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Clear Creek Pre-BMP Water Quality Study

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by

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Prepared in cooperation with the World Wildlife Fund
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ABSTRACT

The mussel population in the North River system of west-central Alabama has declined over the past 20 years, with only remnant populations existing in the upper reaches of North River, most notably in the Clear Creek subwatershed. Clear Creek is threatened by nonpoint source pollution, and the North River Watershed Management Plan has recommended habitat restoration best management practices, outreach education programs, and additional monitoring activities to be conducted in order to recover and restore rare mussel species to the watershed. Through the support of the World Wildlife Fund, the Geological Survey of Alabama has established two water quality monitoring stations to record baseline stream flow data and collect water quality samples to support upcoming restoration efforts. An account of the first six months of data collection is provided in the following report.

INTRODUCTION

The mussel fauna of the southeast U.S.A has been substantially diminished over the past 100 years because of land cover changes and loss of habitat. The mussel's sedentary mode of life and unique reproduction strategies, when combined with habitat disruption and fragmentation, have resulted in a decline of mussel populations to the point that many species are now on the federal threatened and endangered species list (O'Neil and others, 2010).

Currently, 17 species of mussels in the Mobile River Basin are recognized as endangered or threatened by the U.S. Fish and Wildlife Service (USFWS), and 14 species in the genus *Pleurobema,* endemic to the Mobile River Basin, are considered extinct by the USFWS (Hartfield, 1994). The type locality for one of these extinct species, *Pleurobema hagleri* (= *P. furvum*), is the North River where it was reported to exist prior to 1920 (van der Schalie, 1981).

The USFWS has designated 26 river and stream segments (units) in the Mobile River basin (fig. 1) as critical habitat for three threatened and eight

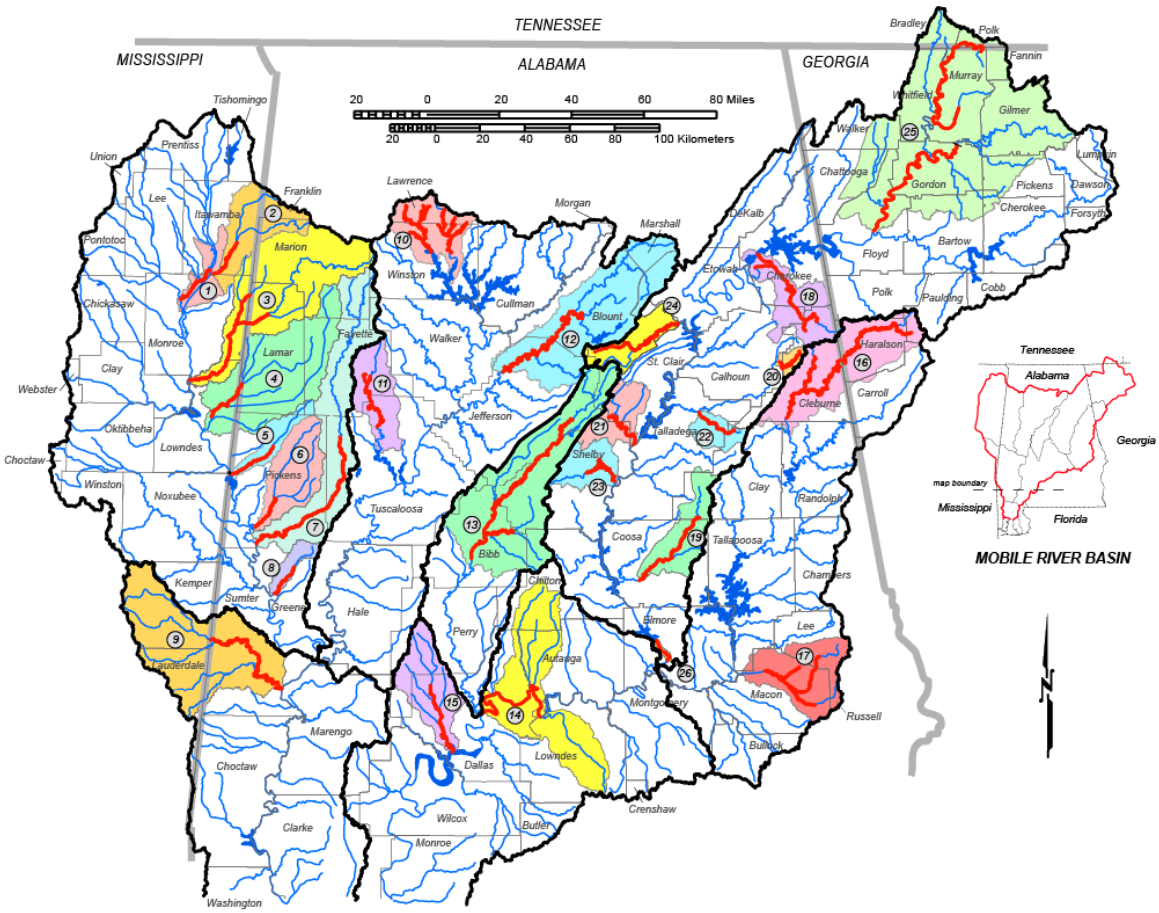
endangered freshwater mussel species under the Endangered Species Act of 1973, as amended (see 69 Federal Register 40084). The critical habitats encompass approximately 1,093 miles of stream and river channels in four states. The critical habitat designations include a significant part of the Mobile River Basin's remaining free-flowing rivers and streams and reflect the variety of small stream to large river habitats once occupied by these species (O'Neil and others, 2008).

The USFWS, in cooperation with the Alabama Aquatic Biodiversity Center (AABC), the Geological Survey of Alabama (GSA) and the Alabama Clean Water Partnership (ACWP) developed the following process model to enhance species recovery opportunities in Mobile River basin critical habitat:

1. Delineation of the watershed boundary upstream of each critical habitat unit. This designated area is referred to as the "strategic habitat unit" (SHU) and created a spatial boundary within which recovery activities could be implemented.

2. Development of SHU-specific watershed information. For successful species recovery, watersheds must be understood from a biological, water quality, habitat, and land use perspective. The type of watershed information developed for each SHU is determined by the type and intensity of threats posed. In this way, areas in need of protection can be identified.

3. Development of an action plan for species recovery and restoration. Once threats are linked with imperiled mussel species, a management plan for recovery can be developed so species restoration can commence. The plan is implemented through a cooperative partnership of local landowners, organizations, and agencies including watershed partnerships, local and county governments, local businesses and farmers, state and federal agencies, and other interested parties using a variety of means including protecting stream habitat through land purchase or landowner conservation agreements; management of habitat and water quality by eliminating polluted runoff sources and by reducing pollutant loads through more restrictive water-quality permitting and more aggressive best management practices (BMP) implementation;



1. East Fork Tombigbee River
2. Bull Mountain Creek
3. Buttahatchee River and Sipsey Creek
4. Luxapalila and Yellow Creeks
5. Coalfire Creek
6. Lubbub Creek
7. Sipsey River
8. Trussels Creek
9. Sucarnoochee River
10. Sipsey Fork and tributaries
11. North River and Clear Creek
12. Locust Fork and Little Warrior River
13. Cahaba and Little Cahaba Rivers
14. Alabama River
15. Bogue Chitto Creek
16. Tallapoosa River and Cane Creek
17. Uphapee, Choctafaula, and Chewacla Creeks
18. Coosa River and Terrapin Creek
19. Hatchet Creek
20. Shoal Creek
21. Kelly and Shoal Creek
22. Cheaha Creek
23. Yellowleaf Creek and Muddy Prong
24. Big Canoe Creek
25. Oostanaula, Coosawattee, and Conasauga Rivers and Floyd Creek
26. Lower Coosa River

Figure 1. Critical mussel habitat in the Mobile River Basin.

conducting riparian improvement or physically repairing a substantially degraded stream reach; restoration of biodiversity with culture-raised species; and implementing a broad spectrum of educational initiatives directed towards schools, government officials and regulators, land owners and business professionals, and the general public with the intent to provide science-based information about the watershed and its importance to the economic health of the region (O'Neil and others, 2010).

The North River of west-central Alabama has been identified as one of the 26 SHUs. The mussel population in the North River system has declined over the past 20 years with only remnant populations existing in the upper reaches of North River, most notably in the Clear Creek subwatershed (fig. 2) (McGregor and Wynn, 2008). The main channel of the North River has been placed on the Alabama Department of Environmental Management (ADEM) 303(d) list for high nutrient levels, excessive sedimentation, and mercury concentrations which have caused habitat degradation in the river system (ADEM, 2010).

The GSA recently completed a watershed assessment of the North River SHU, summarizing the results of various water quality, fish, mussel, and habitat surveys performed in the watershed by GSA and other agencies (O'Neil and others, 2010). A land cover analysis was performed in the assessment to help identify areas at highest risk of producing nonpoint source pollution. Recommendations for additional monitoring activities, habitat restoration BMPs, and outreach education programs were prescribed in the North River Watershed assessment.

The ACWP, GSA, and other stakeholders in the Lower Black Warrior Clean Water Partnership (LBWCWP) produced the North River Watershed Management Plan (NRWMP). This plan recently obtained funding through the ADEM 319 program. The NRWMP outlined the recommendations stated in O'Neil and others (2010). Following the recommendations stated in the NRWMP, GSA recently was awarded a grant by the World Wildlife Fund (WWF) for additional monitoring of the Clear Creek subwatershed. A section of Clear Creek contains critical mussel habitat and harbors the most biologically diverse

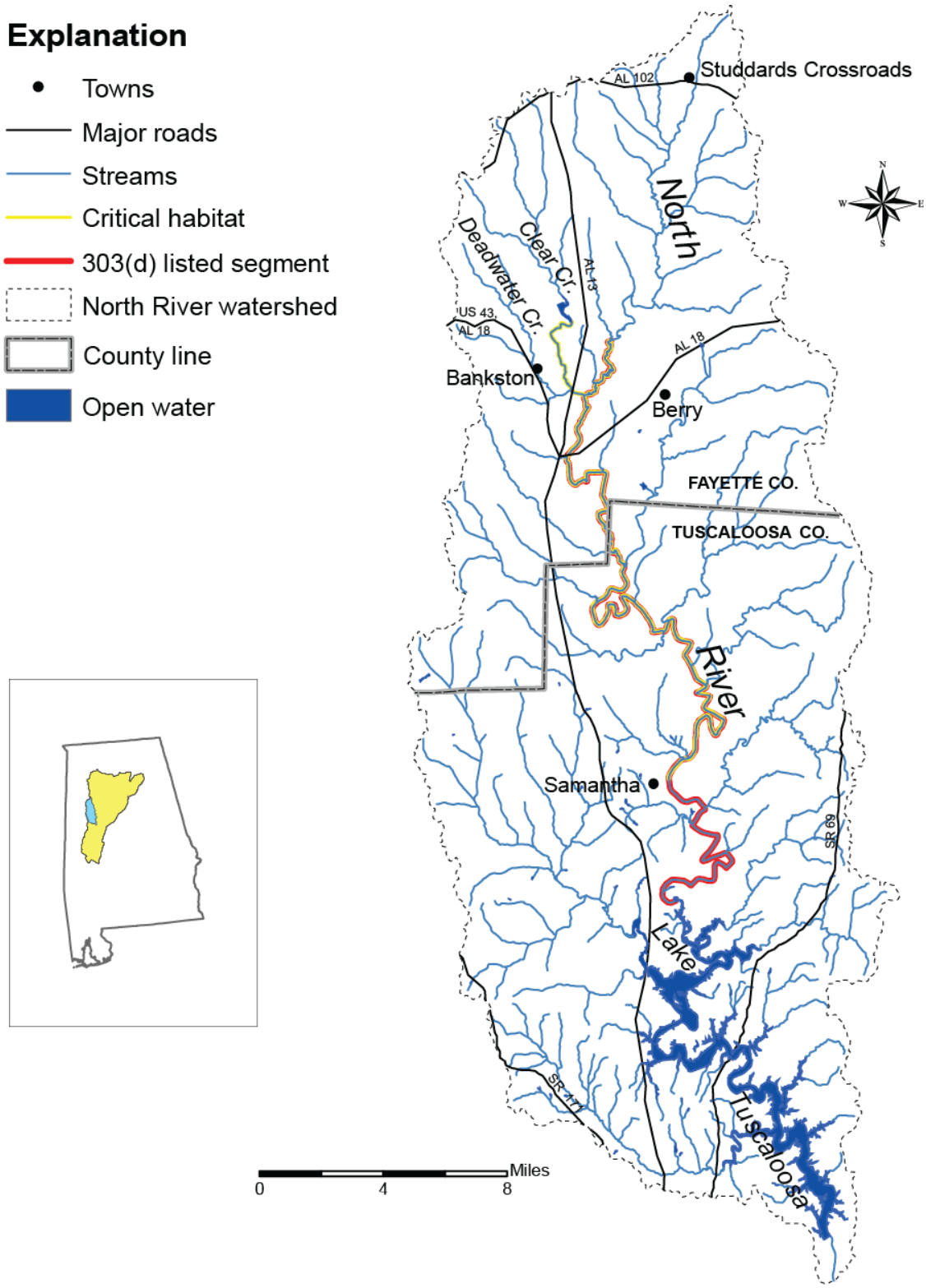


Figure 2. Map of the North River watershed with inset map of Alabama. Inset map displays the Black Warrior basin (yellow) and the North River watershed (blue).

collection of mussels of the North River watershed (McGregor and Wynn, 2008). This critical habitat is also threatened by nonpoint source pollution, and two water quality monitoring stations in Clear and Deadwater Creeks have been set up to record baseline data for future restoration efforts in the watershed.

ACKNOWLEDGMENTS

The Clear Creek Pre-BMP Water Quality Study has been a collaborative effort, and the authors sincerely appreciate all the support they have received. Helen Crockett and Judy Takats of WWF provided grant funding for this project. Phyllis Rainey, John Trimm, and Dwayne Trimm have kindly given permission to establish monitoring sites on their property. Cal Johnson, of GSA, helped install the water monitors and has assisted taking hydrological measurements. Kellie Johnston, with the Cawaco RC&D Council, was instrumental in facilitating the Lower Black Warrior Clean Water Partnership (BWCWP) and developing and receiving 319 funding for the NRWMP. Jeff Powell of the USFWS provided funding and support for the Mobile River Basin Strategic Mussel Habitat project.

STUDY AREA

Clear Creek is a tributary of the North River, which itself is a tributary of the Black Warrior River in west–central Alabama (fig. 2). Clear Creek drains 36 square miles of rural Fayette County (fig. 3). Though historically more heavily used for corn and cotton production (Newell and Newell, 1960), today a large portion of the watershed is covered with stands of second growth timber. Bays Lake, situated on Clear Creek, is the drinking water supply reservoir for the neighboring city of Berry, Alabama. Critical habitat for threatened and endangered mussels extends 3.8 miles from the mouth of Clear Creek to the dam forming Bays Lake (fig 3).

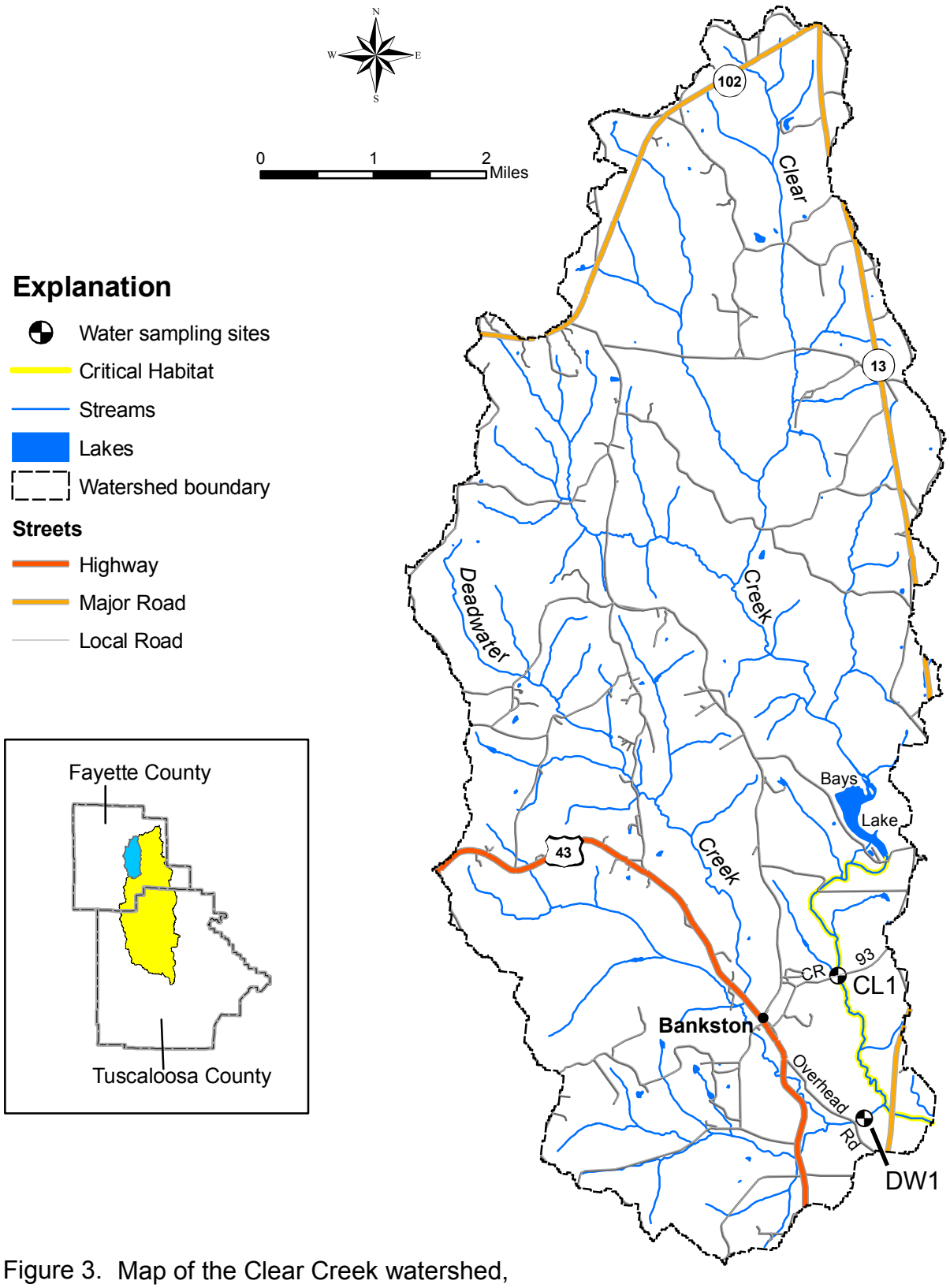


Figure 3. Map of the Clear Creek watershed, displaying the locations of the two water quality monitoring stations. The inset map shows the locations of the Clear Creek subwatershed (blue), nested in the North River watershed (yellow) found in Fayette and Tuscaloosa Counties of Alabama.

METHODS AND RESULTS

Two OTT Orpheus Mini Groundwater Dataloggers (OTT, 2010) were purchased with funds from WWF and installed in the Clear Creek watershed in the fall of 2010. The first monitor, CL1, is located about 50 yards upstream of the bridge crossing of Fayette County Highway 93 on Clear Creek (fig. 3). This station is on the critical habitat segment of Clear Creek, 1.5 miles downstream of Bays Lake Dam. The second monitor, DW1, is located about 200 yards downstream of the bridge crossing of Overhead Road on Deadwater Creek.

At each monitoring site, a 3-inch PVC pipe was secured with steel angle iron along the creek bank and down to the creek bottom (fig. 4a). A 10-foot tall wooden post was erected above the bank (fig. 4b) to keep the communication unit of the probe above flood waters. Two wooden platforms were attached to the post so that workers could safely reach the communication unit and download data onto a laptop computer. A two-inch PVC pipe was secured along the length of the wooden post, and connected to the 3-inch PVC pipe that leads to the creek. This design allowed the entire pressure probe cable, sensor, and communication unit to be housed in the protection of PVC pipe. A well cap lock was secured at the top of the 2-inch PVC pipe (fig. 4c).

The two data loggers were activated in fall 2010 and will collect water level, water temperature, and battery voltage readings hourly until the end of the study period, in the fall of 2015. The data is periodically downloaded as workers visit the two monitoring stations to perform hydrological stream measurements and collect water samples for the analysis of sediment and nutrients. Figure 5 displays the hydrograph of the water level data recorded at Clear Creek during the first six months of monitoring. Figure 6 displays the hydrograph of the water level at Deadwater Creek during the first six months of monitoring.

a

b

c

Figure 4, a - c. Water monitor photographs.

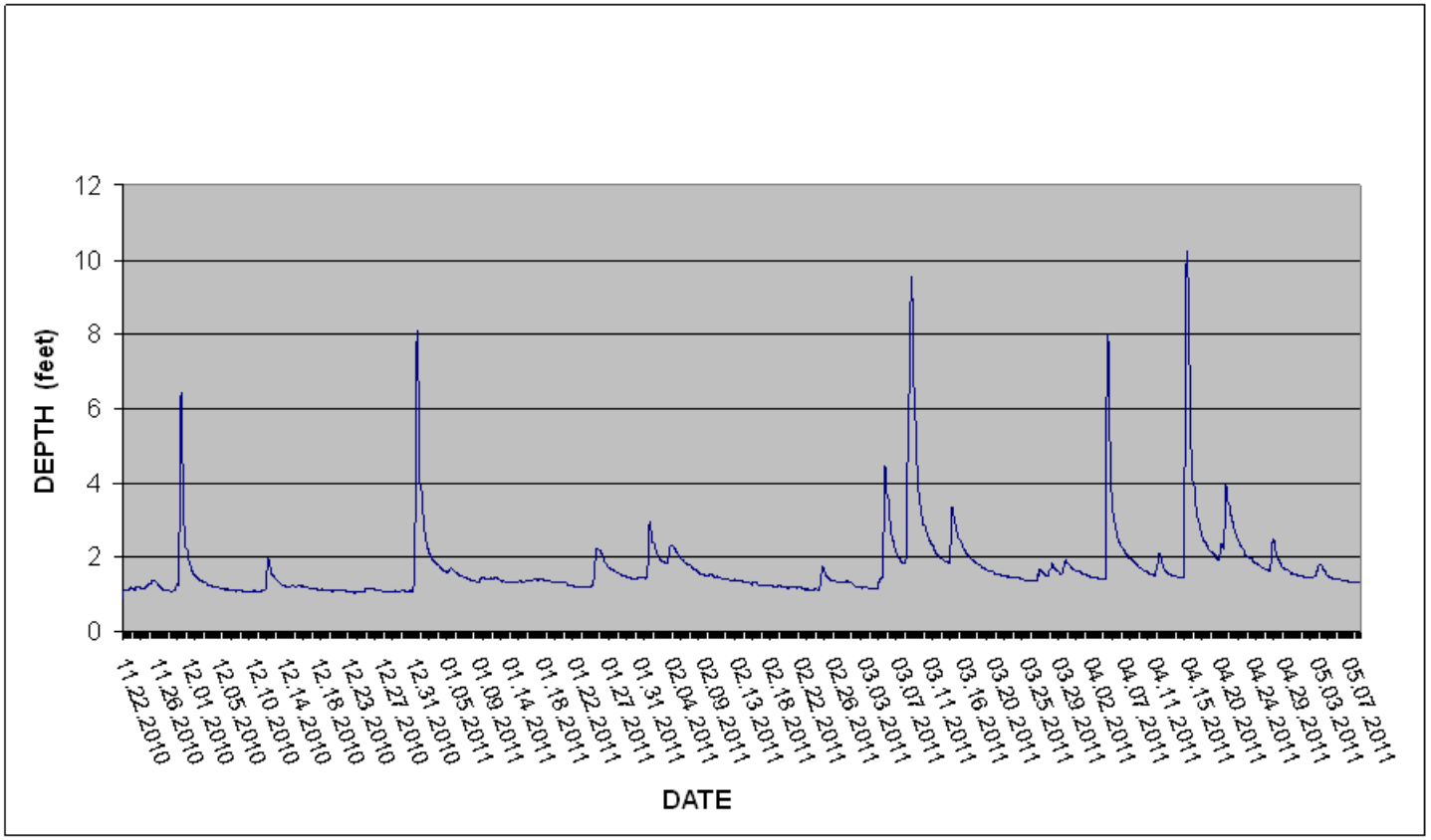


Figure 5. Clear Creek water level from November 22, 2010 – May 9, 2011

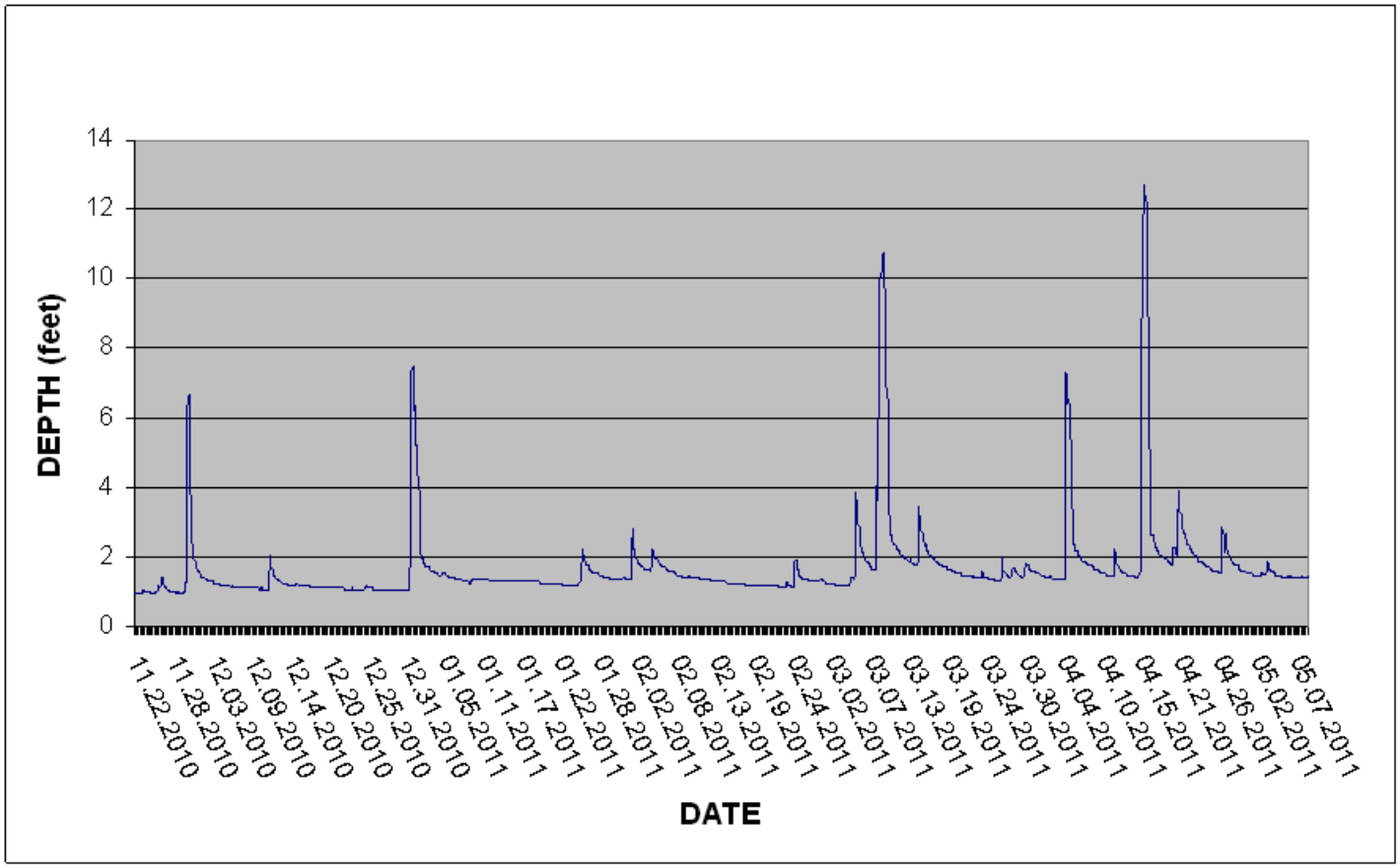


Figure 6. Deadwater Creek water level from November 22, 2010 – May 9, 2011

Water quality data has been collected during low base flows, floods (figs. 7 - 8), and isolated storm events to obtain an accurate representation of the hydrology of the Clear Creek system. Suspended sediment grab samples have been obtained during each field visit, and information on the specific conductivity, pH, temperature, and dissolved oxygen have been collected in situ. Additional raw and filtered water samples collected at each station have been analyzed in the lab of the GSA for nutrient levels and inorganic metal contaminants (table 1).

A permanent cross-section at each station has been established to aid in monitoring change in the channel morphology over time. Flow discharge information is obtained at these cross-sections by stretching a measuring tape across the stream, and taking equally spaced water depth measurements across the channel with a gaging staff. A Price current meter is then used to measure velocity at each recorded depth along the channel (fig. 9). Physical habitat parameters are evaluated each time flow measurements are taken. Parameters noted include the condition of stream substrate, condition of the channel banks, and the adjacent riparian corridor

Stream habitat conditions will also be evaluated at other sites along Clear and Deadwater Creeks to help locate sources of excessive sedimentation in the watershed. Geographical Information Systems (GIS) (ERSI, 2008) is being used to determine habitat assessment sites. The potential nonpoint source pollution index (PNPI) was utilized to model sources of nonpoint source pollution (Munafo and others, 2005).

The PNPI incorporated soil (NRCS, 2006), elevation (USGS, 1999), and land cover (NRCS, 2008) layers in the GIS to create three indicator grids: run-off potential, distance to water, and land cover type. These three indicators were weighted, and combined using ArcMap's raster calculator with the following equation to produce the PNPI (fig. 10). High PNPI values indicated areas in the watershed which had a high probability of contributing nonpoint source pollution.

$$PNPI = 5 * LCI + 3 * DI + 2 * ROI$$

(A)

(B)

Figure 7. Flooding in Clear Creek. (A) Flood stage on March 9, 2011. (B) Receded flow one day later on March 10, 2011.

(A)

Figure 8. Flooding in Deadwater Creek. (A) Flood stage on March 9, 2011, (B – C) Receded flow on March 10, 2011.

(B)

(C)

Table 1. Chemical analysis of water samples collected at stations CL1 and DW1. The full suite of parameters was only available for the 12/20/2011 sampling trip at the time of this report.

Site	CL1	DW1	CL1	DW1	CL1	DW1	CL1	DW1	CL1	DW1	CL1	DW1
Date	12/20/2010	12/20/2010	3/1/2011	3/1/2011	3/9/2011	3/9/2011	3/10/2011	3/10/2011	3/11/2011	3/11/2011	5/9/2011	5/9/2011
Time	10:45	12:15	10:00	12:00	10:30	12:00	10:00	11:20	11:00	12:00	10:00	12:00
Ag	0	0										
Al	0	72										
Alkalinity	9	3										
HCO3	11	4										
CO3	0	0										
CO2, Free	4	2										
Arsenic	0.0	0.0										
B	0	0										
Ba	49.2	79.8										
Be	0	0										
Br	0.00	0.00										
Ca	1.50	2.09										
Cd	0.00	0.25										
Cl	1.96	2.73										
CN	0	0										
Co	0	0										
Conductivity	80	32	29	33	80	20	42	27	19	22	24	26
Cr	0.0	0.0										
Cu	0.0	0.0										
DO	12.1	12.9	10.4	12.2	9.3	8.98	11.30	11.37	11.8	12.2	8.4	10
F	0	0										
Fe	231	433										
Hardness	8	10										
Hg	0	0										
K	1.01	0.60										
Li	0	0										
Mg	0.975	1.090										
Mn	76.3	129.0										
Mo	0	0										
Na	1.52	2.29										
NH3_N	0.059	0.031										
Ni	0	0										
NO2_N	0	0										
NO2_NO2	0.00	0.00										

Table 1. Chemical analysis of water samples collected at stations CL1 and DW1. The full suite of parameters was only available for the 12/20/2011 sampling trip at the time of this report. - *continued*.

Site	CL1	DW1	CL1	DW1	CL1	DW1	CL1	DW1	CL1	DW1	CL1	DW1
Date	12/20/2010	12/20/2010	3/1/2011	3/1/2011	3/9/2011	3/9/2011	3/10/2011	3/10/2011	3/11/2011	3/11/2011	5/9/2011	5/9/2011
NO3_N	0.152	0.127										
NO3_NO3	0.67	0.56										
NOx_N	0.152	0.127										
NOx_NO3	0.67	0.56										
P	0.120	0.124										
PO4_P	0.00	0.00										
Pb	1.3	1.6										
pH	6.7	6.5	6.2	6.4	4.1	5.7	7.1	6.90	5.4	6	6	5.9
Sb	0.0	0.0										
Se	0.0	0.0										
SiO2	5.84	7.48										
Sn	0	0										
SO4	2.47	2.62										
Sr	11.0	13.5										
TDS calculated from conductivity	52	21										
Solids, Total Suspended	12	0										
Temp	5	4	14.7	13.2	14	13	12.1	11.0	13	12	22	23
Ti	0.0	0.0										
TKN	0.53	0.60										
Tl	0.0	0.0										
Turbidity	13.1	5.1										
V	0.0	0.0										
Zn	15.3	43.3										
COD	95	71										
Phenolics	0	0										
Total Organic Carbon	3.93	1.50										

Figure 9. Measuring flow at the Deadwater Creek station on March 11, 2011.

To complement the PNPI, the Analytical Tools Interface for Landscape Assessments (ATtILA) (USEPA, 2004) program was utilized to find unpaved stream crossings using GIS shapefiles of roads and streams. Stream reaches in need of riparian cover were identified and digitized from 2009 aerial photos. Unpaved stream crossings and areas in need of riparian cover were overlaid on the PNPI map to locate sites for assessment (fig. 10).

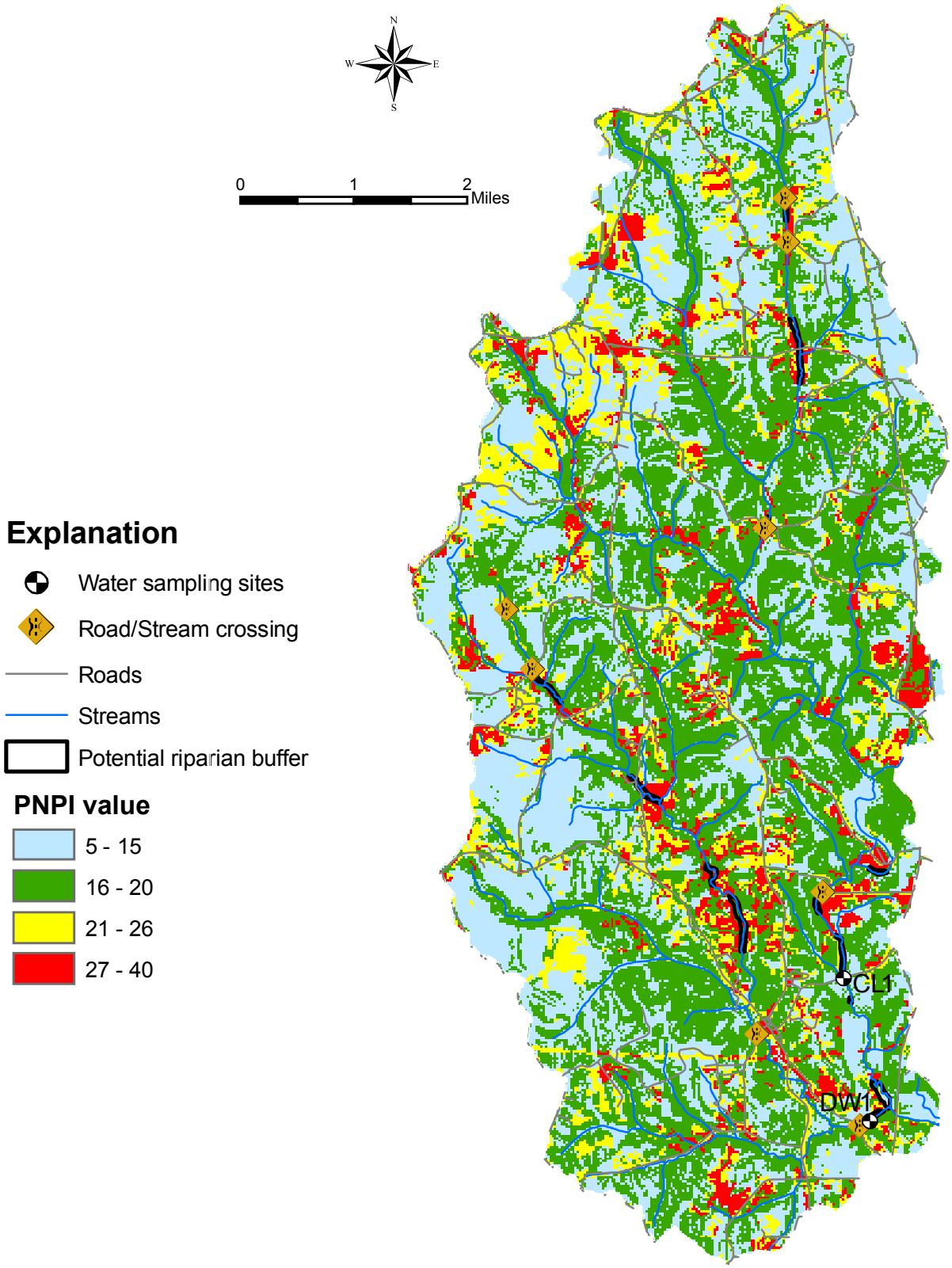


Figure 10. Potential nonpoint source pollution index of the Clear Creek watershed. Locations of unpaved road / stream crossings and stream segments lacking riparian vegetation were also used to help locate sites to sample stream habitat conditions.

The pre-BMP water collection phase of the study will end in the fall of 2011. GSA's geochemical laboratory has been analyzing the water samples, and the results will be utilized in calibrating the pre-BMP sediment loading rates of Clear Creek using the BASINS 4.0 model (USEPA, 2010). BASINS will combine environmental spatial coverages, analytical tools, and modeling programs in a GIS platform to determine the most effective areas to install BMPs in the watershed.

Several of the modules contained in the BASINS program will be used, including the Kinematic Runoff and Erosion Model (KINEROS), Rosgen's Bank Erosion Hazard Index, and the Soil and Water Assessment Tool (SWAT). The model AQUATOX will predict the likely effects of the SWAT output data on the aquatic biota in the receiving stream waters. Historic land use will be analyzed from aerial photography taken in the early 20th century, and this data will be incorporated into the BASINS model to account for the influence of land use legacy effects on current stream conditions.

CONCLUSIONS AND FUTURE WORK

Clear Creek has been designated as a Strategic Habitat Unit by the United States Fish and Wildlife Service for freshwater mussels and contains the best remaining population of mussels in the entire North River system, including one of only two known populations of one critically imperiled species. Samples gathered from impaired habitat reaches occurring upstream of this valuable population will help reveal sources of nonpoint source pollution in the Clear Creek subwatershed, and best management practices can be implemented to restore these degraded sections of the subwatershed. Results from this study will contribute to recovery objectives for federally listed species, support future propagation, augmentation, and reintroduction efforts by the Alabama Aquatic Biodiversity Center, and positively influence water quality and other ecosystem services of the North River, which is currently a 303(d) stream listed for sediment and nutrients.

This study fulfills part of the objectives of the NRWMP, which has been created by the Clean Water Partnership of Alabama, with support from GSA,

Alabama Department of Environmental Management, United States Geological Survey, City of Tuscaloosa, Alabama Department of Health, Natural Resource and Conservation Service, and the Alabama Museum of Natural History. All the agencies listed above are part of the Lower Subbasin of the Black Warrior Clean Water Partnership, which exists to facilitate collaborations between local agencies and stakeholder groups for the purpose of water conservation projects, such as the NRWMP.

The empirical data collected from the stream surveys and land cover analysis outlined in this report will be used to calibrate pre-BMP sediment loading rates in the Clear Creek Watershed. Once the primary sources of sedimentation have been identified in the watershed, the formulation of a BMP treatment plan and the installation of BMPs will be performed through the guidance of the Natural Resource Conservation Service.

Detection of a change in water quality before and after the installation of BMPs is essential to determine the effectiveness of the restoration effort. Post-BMP water quality monitoring will be conducted to collect hydrologic, geochemical, and geomorphic habitat data for three years following the BMP implementation. The rate of total suspended solids will be calculated again to determine if the recommended total maximum daily load sediment reduction has been met for the Clear Creek watershed. Mussel populations will also be monitored to update their status in the post-BMP stage of the study.

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