised edition): Cincinnati, Ohio, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, EPA/600/4-79-020.

___1988, Methods for the determination of organic compounds in drinking water: Cincinnati, Ohio, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, EPA/600/4-88/039, 378 p.

___1990, Methods for the determination of organic compounds in drinking water, supplement 1: Washington, D.C., U.S. Environmental Protection Agency, Office of Research and Development, EPA/600/4-90/020, 232 p.
___1991, Methods for the determination of metals in environmental samples: Washington, D.C., U.S. Environmental Protection Agency, Office of Research and Development, EPA/600/4-91/010, 293 p.
___1993, Methods for the determination of inorganic substances in environmental samples: EPA/600-R93/100, variously paginated.
___1994, Methods for the determination of metals in environmental samples, supplement I: EPA-600/R-94/111, variously paginated.
___1999a, Method 9030B, Acid-soluble and acid-insoluble sulfides: distillation, rev. 2; in Test Methods for Evaluating Solid Waste Physical/Chemical Methods: SW-846, Draft Update IVA, 1 CD-ROM.
___1999b, Method 9034, Titrimetric procedure for acid-soluble and acid insoluble sulfides, rev. 0; in Test Methods for Evaluating Solid Waste Physical/Chemical Methods: SW-846, Draft Update IVA, 1 CD-ROM
Wershaw, R. L., Fishman, M. J., Grabbe, R. R., and Lowe, L. E., eds., 1987, Methods for the determination of organic substances in water and fluvial sediments: Techniques of water-resources investigations of the U.S. Geological Survey, Book 5, Chapter A3, 80 p.

APPENDIX A

Water-quality sampling data from Cane Creek Canyon Nature Preserve,
Colbert County, Alabama, 2011

Parameter	Units	Lower limit of detection	CC1		WC1		CC5	
Date	dd-mm-yy	--	22-Jun-11	24-Aug-11	22-Jun-11	24-Aug-11	22-Jun-11	24-Aug-11
Time	24 hr	--	12:00	10:55	13:15	12:00	14:00	13:05
Discharge	cfs	--	2.887	0.0	0.203	0.0	1.810	0.0
Alkalinity as $CaCO_3$	mg/L	3	64	74	43	56	40	81
pH	units	--	6.5	6.8	6.7	7.1	7.2	7.8
CO_2, Free	mg/L	1	39	23	17	9	5	2
Specific conductance	$\mu S/cm^2$	1	126	183	97	134	100	156
Total dissolved solids	mg/L	1	79.1	91.0	64.5	95.1	60.5	99.8
Total suspended solids	mg/L	4	5	<4	18	4	<4	<4
Total residual chlorine	mg/L	0.02	0.02	0.02	0.06	0.03	<.02	0.07
Turbidity	NTU	1	4.5	1.2	6.6	3.5	41.3	1.9
Hardness as $CaCO_3$	mg/L	1	61.8	70.7	42.9	61.7	51.8	81.8
Temperature	°C	--	22	26	22	23	22	24
Dissolved oxygen	mg/L	0.1	6.9	5.9	8.0	2.7	8.3	8.4
Calcium	mg/L	0.02	21.30	24.20	13.60	19.70	18.00	28.80
Magnesium	mg/L	0.06	2.04	2.45	2.13	3.00	1.63	2.37
Sodium	mg/L	0.06	2.46	2.45	4.02	5.21	1.74	2.09
Potassium	mg/L	0.6	0.84	1.38	1.57	2.35	1.04	1.08
Chloride	mg/L	0.03	1.85	2.03	3.12	6.24	2.03	2.63
Sulfate	mg/L	0.08	4.12	4.68	5.35	7.16	3.24	3.20
Bicarbonate	mg/L	3	78	84	52	60	49	74
Carbonate	mg/L	1	<1	<1	<1	<1	<1	<1
Silica	mg/L	0.06	7.44	7.93	7.00	8.19	8.15	8.21
Fluoride	mg/L	0.02	0.078	<0.02	0.087	<0.02	0.083	<0.02
Ammonia as N	mg/L	0.02	<0.02	0.034	<0.02	0.041	0.046	0.037
Total Kjedahl nitrogen	mg/L	0.07	0.50	0.34	0.61	0.26	0.70	0.33
Nitrite as N	mg/L	0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Nitrate as N	mg/L	0.006	0.112	0.175	0.439	1.080	0.088	0.590
NOx as N	mg/L	0.006	0.112	0.143	0.439	0.760	0.088	0.339
Total phosphorus as P	mg/L	0.01	0.09	0.12	0.11	0.12	0.10	0.11
Phosphate as PO_4	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aluminuim	μg/L	30	<30	<30	<30	<30	106	<30
Antimony	μg/L	3	<3	<3	<3	<3	<3	<3
Arsenic	μg/L	2	<2	<2	<2	<2	<2	<2
Barium	μg/L	1	191	58.7	119	100	113	56.4
Berylium	μg/L	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Boron	μg/L	110	<110	<110	<110	<110	<110	<110
Bromide	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Cadmium	μg/L	0.09	0.1	<.09	<.09	<.09	<.09	<.09
Chromium	μg/L	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8
Cobalt	μg/L	7	<7	<7	<7	<7	<7	<7
Copper	μg/L	5	6.9	<5	9.3	<5	<5	<5
Cyanide	mg/L	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003

Parameter	Units	Lower limit of detection	CC1		WC1		CC5	
Iron	µg/L	4	26.9	8.0	30.2	57.4	109	4.7
Lead	µg/L	0.9	21.1	15.0	7.7	7.9	4.3	5.1
Lithium	µg/L	8	<8	<8	<8	<8	<8	<8
Manganese	µg/L	0.8	12	30	9	266	5	7
Mercury	µg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Molybdenum	µg/L	20	<20	<20	<20	<20	<20	<20
Nickel	µg/L	20	<20	<20	<20	<20	<20	<20
Selenium	µg/L	3	<3	<3	<3	<3	<3	<3
Silver	µg/L	10	<10	<10	<10	<10	<10	<10
Strontium	µg/L	0.5	87.1	102	68	92.8	66.1	98.7
Thallium	µg/L	2	<2	<2	<2	<2	<2	<2
Tin	µg/L	50	<50	<50	<50	<50	<50	<50
Titanium	µg/L	6	<6	<6	<6	<6	<6	<6
Vanadium	µg/L	4	<4	<4	<4	<4	<4	<4
Zinc	µg/L	4	83.1	23.7	78.1	42.5	51.2	25.7
Chemical oxygen demand	mg/L	30	31	71	43	56	68	53
Total phenolics	mg/L	3	<3	<3	<3	<3	<3	<3
Total organic carbon	mg/L	0.4	1.99	1.34	3.63	2.31	9.57	1.31

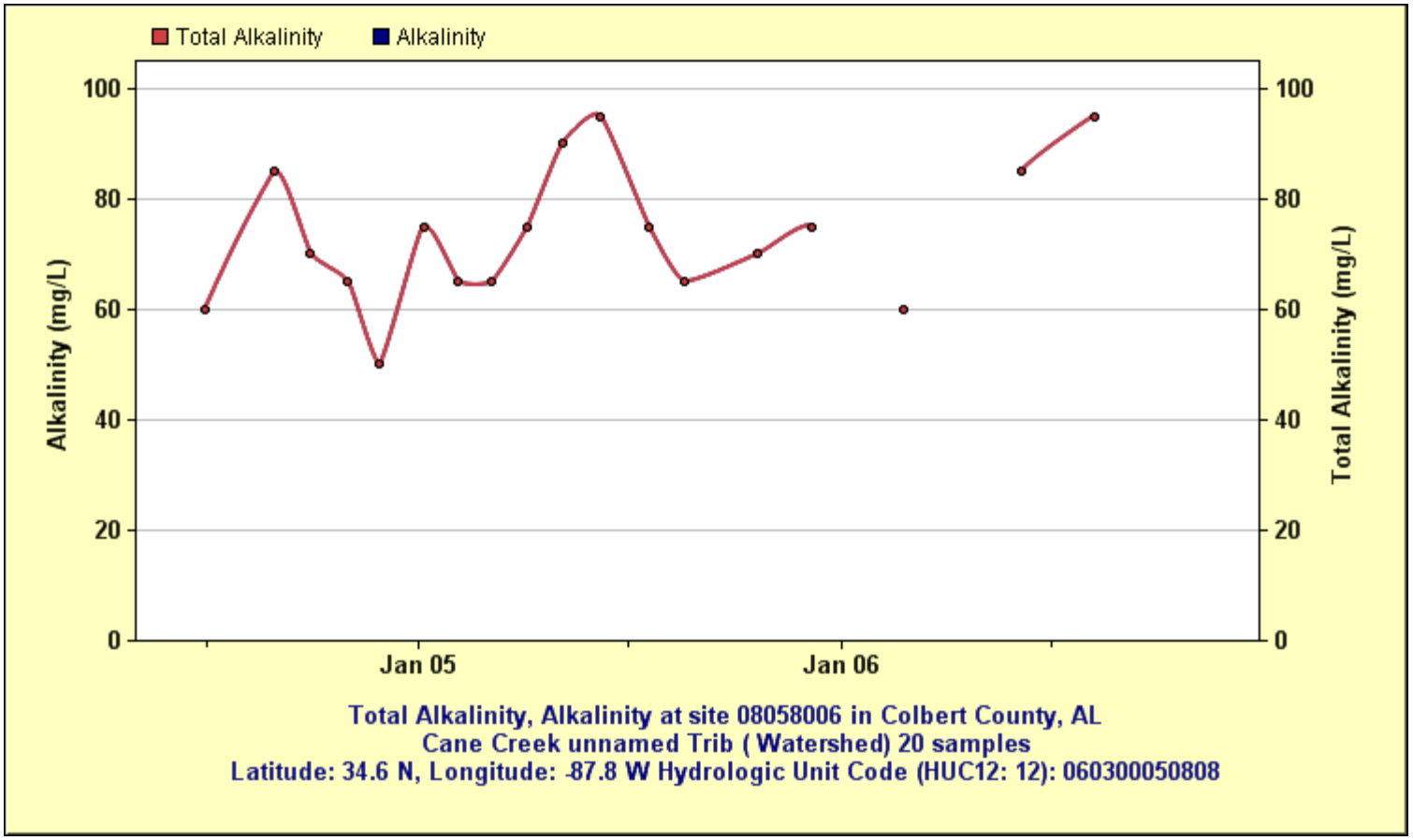
APPENDIX B

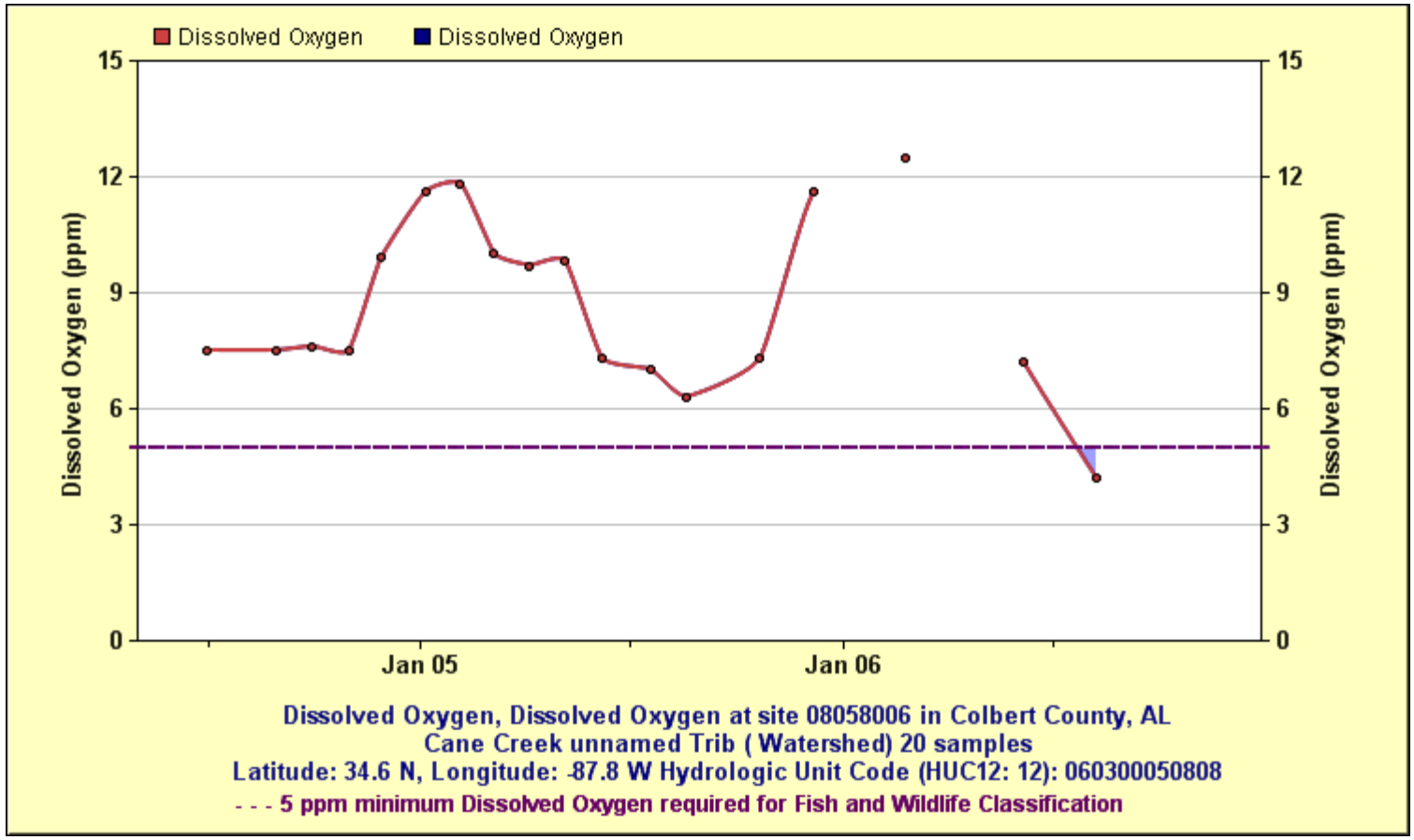
Sediment-quality sampling data from Cane Creek Canyon Nature Preserve,
Colbert County, Alabama, 2011

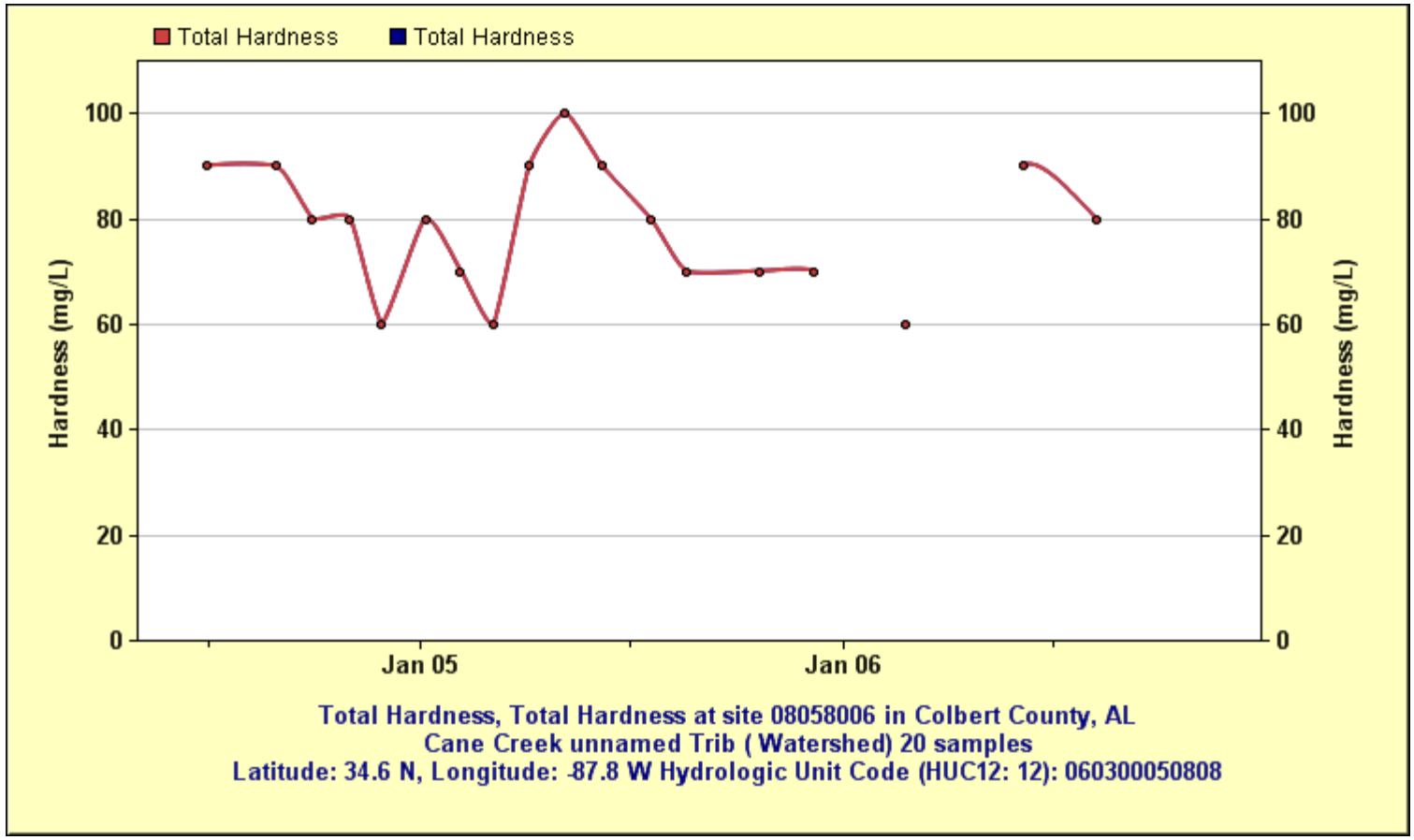
Parameter	Units	Lower limit of detection	WC1	CC5
Date	dd-mm-yy	--	24-Aug-11	24-Aug-11
Time	24 hr	--	12:00	13:05
pH	s.u.	--	5.6	5.9
Ammonia as N	mg/kg	0.4	8.91	10.7
Total Kjeldahl nitrogen	mg/kg	20	250	339
Total nitrite-nitrate as N	mg/kg	0.875	<0.875	<0.875
Total phosphorus as P	mg/kg	0.04	54.3	43.1
Phosphate as PO_4	mg/kg	1	<1	<1
Sulfate	mg/kg	0.8	17.6	30.3
Chloride	mg/kg	0.4	1.28	1.43
Bromide	mg/kg	0.625	<0.625	<0.625
Fluoride	mg/kg	0.375	<0.375	<0.375
Antimony	mg/kg	0.3	<0.3	<0.3
Arsenic	mg/kg	0.3	2.32	3.52
Beryllium	mg/kg	0.006	0.65	0.57
Bismuth	mg/kg	0.6	<0.6	<0.6
Cadmium	mg/kg	0.02	0.12	0.08
Cesium	mg/kg	0.5	<0.5	<0.5
Chromium	mg/kg	0.2	10.4	12.2
Cobalt	mg/kg	0.2	5.4	6.7
Copper	mg/kg	0.2	4.5	5.5
Lead	mg/kg	0.3	4.6	5.2
Lithium	mg/kg	0.3	2.6	3.6
Manganese	mg/kg	0.08	247	317
Mercury	mg/kg	0.002	0.0376	0.187
Molybdenum	mg/kg	0.6	0.7	0.6
Nickel	mg/kg	0.3	6.6	10.3
Rubidium	mg/kg	0.3	6.4	2.5
Selenium	mg/kg	0.3	0.3	0.3
Silver	mg/kg	0.09	<0.09	<0.09
Strontium	mg/kg	0.3	4.5	5.2
Thallium	mg/kg	0.2	<0.2	<0.2
Tin	mg/kg	0.2	1.2	1.41
Vanadium	mg/kg	0.5	21.7	25.5
Zinc	mg/kg	0.2	<0.2	<0.2
Cyanide	mg/kg	0.08	<0.08	<0.08
Total organic carbon	mg/kg	40	5100	10400
Solids, volatile-on-ignition	mg/kg	1	21800	32100

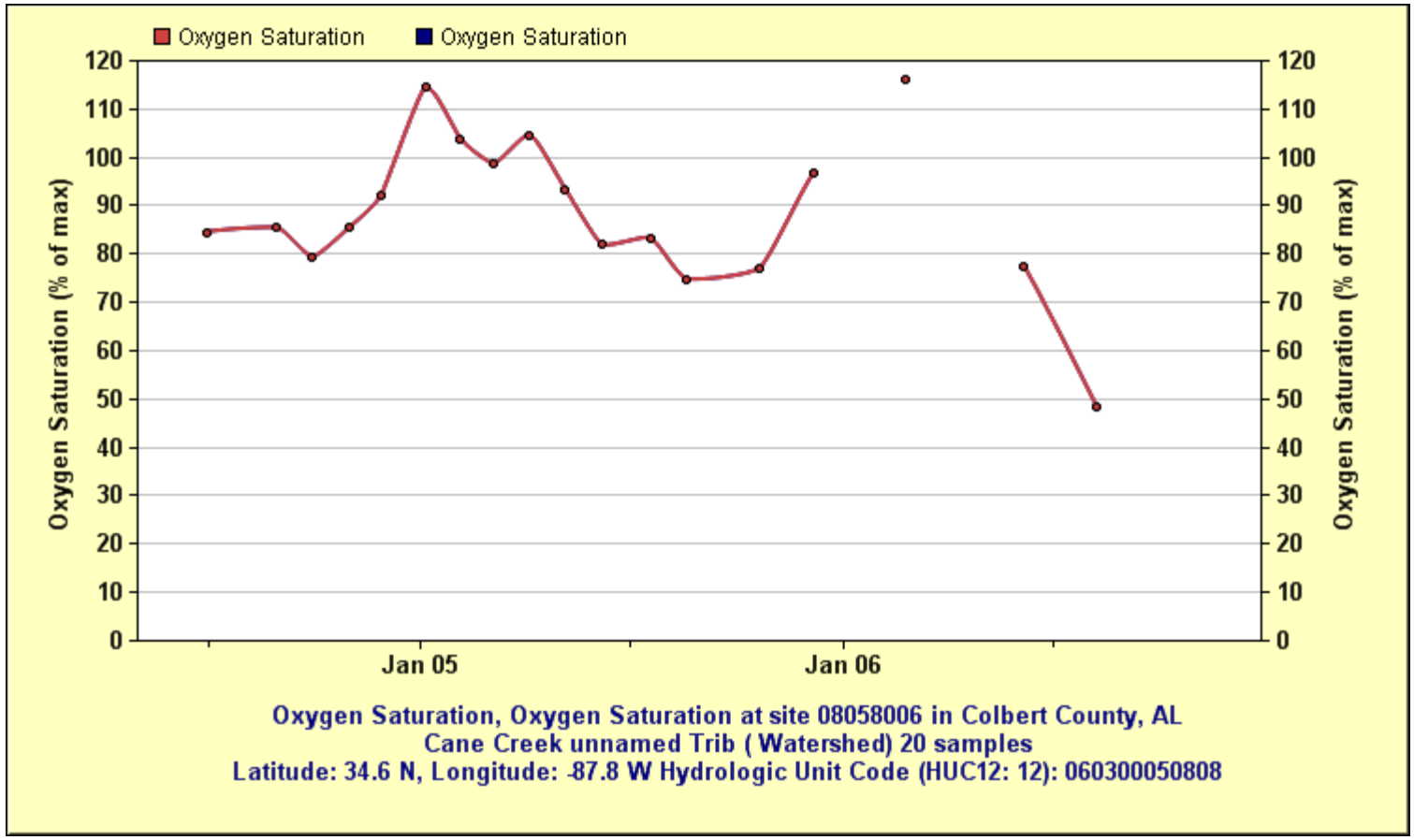
APPENDIX C

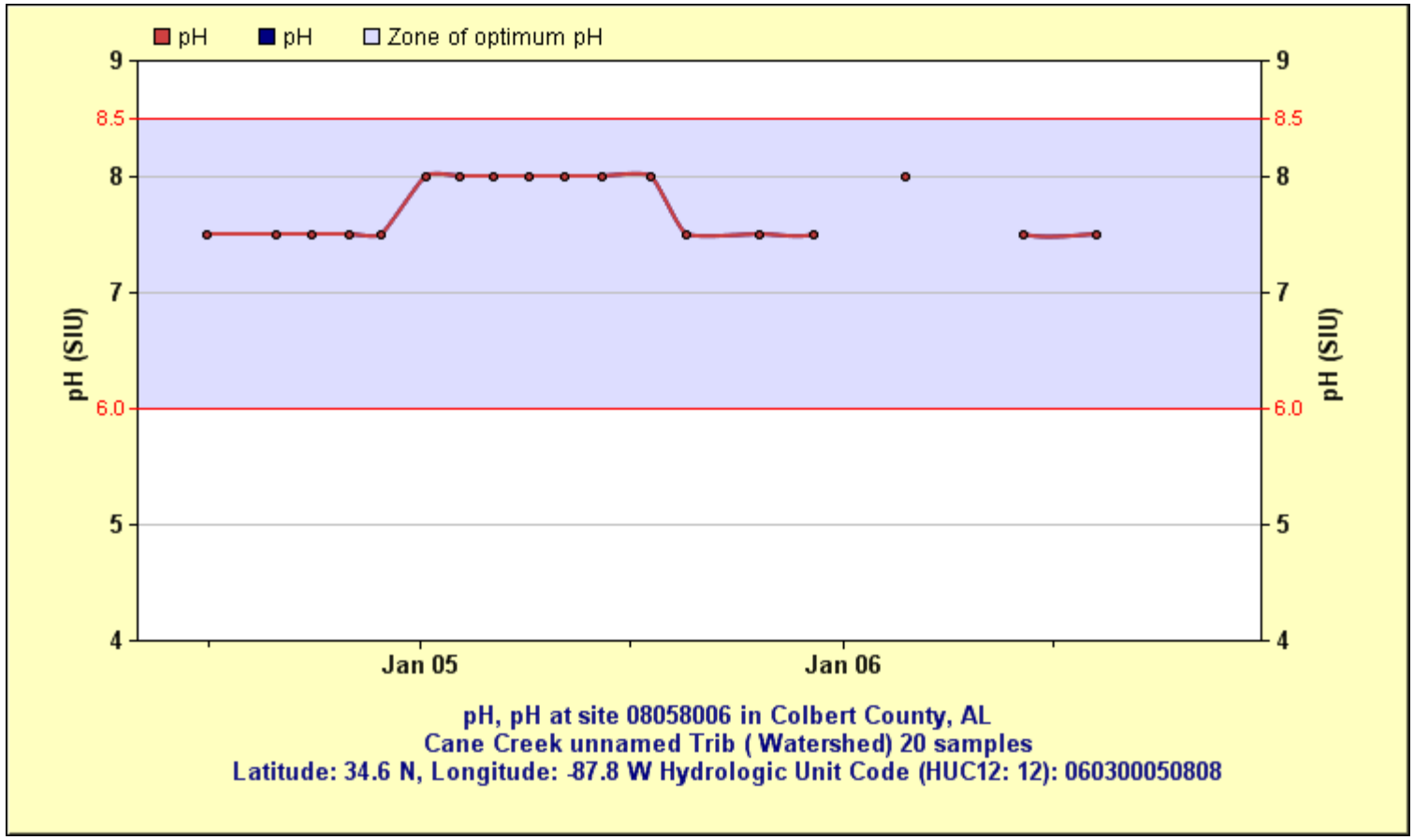
Results of water-quality measurements by Alabama Water Watch
in Waterfall Creek, Colbert County, Alabama, 2004-06

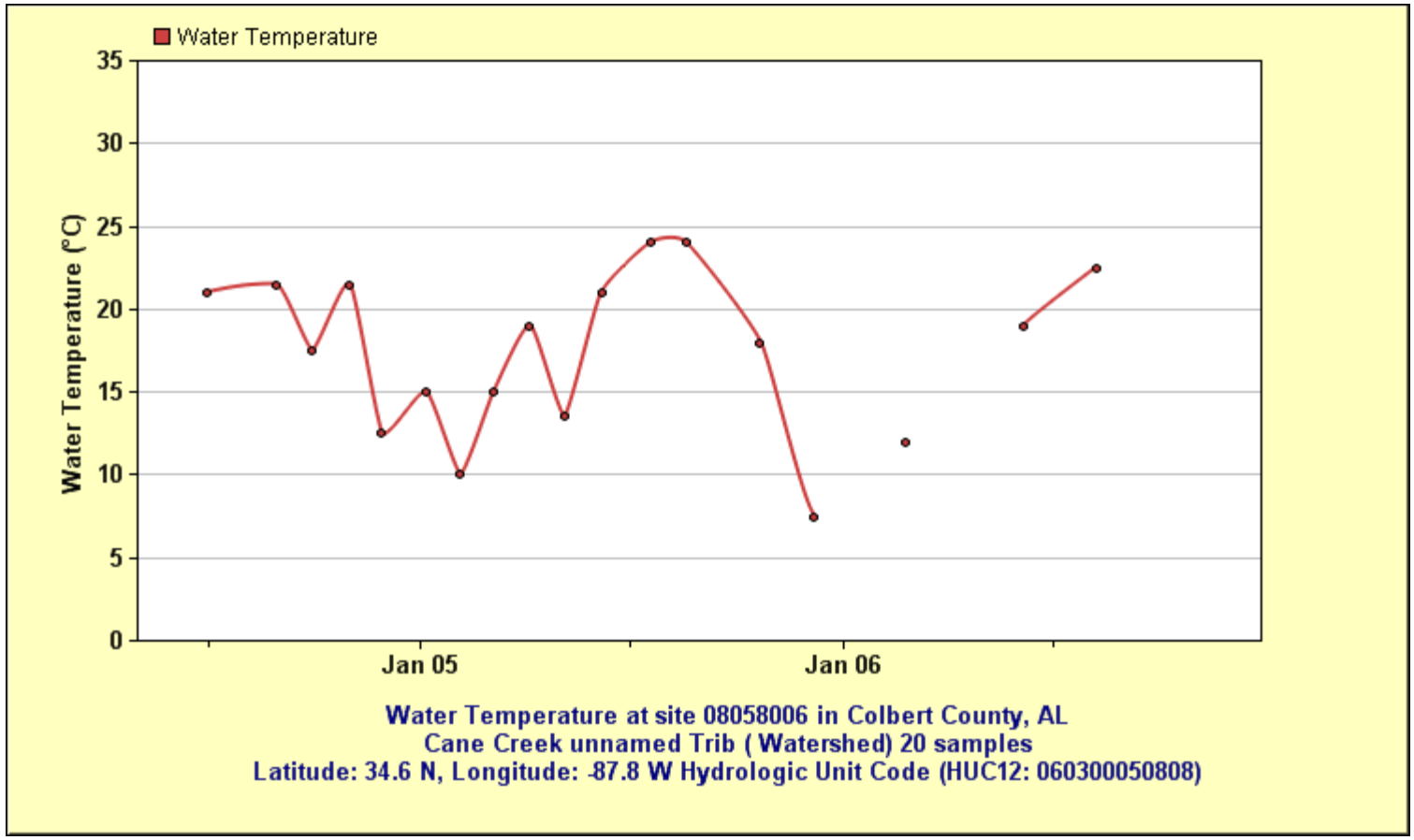

Total Alkalinity
Alkalinity
100
80
60
40
20
0
Alkalinity (mg/L)
Total Alkalinity (mg/L)
Jan 05
Jan 06
Total Alkalinity, Alkalinity at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 12): 060300050808

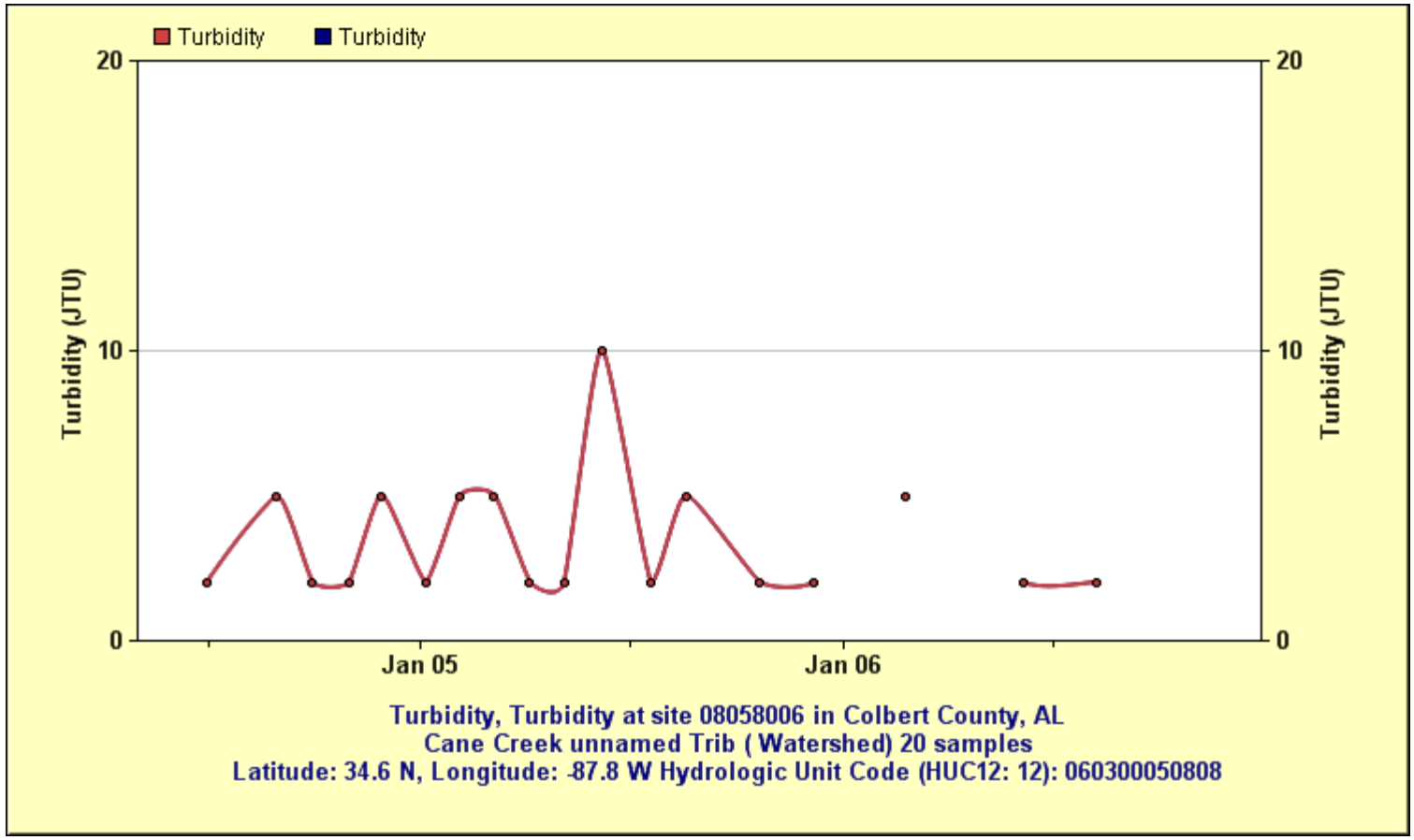

Dissolved Oxygen
Dissolved Oxygen
15
12
9
6
3
0
Dissolved Oxygen (ppm)
Jan 05
Jan 06
Dissolved Oxygen, Dissolved Oxygen at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 12): 060300050808
- - - 5 ppm minimum Dissolved Oxygen required for Fish and Wildlife Classification


Total Hardness
Total Hardness
Hardness (mg/L)
100
80
60
40
20
0
Jan 05
Jan 06
Total Hardness, Total Hardness at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 12): 060300050808


Oxygen Saturation
Oxygen Saturation
Oxygen Saturation (% of max)
120
110
100
90
80
70
60
50
40
30
20
10
0
Jan 05
Jan 06
Oxygen Saturation, Oxygen Saturation at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 12): 060300050808


pH
pH
Zone of optimum pH
9
8.5
8
7
6.0
5
4
pH (SIU)
Jan 05
Jan 06
pH, pH at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 12): 060300050808


Water Temperature
35
30
25
20
15
10
5
0
Water Temperature (°C)
Jan 05
Jan 06
Water Temperature at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 060300050808)


Turbidity
Turbidity
20
10
0
Turbidity (JTU)
Jan 05
Jan 06
Turbidity, Turbidity at site 08058006 in Colbert County, AL
Cane Creek unnamed Trib (Watershed) 20 samples
Latitude: 34.6 N, Longitude: -87.8 W Hydrologic Unit Code (HUC12: 12): 060300050808

APPENDIX D

Summary information for land use/land cover at sampling stations
in Cane Creek Canyon Nature Preserve,
Colbert County, Alabama

Station	Acres	Square Miles	Forest percentage 2006	Forest change (1992 to 2006)	Wetland percentage 2006	Wetland change (1992 to 2006)	Shrub percentage 2006	Shrub change (1992 to 2006)
CC1	3532.06	5.52	69.79	-4.85	0.11	0.00	13.67	5.12
CC2	2974.96	4.65	72.26	-4.76	0.09	0.00	13.88	5.49
CC3	2951.39	4.61	72.18	-4.80	0.09	0.00	13.99	5.53
CC4	1780.04	2.78	79.56	-3.61	0.00	0.00	15.01	4.43
CC5	1685.08	2.63	78.41	-3.82	0.00	0.00	15.86	4.68
CT1	278.88	0.44	80.38	-18.26	0.00	0.00	18.82	18.74
DH1	396.53	0.62	50.79	-4.54	0.34	0.00	10.08	1.68
LD1	248.64	0.39	41.95	-27.01	0.00	0.00	37.21	23.08
WC1	724.56	1.13	46.07	-3.65	0.12	0.00	12.63	4.44
WC2	299.79	0.47	53.78	-9.30	0.00	0.00	25.88	10.18

Station	Acres	Square Miles	Urban percentage 2006	Urban change (1992 to 2006)	Manmade Barren percentage 2006	Manmade barren change (1992 to 2006)	Agriculture percentage 2006	Agriculture change (1992 to 2006)
CC1	3532.06	5.52	2.59	0.01	0.03	0.03	13.81	-0.30
CC2	2974.96	4.65	2.81	0.01	0.00	0.00	10.95	-0.73
CC3	2951.39	4.61	2.84	0.01	0.00	0.00	10.89	-0.74
CC4	1780.04	2.78	2.89	-0.04	0.00	0.00	2.54	-0.78
CC5	1685.08	2.63	3.05	-0.04	0.00	0.00	2.68	-0.82
CT1	278.88	0.44	0.40	0.00	0.00	0.00	0.40	-0.48
DH1	396.53	0.62	1.98	0.01	0.28	0.28	36.52	2.57
LD1	248.64	0.39	0.09	0.00	0.00	0.00	20.75	3.94
WC1	724.56	1.13	4.31	0.12	0.00	0.00	36.86	-0.91
WC2	299.79	0.47	2.92	0.30	0.00	0.00	17.43	-1.18

GEOLOGICAL SURVEY OF ALABAMA
P.O. Box 869999
420 Hackberry Lane
Tuscaloosa, Alabama 35486-6999
205/349-2852

Berry H. (Nick) Tew, Jr., State Geologist

A list of the printed publications by the Geological Survey of Alabama can be obtained from the Publications Office (205/247-3636) or through our web site at http://www.gsa.state.al.us/.

E-mail: publications@gsa.state.al.us

Serving Alabama since 1848