CARBONTON DAM – DEEP RIVER WATERSHED RESTORATION SITE
2006 Annual Monitoring Report (Year 1)

Chatham, Lee and Moore Counties, NC
EEP Project No. D-04012A
Design Firm: Milone and MacBroom, Inc.

October 2006

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Ecosystem Enhancement PROGRAM

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CHATHAM, LEE, AND MOORE COUNTIES, NC

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EXECUTIVE SUMMARY

Introduction

Unlike success measurements required of Rosgen Natural Channel Design mitigation projects, dam removal projects performed pursuant to the North Carolina Dam Removal Task Force (DRTF) (DRTF 2001) are required to quantitatively demonstrate chemical and biological improvements to the watershed in order to achieve compensatory mitigation credit. The following monitoring report documents the unique efforts of Restoration Systems (RS), on behalf of the N.C. Ecosystem Enhancement Program (NCEEP), to achieve these higher standards at the Carbonton Dam removal site (Cape Fear Hydrologic Unit 03030003). The suite of ecological evaluations performed and described here establish a new and higher standard for mitigation monitoring. This higher standard is in keeping with the goal of the North Carolina Department of Environment and Natural Resources (NCDENR), U.S. Army Corps of Engineers (USACE) and the North Carolina Department of Transportation (NCDOT) to provide functional gains to North Carolina watersheds and move beyond the much discredited acre-for-acre and foot-for-foot compensatory programs of the past.

The site of the former Carbonton Dam is approximately 9 miles west of Sanford, North Carolina at the juncture of Chatham, Lee, and Moore Counties, North Carolina (Figure 1, Appendix A). The on-site dam removal activities freed approximately 126,673 linear feet of the Deep River and associated tributaries from the impounding impact of the dam. The limits of the former Site Impoundment have been identified as any stream reach of the Deep River or associated tributaries located above the former Carbonton Dam with a thalweg elevation less than 227.6 feet above mean sea level (MSL), prior to dam removal. Impacts to water quality within the former Site Impoundment (i.e., river and stream reaches formerly impounded by the dam) were manifested in the form of lower dissolved oxygen concentrations, higher temperatures, and increased sedimentation. The character of the aquatic communities within the former Site Impoundment shifted from that representative of a free-flowing (lotic) river system towards an impounded (lentic) condition following construction of a dam at the site. Rare and endangered mussel and fish habitat, which depended on free-flowing lotic conditions, was extirpated or greatly diminished within areas of the Little River impounded by the former dam. These benefited stream reaches will be hereafter referred to as the former "Site Impoundment."

The dam was removed in a manner that minimized impacts to water resources both upstream and downstream of the dam site. Dam removal began with dewatering (lowering) of the Site Impoundment on October 15, 2005, followed by the creation of a breach in the dam on November 11, 2005. Demolition activities continued in stages until dam removal was completed on February 3, 2006.

First year monitoring activities began in March 2006, and will be performed throughout the five-year period or until success criteria are achieved. Post removal monitoring data will be compared to baseline values collected in April-June 2005.

Monitoring Plan

A monitoring plan was developed in accordance with the DRTF guidelines to evaluate success in fulfilling the project's primary success criteria, which include:

1) re-introduction of rare and endangered aquatic species, 2) improved water quality, and 3) an improved aquatic community. Reserve success criteria include: 1) downstream benefits below the dam, and 2) human values (scientific contributions and human recreation).

In order to evaluate project success for the above criteria, a monitoring network was deployed in 2005 throughout the former Site Impoundment, contributing waters, and reference areas both upstream and downstream of the former dam site (Figure 3, Appendix A). Within the established network, biological surveys were conducted to provide baseline (i.e., pre-dam removal) aquatic community data within the Site Impoundment, and will be monitored until 2010 to assess community changes following dam removal. Monitoring cross-section stations were also established to assess changes in bankfull channel geometry, channel substrate composition, and aquatic habitat. Water quality data within the former Site Impoundment and at a downstream reference area were obtained from North Carolina Division of Water Quality (NCDWQ) Ambient Monitoring Stations (AMS).

First Year Monitoring Results

Water Quality

AMS data indicate that dissolved oxygen concentrations within the former Site Impoundment have persisted above the established threshold of 5.0 mg/L required to meet the success criteria. Additionally, mean values of benthic biotic indices (used as a proxy for water quality) from samples within the former Site Impoundment were within one standard deviation of mean values from reference samples, indicating improving water quality.

Aquatic Community

Benthic data from stations within the former Site Impoundment indicate that the number of EPT (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) taxa has not converged with the number of EPT taxa from reference samples. The total number of benthic taxa from samples within the former Site Impoundment is still below the total number of taxa from reference samples.

The results of the Year-1 monitoring fish survey demonstrate successful restoration of lotic conditions within the former reservoir pool in the Deep River and a major tributary, McLendons Creek. Numerous riffle-adapted species were found in relatively high densities at various localities throughout the surveyed reach.

Rare and Endangered Aquatic Species

Rare and Endangered Aquatic Species success criteria within the former Site Impoundment is based on the documented presence of any rare species throughout the monitoring period. No specimens of the federally endangered Cape Fear shiner (*Notropsis mekistocholas*) were collected during the Year-1 fish surveys. Although baseline mollusk community data were obtained during pre-removal biological

surveys in 2005, mollusks will not be sampled again until the fourth year of project monitoring (2009), to allow time for these species to recolonize restored habitats.

Reserve Success Criteria

Reserve Success Criteria have been achieved based on the implementation of scientific research related to the removal of Carbonton Dam, and the establishment of a public park at the location of the former dam. The Carbonton Dam removal project has provided funding to the University of North Carolina at Chapel Hill to support original research by Adam Riggsbee, Ph.D, and a UNC Chapel Hill PhD Candidate Jason Julian. Dr. Riggsbee's published research investigated the effects of the dam's removal on nutrient and sediment dynamics as they are transmitted through the former Site Impoundment (Riggsbee 2006). Furthermore, a public park has been planned at the site of the former dam and on an adjacent parcel purchased for that purpose, and construction efforts began on September 5, 2006.

Summary

After the first year of monitoring, the removal of Carbonton Dam has resulted in the successful restoration of lotic conditions with functional improvements recorded in water quality, fish abindance, and sediment transport. Mitigation success was achieved for the following criteria: Rare and endangered aquatic species habitat improvement and expansion, water quality improvement with respect to dissolved oxygen concentrations and benthic biotic indices, scientific research, and public recreation. Continued monitoring is necessary to determine success for the introduction of rare/endangered species, the increase in benthic EPT taxa, and the recolonization of mollusks in a lotic community.

TABLE OF CONTENTS

1.0 PROJECT BACKGROUND

1.1 Location and Setting

In order to provide stream restoration in the Cape Fear River Basin (Hydrologic Unit 03030003), Restoration Systems, LLC (RS) has removed the Carbonton Dam formerly located at the juncture of Chatham, Lee, and Moore Counties, North Carolina (Figures 1 and 2, Appendix A). The former Carbonton Dam was located on the Deep River approximately 9 miles west of Sanford, North Carolina, immediately downstream of the bridge crossing of NC 42. The Deep River is a 4th-order river with a watershed upstream of the former dam location of approximately 1,000 square miles. For the purposes of this document, the 5.5-acre land parcel that supported the dam will be hereafter referred to as the "Site." All proposed construction activities mentioned in this report occurred on-Site, unless specifically mentioned otherwise.

The on-Site construction activities freed approximately 126,673 linear feet of the Deep River and associated tributaries from the impounding impact of the dam. These benefited stream reaches will be hereafter referred to as the "Site Impoundment." The limits of the Site Impoundment have been identified as any stream reach of the Deep River or associated tributaries located above the former Carbonton Dam with a thalweg elevation less than 227.6 feet above mean sea level (MSL), prior to dam removal.

1.2 Restoration Structure and Objectives

The Site Impoundment formerly covered approximately 116 acres with water depths up to 25 feet and bank-to-bank impoundment widths from 150 to 260 feet. The former Site Impoundment occurred within the channel of the Deep River, which is characterized by steep banks with occasional areas of bank failure in locations where mature trees have been toppled by storms or flood flows. The lentic flow that characterized the Site Impoundment resulted in a stratified water column, where velocities were low near the surface, and stagnant at depths below the crest pool elevation.

Site restoration efforts consisted primarily of the physical removal of the Carbonton Dam. Construction activities associated with the removal of the dam were phased in order to minimize impacts to aquatic resources upstream, downstream, and in the immediate vicinity of the Site. Furthermore, throughout the dam removal process, numerous construction practices were undertaken to minimize potential impacts to aquatic resources.

The demolition of the Carbonton Dam is expected to generate at least 90,494 Stream Mitigation Units (SMUs) for use by the North Carolina Ecosystem Enhancement Program (EEP). The majority of the credits generated by this project will be validated by evaluating the ecological benefits that occur in the Deep River over the five-year, post-removal monitoring period. Bonus factors (reserve success criteria) include downstream benefits and human values such as recreation and scientific research. Table 1 displays the amount of SMU credits that are proposed for this project. The primary success criteria are being monitored in accordance with the Dam Removal Task Force (DRTF) guidance. The mitigation ratios have also been derived from the DRTF guidance (DRTF 2004). The amount of restored channel was determined through methods described in Section 1.1.2 and the Restoration Plan (Restoration Systems 2005). The number of SMUs were determined by multiplying the amount of channel impacted (linear feet) by the mitigation ratios. While up to 114,356 SMUs may be potentially created in

accordance with the DRTF guidance, the project will only be evaluated for the amount of credit that is committed to EEP. Any reserve credit may be used to offset unanticipated loss of credits from other aspects of the project.

Table 1. Stream Mitigation Units (SMUs)[1] Generated by Removal of the Carbonton Dam

Primary Success Criteria	Channel Restored (feet)	Mitigation Ratio	SMU
1) Rare and Endangered Aquatic Species 2) Water Quality, 3) Improved Aquatic Community	126,673 feet of free-flowing river and tributaries **under the crest pool**	0.7:1	88,671
Reserve Success Criteria	**Channel Restored (feet)**	**Mitigation Ratio**	**SMU**
Downstream Benefits Below the Dam	~ 500 feet below dam	0.7:1	350
Human Values 1) Scientific value 2) Human recreation	-----	Up to 20 percent bonus	Up to 25,335
Total Potential SMUs			114,356
Total Commited SMUs			**90,494**

[1] Primary success criteria will be monitored to verify and confirm positive changes to each functional criterion as outlined in this report and in the Dam Removal Guidance. Reserve criteria will be monitored for possible augmentation of the primary SMUs.

1.3 Project History and Background

Table 2. Project Activities and Reporting History: Carbonton Dam Restoration Site

Activity Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
Restoration Plan	July 2004	N/A	August 2005
Final Design	July 2004	N/A	August 2005
Construction	February 2006	N/A	February 2006
Temporary S&E mix applied to entire project area	February 2006	N/A	February 2006
Permanent seed mix applied to reach/segments	February 2006	N/A	February 2006
Bare Root Seedling Installation	March 2006	N/A	March 2006
Mitigation Plan	January 2005	N/A	June 2006
Minor repairs made filling small washed out areas	N/A	N/A	N/A
Final Report	N/A	N/A	N/A
Year 1 Vegetation Monitoring	N/A	N/A	N/A
Year 1 Stream Monitoring	September 2006	July 2006	September 2006

1.4 Project Mitigation Goals

The desired result of this project is ecological improvement within the former Site Impoundment through restoration of natural, lotic flow conditions.

The specific goals of this project include:

- Restoration of approximately 126,673 linear feet of inundated river and stream channels to natural free-flowing riverine conditions.
- Restoration of previously inundated shallow water habitat for the Cape Fear shiner (*Notropis mekistocholas*), a federally endangered species of freshwater fish.
- Reduction or prevention of stratified water temperature profiles typical of deepwater habitats and seasonal declines in dissolved oxygen concentrations below levels measured in reference reaches.
- Restoration of appropriate in-stream substrate.
- Restoration of upstream and downstream fish passage, and reconnection of currently disjunct populations of rare aquatic species of concern.
- Restoration of lotic mussel habitat.
- Improvement in the diversity and water quality tolerance metrics for benthic macroinvertebrate communities.
- Provide compatible legal and public recreational opportunities at the site of the former dam.
- Provide academic grade data and/or peer-reviewed publications regarding the ecological consequences of large dam removal.

Table 3. Project Contacts: Lowell Mill Dam Restoration Site

Designer Milone and MacBroom, Inc. (MMI)	307B Falls Street Greenville, SC 29601 (864) 271-9598
Construction Contractor Backwater Environmental, Inc.	P.O. Box 1654 Pittsboro, NC 27312 (919) 523-4375
Planting Contractor Carolina Silvics, Inc.	908 Indian Trail Road Edenton, NC 27932 (252) 482-8491
Seeding Contactor Backwater Environmental, Inc.	P.O. Box 1654 Pittsboro, NC 27312 (919) 523-4375
Seed Mix Sources Mellow Marsh Farm	1312 Woody Store Road Siler City, NC 27344 (919) 742-1200
Nursery Stock Suppliers Mellow Marsh Farm Coastal Plain Conservation Nursery Taylor's Nursery International Paper Nursery	1312 Woody Store Road Siler City, NC 27344 (919) 742-1200 3067 Conners Drive Edenton, NC 27932 (252) 482-5707 3705 New Bern Avenue Raleigh, NC 27610 (919) 231-6161 5594 Highway 38 South Blenheim, SC 29516 (800) 222-1290
Monitoring Performers EcoScience Corporation	1101 Haynes Street Suite 101 Raleigh, NC 27604 (919) 828-3433
Stream Monitoring POC	Matt Cusack
Vegetation Monitoring POC	N/A (project does not require vegetation monitoring)

Table 4. Project Background Carbonton Dam Restoration Site

Project County	Chatham, Lee, and Moore Counties NC
Drainage Area	Approximately 1000 square miles
Impervious cover estimate (%)	10%
Stream Order	4th-order
Physiographic Region	Piedmont
Ecoregion (Griffith and Omernik)	Triassic Basin
Rosgen Classification of As-built	N/A
Cowardin Classification	R2SB3/4
Dominant soil types	N/A (stream restoration project only)
Reference Site ID	Deep River
USGS HUC for Project and Reference	03030003
NCDWQ Sub-basin for Project and Reference	03-06-10
NCDWQ classification for Project and Reference	WS-V HQW, WS-IV HWQ
Any portion of any project segment 303d listed?	Yes, Big Governors Creek to former Carbonton Dam (NCDWQ 2006)
Reasons for 303d listing or stressor	Chlorophyll A
Any portion of any project segment upstream of a 303d listed segment?	Yes, Deep River, Sub-basin 03-06-11 (NCDWQ 2006)
Reasons for 303d listing or stressor	Fish Advisory - Mercury
Percent of project easement fenced	N/A

2.0 PROJECT MONITORING AND RESULTS

The monitoring results described herein will document the Year-1 (2006) monitoring activities performed to achieve success in meeting the stated mitigation goals. Monitoring activities occurred at fifty-one (51) stations established prior to dam removal in 2005, as part of the monitoring deployment network (Figure 3, Appendix A). One (1) additional station was added in 2006 for a total of fifty-two (52). A comparison between pre-removal baseline data (2005) and Year-1 monitoring data will be compared to evaluate improvements in water quality, the aquatic community, rare and endangered species, and cultural resources within the former Site Impoundment.

2.1 WATER QUALITY

2.1.1 Biotic Indices

After identification of collected macroinvertebrates, the North Carolina Tolerance Values or Hilsenhoff Tolerance Values were assigned to each of the collected species. These Tolerance Values range from 0 for organisms intolerant of organic wastes to 10 for organisms very tolerant of organic wastes. The biotic indices of each station sampled for benthic macroinvertebrates were tallied, and then summary data were generated for comparison between impounded and reference stations. These summary data for Year-1 Monitoring (2006) are provided in Table 5. The data show that the mean biotic index of the impounded stations is 0.83 higher than the mean of the reference stations. Success for this particular mitigation goal is defined as follows: the mean biotic index of the impounded stations must be within one standard deviation of the mean biotic index of the reference stations. The mean biotic index of the impounded

stations is below one standard deviation of the mean biotic index (7.20) of the reference stations, indicating water quality improvement. Since the mean of the impounded stations lies within one standard

Table 5. Biotic Indices Summary Data from Year-1 Monitoring.

	IMPOUNDED STATIONS	REFERENCE STATIONS
	Biotic Index	Biotic Index
High	8.58	7.62
Low	5.76	4.29
Mean	**6.99**	**6.16**
Median	6.72	6.02
Standard Deviation	0.95	1.04
Standard Deviation of Reference Mean (**Success Criterion**)	**7.20**	

deviation of the reference mean, it suggests that the impounded stations are no longer outlying data points when compared to the reference data. Despite meeting the success criteria with respect to biotic indices, overall benthic macroinvertebrate sampling did not improve in Year-1 Monitoring (see Section 2.2.1) and continued sampling throughout the monitoring period is recommended.

2.1.2 Ambient Monitoring Station Network

Aside from the *in situ* sampling occurring at each monitoring cross-section, physical water quality parameters are currently collected at an Ambient Monitoring Station (AMS) located within the former Site Impoundment at NC 42 (B5575000), immediately upstream of Carbonton Dam. A reference AMS is located on the Deep River at Ramseur, NC (B5070000). These data have been obtained from the North Carolina Division of Water Quality (NCDWQ), and data coverage exists on a monthly basis back at least 10 years. AMS data dating back five years prior to dam removal will be used to provide a historical record of water quality that can be compared to post dam removal sampling. The most recent AMS data available from NCDWQ is through April 20, 2006. Data collected by the AMS are not standard for all samples, but are always sampled at 0.1 meter depth and can include: water temperature (ºC), dissolved oxygen (mg/L), pH (field measured), conductance at 25ºC (µmhos/cm), turbidity (NTU), fecal coliform bacteria (number of colonies/100 milliliters), suspended residue (total suspended solids) (milligrams/Liter), ammonia as nitrogen (milligrams/Liter), total Kjeldahl nitrogen (milligrams/Liter), nitrite and nitrate as nitrogen (milligrams/Liter), total phosphorus (milligrams/Liter), and assorted metals. These data will provide acceptable coverage of physical water chemistry and parameters throughout monitoring activities. Water quality trends from these data, and comparisons made against the state standards established by NCDWQ's "Redbook" will be used to support success evaluation.

2.1.2.1 Dissolved Oxygen

In order to achieve success, dissolved oxygen concentrations within the former Site Impoundment cannot fall below the minimum NCDWQ standard for Class WS-IV waters. The NCDWQ standard is an instantaneous value of no less than 4.0mg/L, or a daily average of no less than 5.0 mg/L**.** Table 6 provides the minimum, maximum, and mean values for dissolved oxygen recorded within the former Site

Impoundment, as well as the number of samples that fell below the state standard following dam removal on February 3, 2006.

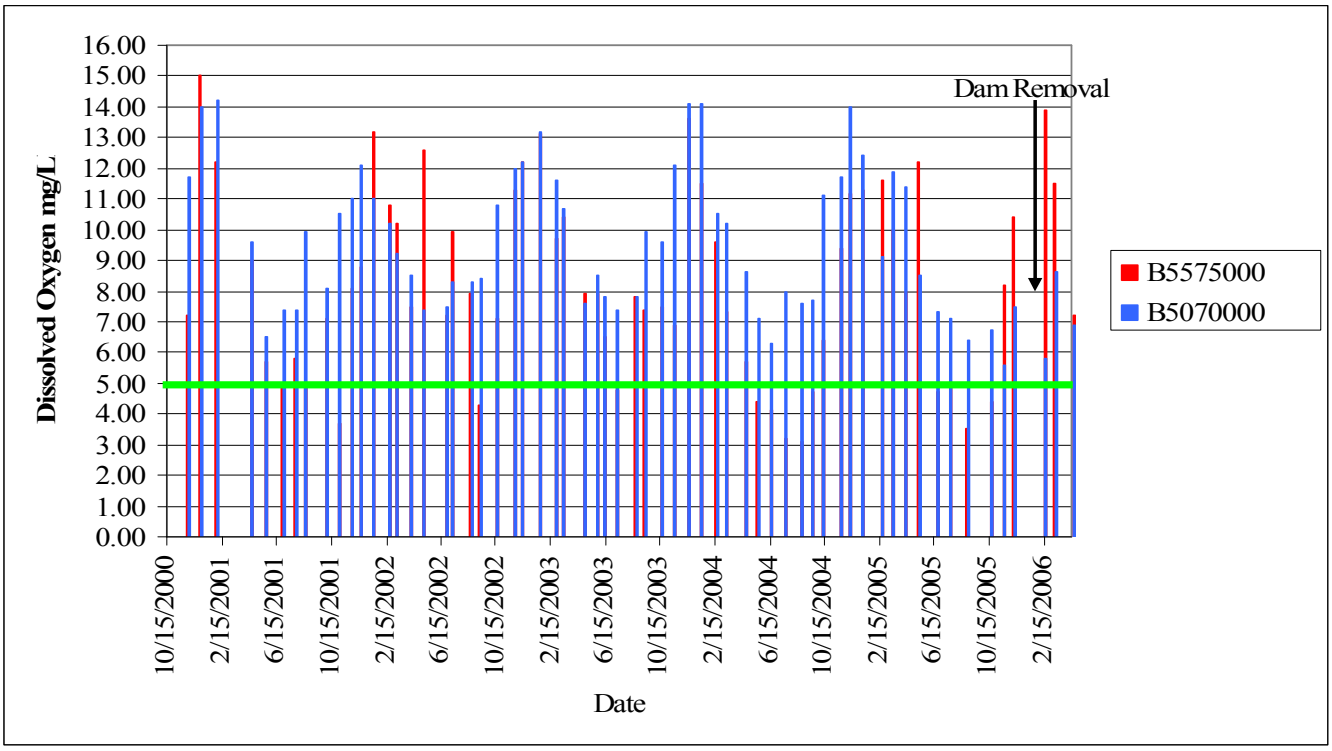
Table 6. Dissolved oxygen summary data

Minimum Value	7.2 mg/L
Maximum Value	13.9 mg/L
Mean Value	10.87 mg/L
Number of Samples Below State Standard	0

Graph 1 depicts the AMS dissolved oxygen concentrations measured at a 0.1 meter depth within the Site Impoundment (B5575000), and at the reference location (B5070000). Since the removal of Carbonton Dam, dissolved oxygen concentrations within the former Site Impoundment have remained at or above 5.0 mg/L. Since dam removal, dissolved oxygen concentrations within the former Site Impoundment are also considerably higher than those at the reference station.

Throughout the five-year monitoring period following dam removal, it is expected that mean dissolved oxygen values recorded at NC 42 will continue to demonstrate improvement as the river returns to lotic conditions. It is also expected that the number of days below the state standard will decrease as free-flowing conditions replace lake-like flows.

Graph 1. Recorded dissolved oxygen concentrations over the Deep River (Green line indicates state standard of 5.0mg/L)



2.1.2.2 Temperature

In order to achieve success, the water temperature within the former Site Impoundment cannot exceed the NCDWQ standard of 90 degrees Fahrenheit during the monitoring period. Table 7 provides the

minimum, maximum, and mean values for water temperature recorded within the former Site Impoundment, as well as the number of samples the recorded value exceeding the state standard following dam removal. Water temperature within the former Site Impoundment has not exceeded the state standard of 90 degrees Fahrenheit since dam removal on February 3, 2006.

Table 7. Water temperature summary data

Minimum Value	41.18 deg F
Maximum Value	64.58 deg F
Mean Value	52.76 deg F
Number of Samples Exceeding Standard	0

The stratification of water temperature was measured within the former Site Impoundment during the 2005 monitoring period. Following dam removal, free flowing water replaced the previously impounded river, and stratified water temperatures have diminished. Temperatures recorded within the top 1 foot of the river were identical or much closer to the temperatures recorded near the streambed. Water temperature values will be gathered throughout the five-year monitoring period and stratified water temperatures are expected to continue to be either absent or greatly reduced. Temperatures within the former impoundment are also expected to stay below the state standard of 90 degrees Fahrenheit.

2.1.2.3 Fecal Coliform

In order to achieve success, fecal coliform concentrations within the former Site Impoundment can not exceed an average daily value of 200/100 ml in any 30-day period. Table 8 shows the minimum, maximum, and mean values for fecal coliform recorded within the former Site Impoundment, as well as the number of samples the recorded value exceeded the state standard following dam removal.

Table 8. Fecal coliform summary data

Minimum Value	22 ml
Maximum Value	47 ml
Mean Value	35.67 ml
Number of Samples Exceeding Standard	0

Fecal coliform within the former Site Impoundment has not exceeded the state standard of 200/100 ml since dam removal on February 3, 2006. Fecal coliform data will continue to be monitored over the 5 year period, but no success criteria are proposed.

2.2 AQUATIC COMMUNITIES

To determine success for the aquatic communities habitat criterion, the former Site Impoundment was monitored for baseline data and included benthic macroinvertebrates, fishes, mussels, and snails, as well as the quality of available microhabitats that developed. Benthos and fishes will be sampled each monitoring year, while mussels and snails will be sampled again in 2009. Delayed sampling of mussels and snails will allow time for these species to recolonize restored habitats

2.2.1 Benthic Macroinvertebrates

Benthic macroinvertebrates were sampled within the former Site Impoundment, as well as in the reference reaches both within the Deep River and its major tributaries. Stations were visited prior to dam

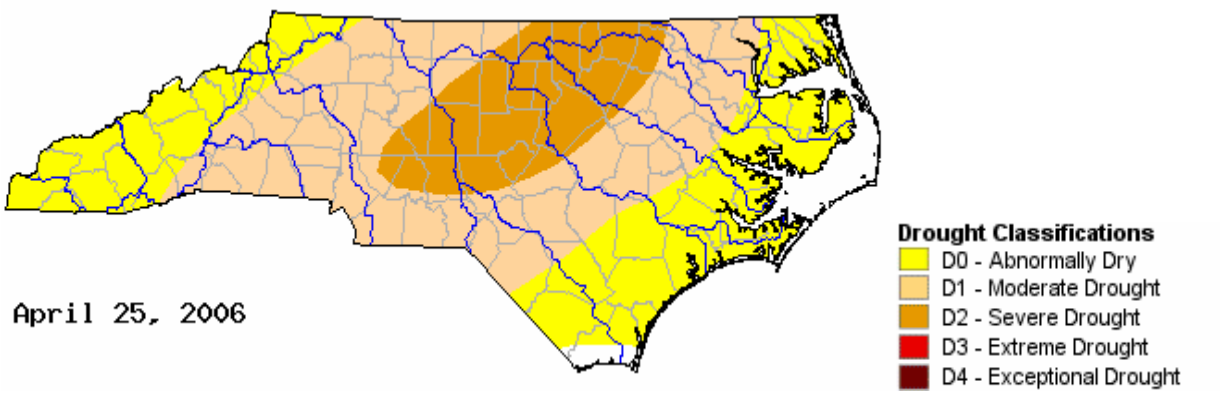
removal (2005) and subsequently sampled in 2006 at the same locations. The comparative metrics utilized for the success evaluation include the total number of organisms collected, the total taxa represented in the samples, the richness (diversity) of taxa from the Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) Orders (hereafter referred to as EPT taxa), and the biotic index of organic waste tolerance. Benthic macronivertebrate data is located in Appendix B. Data in Appendix B are based on laboratory identifications of benthic macroinvertebrate taxa by Pennington and Associates, Inc. (P&A) of Cookeville, Tennessee. P&A is a North Carolina Division of Water Quality (NCDWQ)-certified benthic identification laboratory. Table 9 provides the summary data for the benthic macroinvertebrate

Table 9. Benthic macroinvertebrate summary data from Years 2005 and 2006 collections

2005	Impounded Stations				Reference Stations			
	Total Organisms	Total Taxa	EPT Richness	Biotic Index	Total Organisms	Total Taxa	EPT Richness	Biotic Index
High	403.00	62.00	10.00	7.97	1168.00	70.00	24.00	6.91
Low	97.00	18.00	1.00	5.67	237.00	41.00	14.00	4.78
Mea n	223.33	39.78	5.89	6.83	549.75	54.88	19.13	5.90
Median	207.00	43.00	6.00	6.79	404.00	56.00	19.00	5.99
Standard Deviation	96.69	12.02	2.76	0.83	340.66	10.33	3.14	0.75
2006	Impounded Stations				Reference Stations			
	Total Organisms	Total Taxa	EPT Richness	Biotic Index	Total Organisms	Total Taxa	EPT Richness	Biotic Index
High	360.00	49.00	15.00	8.58	546.00	61.00	21.00	7.62
Low	55.00	17.00	0.00	5.76	89.00	33.00	5.00	4.29
Mea n	177.50	33.00	7.70	6.99	220.63	42.63	12.50	6.16
Median	160.00	33.50	6.50	6.72	155.00	37.00	12.50	6.02
Standard Deviation	87.71	11.65	5.85	0.95	158.86	10.76	5.81	1.04

The summary data in Table 9 shows that following dam removal the mean number of organisms and mean number of taxa decreased at both impounded and reference stations. Mean EPT richness and mean biotic index increased following dam removal in impounded stations. The summary data for both the impounded and reference stations shifted similarly following dam removal. The fluctuating response in reference benthic data can be attributed to a temporary response to the dam removal, or more likely the severe drought conditions that affected the Deep River watershed during the entire benthic sampling period. The following Diagram 1 (using data from N.C. Drought Advisory Council, 2006) shows the drought conditions on April 25, 2006 for North Carolina. The Deep River watershed and former Site Impoundment lie within the Severe Drought classification.

Diagram 1. N.C. Drought Conditions in April 2006 (from N.C. Drought Management Advisory Council)



Drought conditions within the Deep River watershed continued into mid June 2006, throughout the benthic monitoring period. Rivers in the Triassic basin experience low flow conditions during summer months and flows are even further diminished when drought conditions are introduced. Drought conditions play a major role in altering the composition of the benthic community and have contributed to a decline in benthic sampling results. Continued benthic monitoring is recommended until success criteria are achieved.

2.2.2 Fishes

Fish surveys were conducted at all the fish monitoring stations established during the pre-removal monitoring period. Additional sites were added in 2006 due to the presence of habitat conditions that favored the presence of the targeted Cape Fear Shiner. Data indicate that the former Site Impoundment fish communities are transitioning from those characteristic of impounded, lentic conditions to lotic, free-flowing conditions. Qualitative observations during aquatic surveys by TCG revealed that habitat for fish started to transition from lentic to lotic conditions in direct response to dam removal. In general, a greater number of fish species were documented throughout the former impoundment in Year 1 (2006) relative to baseline (2005) sampling. For additional information, please consult TCG's report located in Appendix C.

2.2.3 Mollusks

Mussel, snail, and clam sampling data will be used to support success evaluation for the aquatic community and threatened and endangered aquatic species criteria. Mollusks were sampled at the fish, mussel, and snail survey locations (Figure 3, Appendix A) by TCG preceding dam removal to obtain baseline data. Since these fauna are slow colonizers due to their dependence on host fish species, they will be re-sampled in Year 4 (2009). The samples will be compared by catch per unit effort (CPUE) for a qualitative change. CPUE is defined as the number of individuals found per person hour of search time. The data will also be evaluated for a quantitative difference in abundance and diversity between lotic and lentic stations. As lentic stations transition to lotic, success will be evaluated based upon values of the community data more closely representing the values of the lotic, reference stations than the pre-removal data for that station.

2.2.4 Habitat Assessment

Habitat assessment data were collected at all 52 monitoring stations to evaluate aquatic habitat to support improvement in community populations. The NCDWQ Habitat Assessment Field Data Sheet was

completed at each station in order to evaluate the quality and character of the sampled habitat niches and to provide a comparable score that describes the available habitat. Table 10 displays the NCDWQ Habitat Assessment Field Data Sheet scores for each monitoring station in Years 2005 and 2006. As expected, the mean scores of the impounded stations have quantitatively increased following dam removal and the establishment of lotic flow conditions. The mean score for impounded stations increased from 42.39 in 2005 to 54.91 in 2006. The mean score for reference stations remained relatively unchanged with an increase of only 0.83. Success evaluation is defined as a perceived progression of the former Site Impoundment habitat values toward those of the lotic reference stations. Following dam removal, the mean score for stations in the former Site Impoundment increased 29.5 percent, and shifted to within only 5.83 points of matching the mean score of the reference stations.

Table 10. Comparison of Habitat Assessment Data from Years 2005 and 2006 for Impounded and Reference Stations

	BASELINE (2005)									YEAR-1 MONITORING (2006)									
		Metric Subtotals									Metric Subtotals								
	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE	Station	Channel Modification	Instream Habitat	Bottom Substrate	Pools	Riffles	Bank Stability	Light Penetration	Riparian Zone	TOTAL SCORE
IMPOUNDED STATIONS	1	4	7	1	0	0	9	0	7	**28**	1	4	16	12	10	14	12	0	7	**75**
	2	4	11	1	0	0	12	0	10	**38**	2	4	10	3	4	7	12	0	10	**50**
	3	5	12	3	0	0	14	2	9	**45**	3	5	11	3	8	0	13	2	9	**51**
	4	4	14	1	0	0	14	2	10	**45**	4	4	16	1	8	0	8	2	10	**49**
	5	4	12	1	0	0	14	2	10	**43**	5	4	12	6	8	12	14	2	10	**68**
	6	4	10	1	0	0	12	0	10	**37**	6	4	11	3	8	0	10	0	10	**46**
	7	4	10	1	0	0	12	0	9	**36**	7	4	6	8	8	0	9	0	9	**44**
	8	4	12	8	0	0	14	2	7	**47**	8	4	10	6	4	7	12	2	7	**52**
	9	4	10	1	0	0	14	2	8	**39**	9	4	16	3	8	0	8	2	8	**49**
	10	5	16	12	0	0	14	2	10	**59**	10	5	10	11	4	3	12	2	10	**57**
	11	4	14	12	0	0	11	2	10	**53**	11	4	20	1	0	7	10	2	10	**54**
	20	4	7	1	0	0	6	0	10	**28**	20	4	10	1	8	0	9	0	10	**42**
	21	5	6	1	0	0	4	0	2	**18**	21	5	7	1	8	0	5	0	2	**28**
	22	5	5	1	0	0	4	0	8	**23**	22	5	9	1	8	0	10	0	8	**41**
	23	5	9	1	0	0	5	2	8	**30**	23	5	9	1	3	12	11	2	8	**51**
	24	4	11	1	0	0	10	7	4	**37**	24	4	7	1	3	7	12	7	4	**45**
	27	5	9	1	0	0	12	10	10	**47**	27	5	12	8	4	16	10	10	10	**75**
	29	5	5	1	0	0	12	10	10	**43**	29	5	15	1	8	0	10	10	10	**59**
	30	5	13	1	0	0	14	10	10	**53**	30	5	11	1	8	0	12	10	10	**57**
	31	5	10	1	0	0	12	10	10	**48**	31	5	11	1	8	0	10	10	10	**55**
	32	4	5	1	0	0	10	8	10	**38**	32	4	10	1	7	7	12	8	10	**59**
	34	4	11	1	0	0	14	10	10	**50**	34	4	0	1	8	0	14	10	10	**47**
	36	4	6	1	0	0	4	8	8	**31**	36	4	10	1	8	0	11	8	8	**50**
	38	5	19	1	0	0	5	10	10	**50**	38	5	12	1	8	0	12	10	10	**58**
	40	2	16	1	0	0	14	8	10	**51**	40	2	10	1	8	0	6	8	10	**45**
	41	5	6	1	0	0	12	8	10	**42**	41	5	15	1	8	7	12	8	10	**66**
	42	5	11	1	0	0	12	10	10	**49**	42	5	10	1	8	0	12	10	10	**56**
	43	5	6	1	0	0	10	10	10	**42**	43	5	11	1	8	0	12	10	10	**57**
	47	5	11	6	0	0	14	10	10	**56**	47	5	14	11	10	14	13	10	10	**87**
	48	5	11	1	0	0	12	7	10	**46**	48	5	14	1	3	0	12	7	10	**52**
	49	5	11	1	0	0	12	7	10	**46**	49	5	16	2	6	3	12	7	10	**61**
	50	4	15	3	0	0	12	7	10	**51**	50	4	11	1	4	3	12	7	10	**52**
	51	5	12	1	0	0	12	10	10	**50**	51	5	6	1	8	0	12	10	10	**52**
	55	Station not established in 2005								**N/A**	55	5	18	11	4	12	12	7	8	**77**
	MEAN	**4.45**	**10.39**	**2.15**	**0.00**	**0.00**	**10.97**	**5.33**	**9.09**	**42.39**	**MEAN**	**4.47**	**11.35**	**3.18**	**6.65**	**3.85**	**10.97**	**5.38**	**9.06**	**54.91**
REFERENCE STATIONS	12	4	20	12	6	7	14	2	10	**75**	12	4	15	12	4	12	12	2	10	**71**
	14	2	14	3	4	10	4	2	0	**39**	14	4	11	8	4	12	12	2	0	**53**
	15	4	11	8	8	0	10	7	10	**58**	15	4	12	14	10	0	14	7	10	**71**
	16	4	11	12	8	0	12	2	10	**59**	16	4	6	4	8	0	12	2	10	**46**
	17	4	11	2	4	3	12	2	10	**48**	17	4	15	1	8	0	14	2	10	**54**
	18	4	11	8	6	3	10	7	6	**55**	18	4	7	11	8	0	12	7	6	**55**
	19	4	16	11	6	0	12	2	10	**61**	19	4	12	11	9	0	14	2	10	**62**
	25	5	8	1	8	0	12	10	10	**54**	25	5	14	2	8	0	10	10	10	**59**
	26	5	10	1	8	0	14	10	10	**58**	26	5	9	1	8	0	7	10	10	**50**
	33	5	6	8	8	16	13	10	10	**76**	33	5	12	8	6	7	12	10	10	**70**
	35	4	5	1	4	0	10	8	10	**42**	35	4	9	1	2	0	12	8	10	**46**
	37	5	16	1	3	7	14	10	9	**65**	37	5	11	1	8	0	14	10	9	**58**
	39	5	11	3	6	0	12	7	9	**53**	39	5	14	1	8	0	14	7	9	**58**
	44	4	16	2	8	3	13	7	10	**63**	44	4	20	8	8	3	12	7	10	**72**
	45	4	15	6	6	0	12	8	10	**61**	45	4	16	11	10	7	13	8	10	**79**
	52	4	20	15	6	7	14	0	10	**76**	52	4	11	12	4	16	12	0	10	**69**
	53	4	20	11	4	14	12	2	9	**76**	53	4	15	12	4	12	12	2	9	**70**
	54	5	6	1	8	0	13	10	10	**53**	54	5	0	1	8	0	10	10	10	**44**
	MEAN	**4.22**	**12.61**	**5.89**	**6.17**	**3.89**	**11.83**	**5.89**	**9.06**	**59.56**	**MEAN**	**4.33**	**11.61**	**6.61**	**6.94**	**3.83**	**12.11**	**5.89**	**9.06**	**60.39**

2.2.4.1 Sediment Class Size Distribution

Sediment grain size distribution was analyzed at all 52 monitoring stations in 2006. Weighted sieve analyses (using Rosgen [1994] methodology for performing bar samples) were performed to assess sediment grain size distributions of monitoring stations with water depths exceeding 3 feet, where a ponar dredge was used to collect sediment samples (see Mitigation Plan [Restoration Systems 2006] for sampling methodology details). For water depths less than 3 feet (i.e., wadeable areas), 100-count pebble counts were performed consistent with the Wolman method (Rosgen 1994).

As expected, the D16, D50, and D84 values from stations within the former Site Impoundment coarsened following dam removal. The medium grain size (D50) for impounded stations sampled in 2006 is 3.56 mm (69-percent) courser than prior to dam removal. The D16 and D84 size class indices also coarsened within impounded stations following dam removal. Reference stations showed only minor changes in sediment size class following dam removal. Changes in reference stations are possibly the result of an increased sample size, natural bed form changes, or a potential increase in fine sediments transported downstream from the former impoundment. Table 11 provides baseline and Year-1 sediment grain size distributions for both reference and impounded stations.

Sediment grain size classes are defined as follows (per Rosgen 1994):

Particle Size	Size Class
<2 mm	Sand/silt
2-8 mm	Fine gravel
8-16 mm	Medium gravel
16-32 mm	Coarse gravel
32-64 mm	Very coarse gravel
64-128 mm	Small cobble
128-256 mm	Large cobble
>256 mm	Boulder

Table 11. Sediment class size distribution

	Station	Baseline (2005)			Year 1 (2006)		
		d16	d50	d84	d16	d50	d84
IMPOUNDED STATIONS	1	<2 mm	<2 mm	<2 mm	2-8 mm	16-32 mm	32-64 mm
	2	<2 mm	2-8 mm	8-16 mm	<2 mm	<2 mm	64-128 mm
	3	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	>256 mm
	4	<2 mm	<2 mm	<2 mm	2-8 mm	8-16 mm	16-32 mm
	5	No data			<2 mm	<2 mm	<2 mm
	6	16-32 mm	16-32 mm	16-32 mm	2-8 mm	2-8 mm	2-8 mm
	7	<2 mm	2-8 mm	16-32 mm	<2 mm	2-8 mm	128-256 mm
	8	<2 mm	<2 mm	<2 mm	<2 mm	8-16 mm	16-32 mm
	9	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	10	2-8 mm	8-16 mm	16-32 mm	<2 mm	2-8 mm	32-64 mm
	11	No data			<2 mm	2-8 mm	32-64 mm
	20	<2 mm	<2 mm	<2 mm	32-64 mm	32-64 mm	32-64 mm
	21	<2 mm	<2 mm	<2 mm	<2 mm	16-32 mm	16-32 mm
	22	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	23	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	24	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	27	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	8-16 mm
	29	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	30	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	31	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	32	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	34	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	36	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	38	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	40	<2 mm	<2 mm	<2 mm	16-32 mm	32-64 mm	32-64 mm
	41	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	42	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm
	43	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	47	<2 mm	<2 mm	16-32 mm	<2 mm	8-16 mm	16-32 mm
	48	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	49	<2 mm	<2 mm	<2 mm	2-8 mm	2-8 mm	2-8 mm
	50	<2 mm	<2 mm	16-32 mm	<2 mm	<2 mm	<2 mm
	51	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm
	55	Cross-section not established in 2005			2-8 mm	8-16 mm	16-32 mm
REFERENCE STATIONS	12	8-16 mm	16-32 mm	>256 mm	2-8 mm	8-16 mm	64-128 mm
	14	<2 mm	64-128 mm	>256 mm	<2 mm	2-8 mm	128-256 mm
	15	<2 mm	8-16 mm	32-64 mm	<2 mm	<2 mm	8-16 mm
	16	<2 mm	2-8 mm	32-64 mm	2-8 mm	16-32 mm	32-64 mm
	17	<2 mm	2-8 mm	8-16 mm	<2 mm	2-8 mm	16-32 mm
	18	<2 mm	32-64 mm	32-64 mm	8-16 mm	32-64 mm	64-128 mm
	19	2-8 mm	32-64 mm	32-64 mm	<2 mm	<2 mm	32-64 mm
	25	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	26	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	33	<2 mm	2-8 mm	16-32 mm	<2 mm	2-8 mm	8-16 mm
	35	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	37	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	39	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	44	<2 mm	8-16 mm	16-32 mm	<2 mm	<2 mm	8-16 mm
	45	<2 mm	8-16 mm	64-128 mm	<2 mm	<2 mm	16-32 mm
	52	8-16 mm	32-64 mm	64-128 mm	2-8 mm	8-16 mm	128-256 mm
	53	<2 mm	32-64 mm	128-256 mm	2-8 mm	8-16 mm	>256 mm
	54	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm

2.2.4.2 Channel Cross-sections

Channel cross-sections were performed at all 52 monitoring stations during 2006. Thirty-three (33) permanent cross-sections established in 2005 were revisited throughout the former Site Impoundment. and on tributaries where functional restoration is expected to occur. One additional station (Station 55) within the limits the former impoundment was added for monitoring in 2006 due to the re-establishment of a riffle following dam removal (Picture 1). Seventeen (17) permanent cross-sections were revisited on reference reaches above and below the former Site Impoundment. Cross-section locations are displayed on Figure 3 (Appendix A). Baseline and Year-1 cross-sectional surveys are displayed on Figures 4A-4D (Appendix A). Table 12 provides baseline and Year-1 bankfull channel geometry, including bankfull cross-sectional area (Abkf), bankfull width (Wbkf), maximum bankfull depth (Dmax), mean bankfull depth (dbkf), and width-to-depth ratio (width:depth).

In general, bankfull channel parameters were largely unchanged from baseline conditions during the first monitoring year. Scouring and transportation of bank and bed material was detected at some monitoring cross- sections. Others showed signs of an influx of bed material as sediment was redeposited. Station 55 was established following dam removal and therefore no baseline (2005) bankfull channel geometry data is available for this station. At Stations 7, 15, and 17, only one of the original benchmark pins was recovered and a new pin was established. Hence, the discrepancies in cross-sectional dimensions and bankfull channel geometry between the baseline and Year-1 monitoring data at these locations.

Picture 1. Station 55 established in Year-1 Monitoring

Table 12. Cross-section bankfull channel geometry

	Station	2005 (Baseline)					2006 (Year 1)				
		Abkf (sq. ft)	Wbkf (ft)	Dmax (ft)	dbkf (ft)	width: depth	Abkf (sq. ft)	Wbkf (ft)	Dmax (ft)	dbkf (ft)	width: depth
Impounded Stations	1	4707.0	235.2	27.2	20.0	11.8	4702.7	235.0	27.7	20.0	11.8
	2	3837.0	196.3	28.0	19.6	10.0	3771.9	196.0	27.0	19.2	10.2
	3	2849.0	166.2	23.9	17.1	9.7	2897.2	158.8	24.3	18.2	8.7
	4	4229.1	185.2	29.9	22.8	8.1	3632.1	193.7	24.4	18.8	10.3
	5	2783.1	174.6	23.7	15.9	11.0	2792.5	165.8	23.2	16.8	9.9
	6	3362.5	188.2	22.8	17.9	10.5	3450.9	187.7	22.8	18.4	10.2
	7*	2443.2	149.8	19.0	16.3	9.2	2869.7	173.8	20.4	16.5	10.5
	8	3098.8	181.6	24.1	17.1	10.6	3341.5	185.2	28.6	18.0	10.3
	9	2064.0	172.5	15.0	12.0	14.4	2108.0	173.5	15.0	12.2	14.2
	10	2221.5	199.0	18.0	11.2	17.8	2423.6	195.9	18.6	12.4	15.8
	11	3591.3	199.5	24.3	18.0	11.1	3720.9	199.3	24.6	18.7	10.7
	20	72.2	42.9	3.6	1.7	25.2	86.2	44.1	4.4	2.0	22.1
	21	149.6	57.9	3.6	2.6	22.3	187.8	77.9	4.4	2.4	32.5
	22	148.9	49.1	4.8	3.0	16.4	184.1	56.8	5.8	3.2	17.8
	23	76.6	30.2	4.7	2.5	12.1	104.8	34.5	5.7	3.0	11.5
	24	65.6	39.6	2.9	1.7	23.3	54.4	37.1	2.4	1.5	24.7
	27	62.3	24.9	3.9	2.5	10.0	73.4	28.6	4.5	2.6	11.0
	29	43.2	13.5	4.8	2.5	5.4	64.2	16.6	6.2	10.4	1.6
	30	153.2	22.1	8.8	6.9	3.2	115.5	29.5	6.5	3.9	7.6
	31	141.2	29.3	6.5	4.8	6.1	147.3	28.9	6.9	5.1	5.7
	32	72.1	15.5	7.5	4.6	3.4	75.7	15.9	8.0	4.8	3.3
	34	37.1	18.7	4.1	2.0	9.4	39.8	18.7	4.2	2.1	8.9
	36	111.3	21.5	9.2	5.2	4.1	111.6	21.1	9.3	5.3	4.0
	38	269.7	43.2	8.6	6.2	7.0	256.3	40.7	8.0	32.0	1.3
	40	329.2	53.3	8.2	6.2	8.6	431.2	53.3	10.6	8.1	6.6
	41	429.9	50.3	11.4	8.6	5.9	521.8	48.2	13.4	10.8	4.5
	42	139.4	30.9	6.0	4.5	6.9	156.9	32.1	7.0	4.9	6.6
	43	155.9	29.4	6.7	5.3	5.6	176.8	31.1	7.4	5.7	5.5
	47	318.5	60.5	7.8	5.3	11.4	312.7	56.3	8.0	5.6	10.1
	48	695.0	72.9	13.8	9.5	7.7	630.8	69.5	13.4	9.1	7.6
	49	550.4	59.7	13.7	9.2	6.5	380.5	59.1	10.1	6.5	9.1
	50	378.9	59.8	7.7	6.3	9.5	388.6	59.2	8.7	6.6	9.0
	51	209.5	39.9	10.8	5.3	7.5	203.9	35.6	10.7	5.7	6.2
	55	N/A	N/A	N/A	N/A	N/A	3357.6	228.4	18.0	14.7	15.5
Reference Stations	12	3054.7	212.8	17.4	14.4	14.8	3029.3	213.0	17.5	14.2	15.0
	14	6111.5	393.8	22.6	15.5	25.4	5924.9	402.6	21.6	14.7	27.4
	15*	3241.5	187.2	23.7	17.3	10.8	3583.2	200.0	24.9	17.9	11.2
	16	2370.1	176.7	16.3	13.4	13.2	2382.1	173.3	16.6	13.7	12.7
	17*	2864.3	193.5	24.7	20.0	9.7	3466.6	201.9	22.7	17.2	11.7
	18	1722.0	181.5	12.3	9.5	19.1	1697.3	174.5	12.2	9.7	18.0
	19	2647.0	167.9	21.1	15.8	10.6	2581.6	167.6	20.6	15.4	10.9
	25	22.7	19.9	2.3	1.1	18.1	24.4	20.7	2.3	10.6	2.0
	26	5.9	13.1	0.9	0.5	26.2	5.9	12.7	0.8	0.5	25.4
	33	9.6	7.0	2.2	1.4	5.0	15.4	9.8	3.0	1.6	6.1
	35	93.2	28.1	6.3	3.3	8.5	102.8	26.9	6.3	3.8	7.1
	37	6.2	11.3	1.0	0.6	18.8	6.0	9.5	1.1	0.6	15.8
	39	287.6	42.0	9.3	6.9	6.1	272.5	40.4	8.7	6.8	5.9
	44	310.3	49.7	8.1	6.2	8.0	332.3	51.9	8.4	6.4	8.1
	45	289.3	59.8	8.9	4.8	12.5	293.7	56.0	9.0	5.2	10.8
	52	2909.8	228.1	16.0	12.8	17.8	2798.1	220.9	15.6	12.7	17.4
	53	2146.7	165.6	20.4	13.0	12.7	1882.9	160.7	19.3	11.7	13.7
	54	17.7	10.7	2.7	1.7	6.3	14.6	9.4	2.4	1.6	5.9

* Only one of the original benchmark pins was recovered at the site, so new pins were established in 2006. This explains discrepancies in channel dimension.

2.2.4.3 Riffle Establishment

Following dam removal and the return of lotic flow conditions, numerous riffle areas have established throughout the Site Impoundment on the Deep River. These riffle areas that were previously submerged by the former Impoundment are new sites for potential enhanced habitat. In total, 17 new riffle locations on the Deep River have been identified, photographed, and located with GPS technology. Figure 5 (Appendix A) displays the location of the new riffles. Pictures of each re-established riffle are contained in Appendix E.

2.2.4.4 Flow Velocity

Flow velocity was measured at all 52 monitoring stations during 2006. Table 13 displays flow velocity data for Years 2005 and 2006 for both impounded and reference stations. For each flow regime, summary data are provided for one-foot below the water surface [surface] and one-foot above the stream bottom at stations with a maximum depth greater than 4-feet [depth]. As expected, flow velocities increased substantially within the former Site Impoundment following dam removal. The mean maximum flow velocity recorded at the water's surface increased from 0.03 m/sec to 0.76 m/sec within the Site Impoundment. The mean maximum flow recorded near the stream bottom also increased substantially from 0.03 m/sec to 0.62 m/sec within the former Impoundment. Thus, surface and stream bottom flow velocities in the former Impoundment exhibited an increase greater than one order of magnitude.

Table 13. Flow velocity summary data

	Site Impoundment				**Reference Reaches**			
	2005		**2006**		**2005**		**2006**	
	Max Flow Velocity (m/sec) [surface]	Max Flow Velocity (m/sec) [depth]	Max Flow Velocity (m/sec) [surface]	Max Flow Velocity (m/sec) [depth]	Max Flow Velocity (m/sec) [surface]	Max Flow Velocity (m/sec) [depth]	Max Flow Velocity (m/sec) [surface]	Max Flow Velocity (m/sec) [depth]
HIGH	0.16	0.34	4.10	1.09	0.29	1.51	3.10	0.97
LOW	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.47
MEAN	**0.03**	**0.03**	**0.76**	**0.62**	**0.07**	**0.62**	**1.22**	**0.72**
Standard Deviation	0.04	0.07	0.92	0.33	0.09	0.57	0.94	0.35

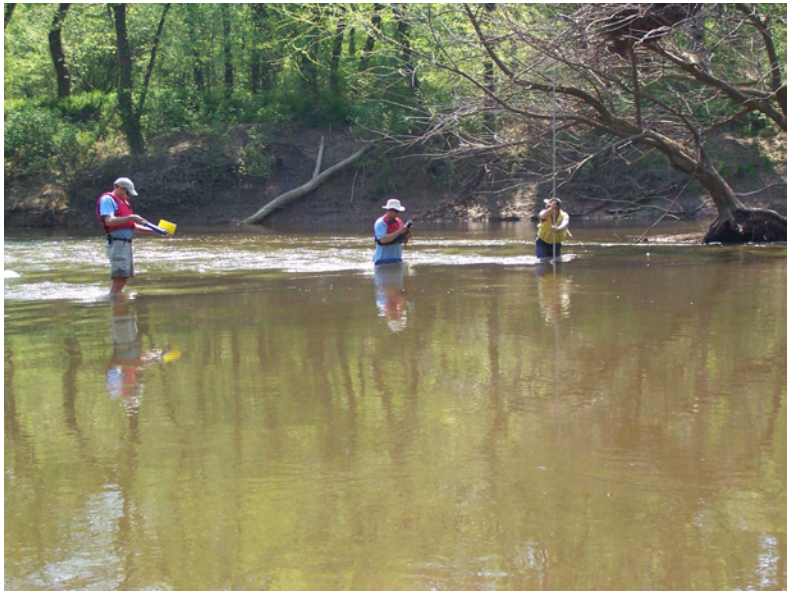
2.2.4.4 Photography and Videography

As discussed in the project's Mitigation Plan (Restoration Systems 2006), photography and/or videography were conducted during baseline and Year-1 monitoring data collection to assess qualitative changes in channel cross-sections and in-stream habitat. The following pictures (Pictures 2-5) of monitoring stations 8 and 52 were taken during baseline and Year-1 Monitoring. The pictures characterize the restoration of the Deep River following dam removal. Both station 8 and 52 display lotic flow conditions with increased stream habitat and bank vegetation. Monitoring pictures and/or videos for all stations have been included on 2 data compact discs in Appendix H.

Picture 2: Station 8 in 2005 Baseline Monitoring

Picture 3: Station 8 in 2006 Year-1 Monitoring

Picture 4: Station 52 in 2005 Baseline Monitoring



Picture 5: Station 52 in 2006 Year-1 Monitoring

2.3 PROTECTED SPECIES

The documented presence of any rare species within the former Site Impoundment throughout the five-year monitoring period will constitute success in fulfilling the rare and endangered aquatic species criterion. No threatened or endangered fish species were found during Year-1 fish surveys by TCG. Although no targeted species were found, favorable habitat areas for the Cape Fear shiner have developed at many locations, and the recruitment of new populations is expected over time. Although baseline mollusk community data were obtained during pre-removal biological surveys in 2005, mollusks will not be sampled again until the fourth year of project monitoring (2009), to allow time for rare species recolonization.

2.4 RESERVE CRITERIA

2.4.1 Public Recreation

The establishment of a recreational park in the vicinity of the former Carbonton Dam began on September 5, 2006. Plans consist of vehicle parking, picnicing sites, bank fishing, and improved access to the river for kayakers and canoeists. Detailed site plans for Deep River Park, provided by Milone and McBroom Inc. are located in Appendix F.

The amount of credit to be derived from the successful implementation of the park has not yet been determined. Under exceptional circumstances, if all primary criteria are successfully met, these reserve criteria should result in excess, unsold credits becoming available at the end of the monitoring period. Additionally, resulting credit may be used to offset any potential loss of credits from other aspects of the project.

2.4.2 Scientific Research

The former Site Impoundment is subject to an ongoing study by Adam Riggsbee, Phd and a University of Chapel Hill (UNC-CH) PhD Candidate Jason Julian. RS has provided UNC-CH with funding for any research project the university deems necessary. Julian's project involves the physical processes that control the availability of light near the river bottom, and how the available light affects primary and secondary productivity (Julian 2007). The research may be beneficial in measuring the positive impacts to biological productivity that occurs from lowering the water levels after dam removal to facilitate light penetration to the riverbed. Additional research by Riggsbee investigates the role of sediment suspensions (resulting from dam removal) on nutrient and organic matter availability within the downstream water column (Riggsbee 2006). This research is still underway, and the details of the study and its findings will be completed prior to the end of the monitoring period.

The amount of credit to be derived from the successful support of this research by RS has not yet been determined. Under exceptional circumstances, if all primary criteria are successfully met, these reserve criteria should result in excess, unsold credits becoming available at the end of the monitoring period. Additionally, resulting credits may be used to offset any potential loss of credit from other aspects of the project.

2.5 EROSION EVALUATION

ESC performed bank erosion evaluations of the former Site Impoundment following rain events that result in a rise in river stage of more than 1500 cubic feet per second (cfs) at the Ramseur gauging station. The erosion evaluation consists of a canoe transit of the Deep River within the former impoundment, as well as land investigations of tributaries from public road crossings. These evaluations were performed to document any evidence of erosion within the former impoundment including but not limited to bank failure, loss of stream bank trees, severe head-cuts, and the loss or gain of large depositional features. Erosion evaluations were performed on May 1, 2006 and June 26, 2006. During these evaluations, minor erosion throughout the former impoundment was observed. Headcuts were noted at the confluence of some tributaries to the Deep River, and scrouring of tributary banks was observed in areas where vegetation had not established. The banks of the Deep River were generally stable and showed only minor evidence of erosion. Detailed reports submitted for each of these evaluations are included in Appendix G.

2.6 SUMMARY

Table 14 shows the primary and reserve mitigation success criteria and parameters for this project. The final column evaluates the success in fulfilling project criteria. Any criterion for which success was not met in Year-1 Monitoring, will continue to be sampled throughout the monitoring period.

Table 14. Mitigation Success Criteria Summary

	Criterion	Parameter	Anticipated Change/Result	2006 Success
Primary success criteria:	Re-introduction of rare and endangered aquatic species	Presence/absence of rare/endangered individuals	Unknown	Pending
		Rare/endangered species habitat	Improvement/expansion	Yes
	Improved water quality	Benthic biotic indices	Decrease (i.e., improve)	Yes
		AMS dissolved oxygen data	Increase within former Site Impoundment (must be ≥ 5.0 mg/L or consistent with reference station data)	Yes
	Improved aquatic community	Ephemeroptera, Plecoptera, and Trichoptera taxa, total number of benthic taxa	Increase (i.e., converge with reference station data)	Pending
		Fish, Mussel, and Snail community data	Demonstrated shifts in communities from lentic to lotic character	Pending
Reserve success criteria:	Downstream benefits below dam	Deep River bankfull channel within formerly eddied/scoured areas below dam	Narrowing/increased stabilization of channel	Ongoing
	Scientific value	Published research	Successful completion	Yes
	Public recreation	Construction of planned on-Site park	Successful completion	Yes

3.0 REFERENCES

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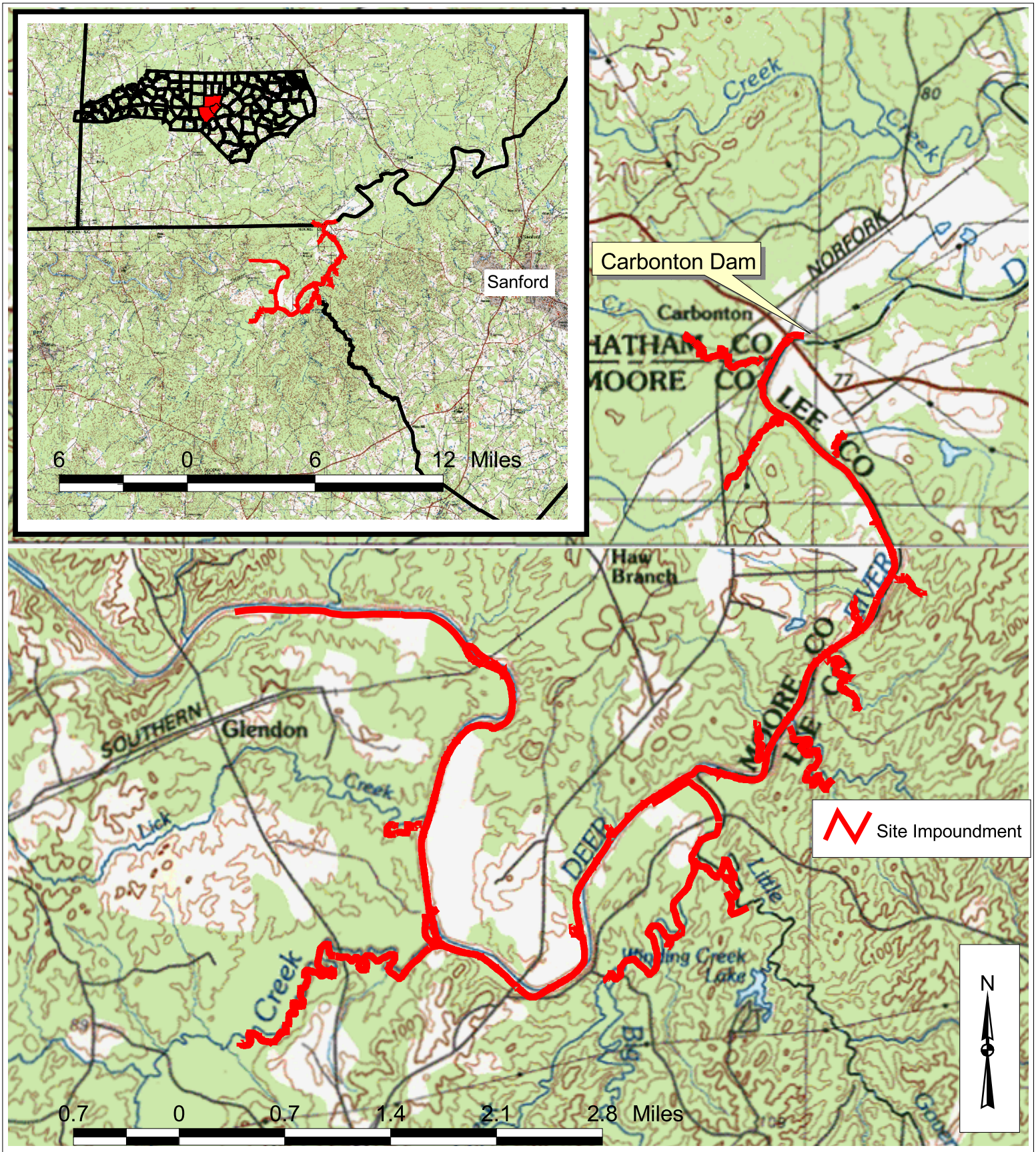
APPENDIX A: FIGURES



Site Location

Deep River- Carbonton Dam Restoration Site

Lee, Chatham, and Moore Counties, North Carolina

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

FIGURE 1

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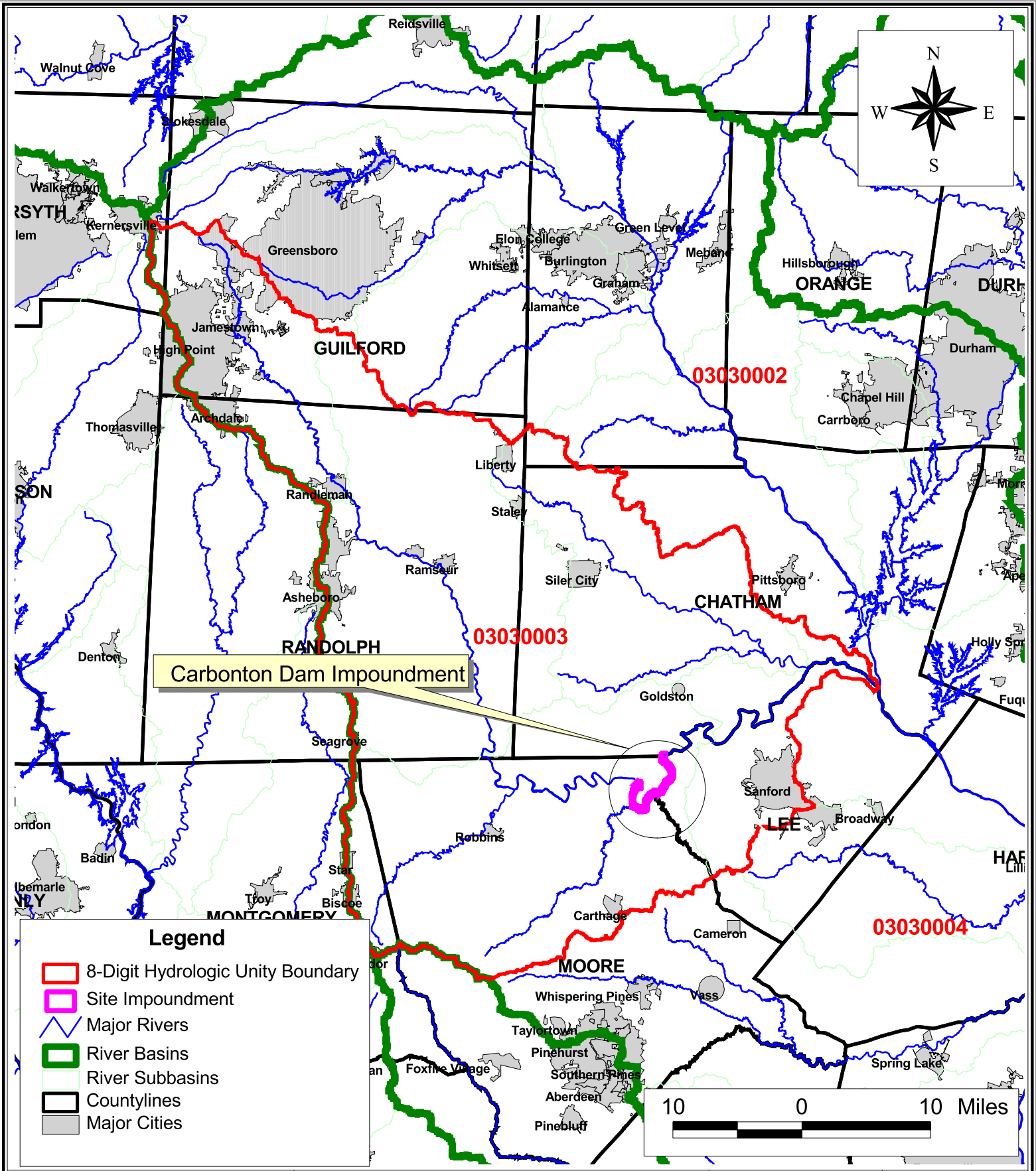
Chkd By: APS	Project No: 06-288.03

SCALE: AS SHOWN



EcoScience Corporation
Raleigh, North Carolina

Hydrologic Units

Deep River-Carbonton Dam Restoration Site

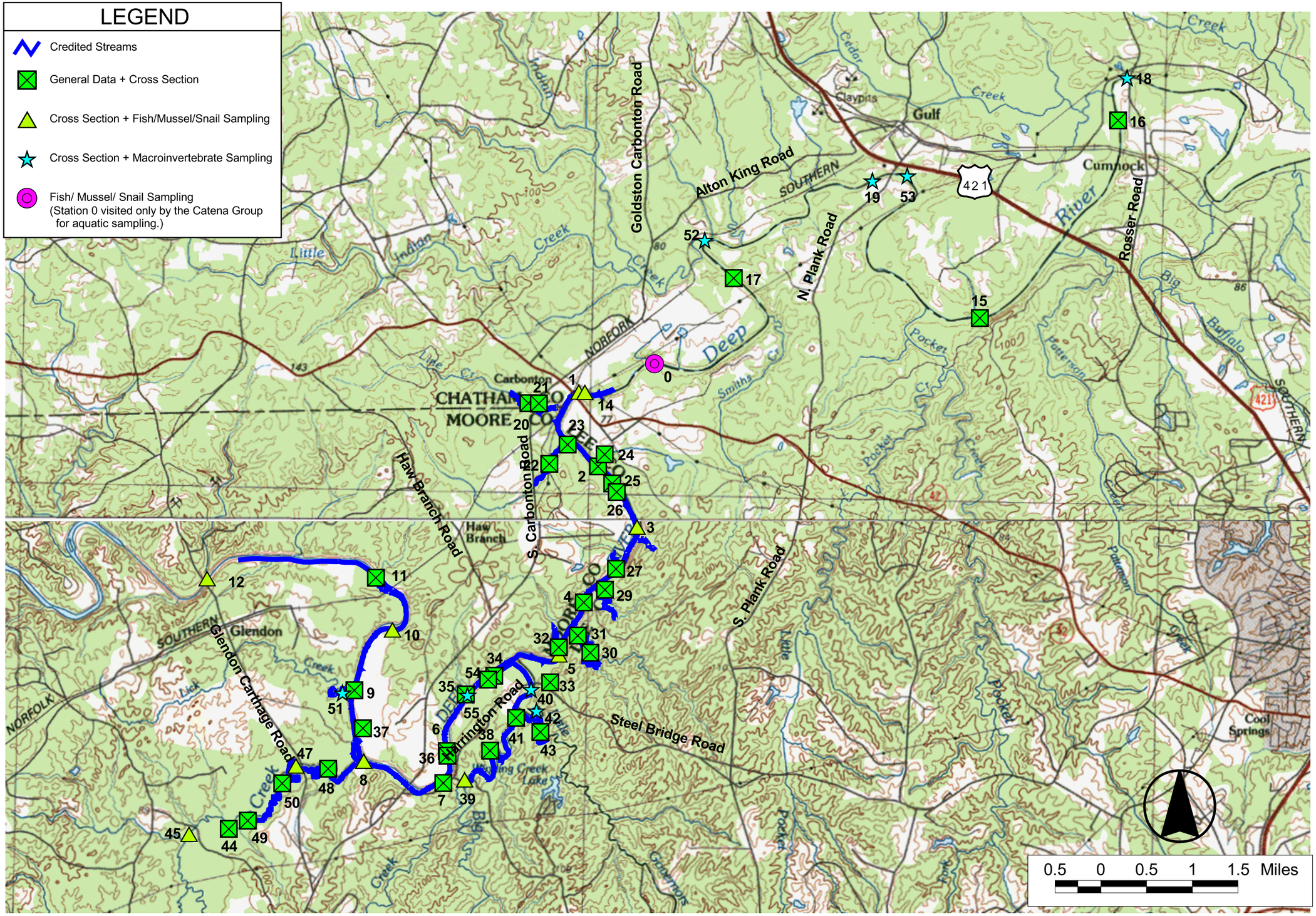
Chatham, Lee, and Moore Counties, North Carolina

Drawn By: MTC
Chkd By: GRM
Date: SEP 2006
Project: 06-288

FIGURE 2

LEGEND

- Credited Streams
- General Data + Cross Section
- Cross Section + Fish/Mussel/Snail Sampling
- Cross Section + Macroinvertebrate Sampling
- Fish/ Mussel/ Snail Sampling
  (Station 0 visited only by the Catena Group for aquatic sampling.)



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Raleigh, North Carolina

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

CLIENT:
Ecosystem Enhancement Program

PROJECT:

CARBONTON DAM-DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

TITLE:

MONITORING STATION LOCATIONS

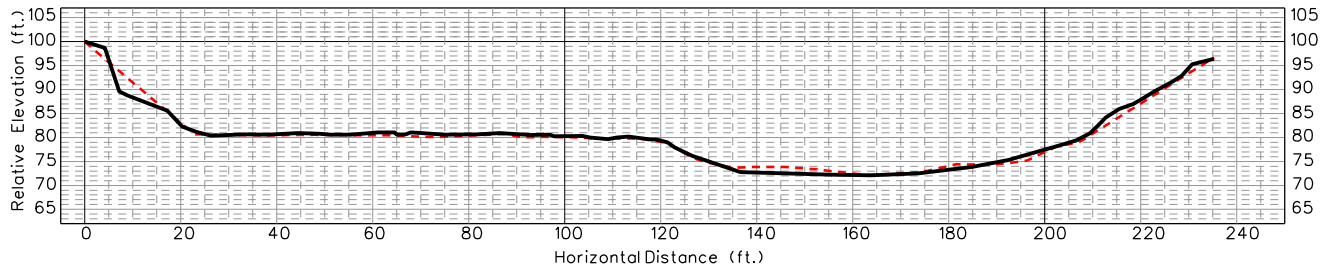
Dwn By:	Date:
MCG	SEPT 2006
Ckd By:	Scale:
MTC	AS SHOWN

ESC Project No.: 06-288

FIGURE

3

STATION 1



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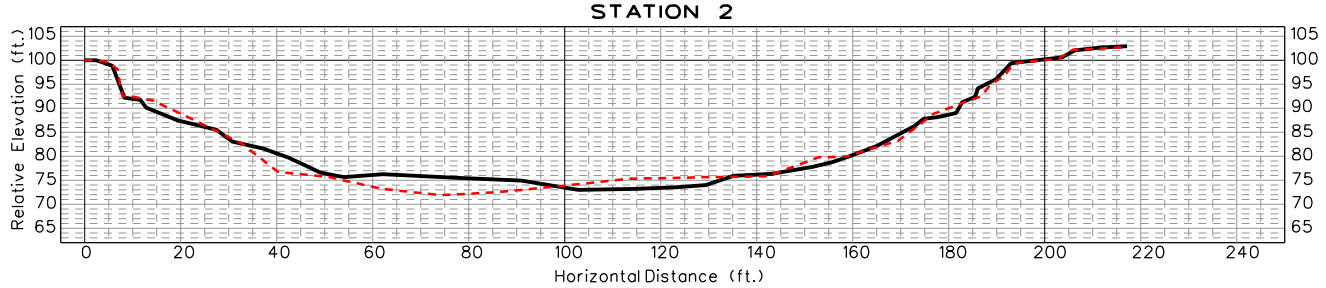

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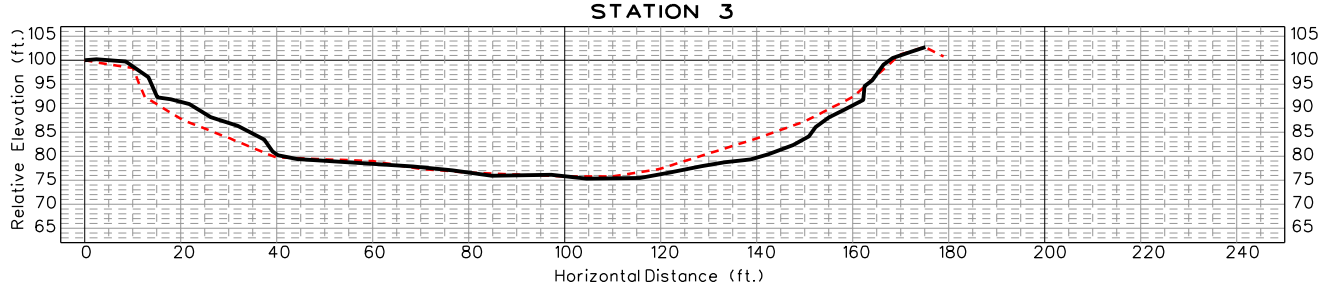

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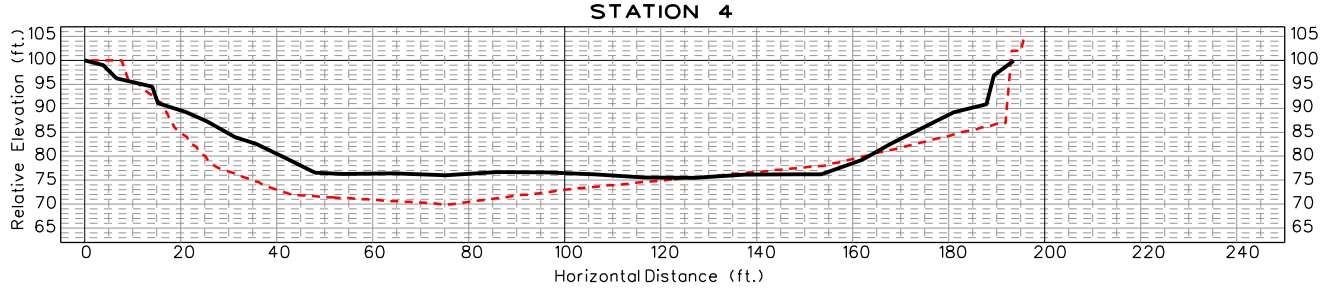

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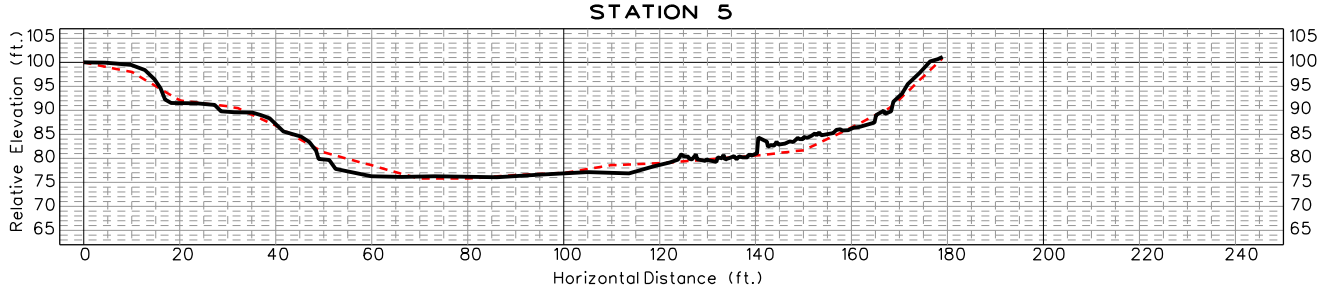

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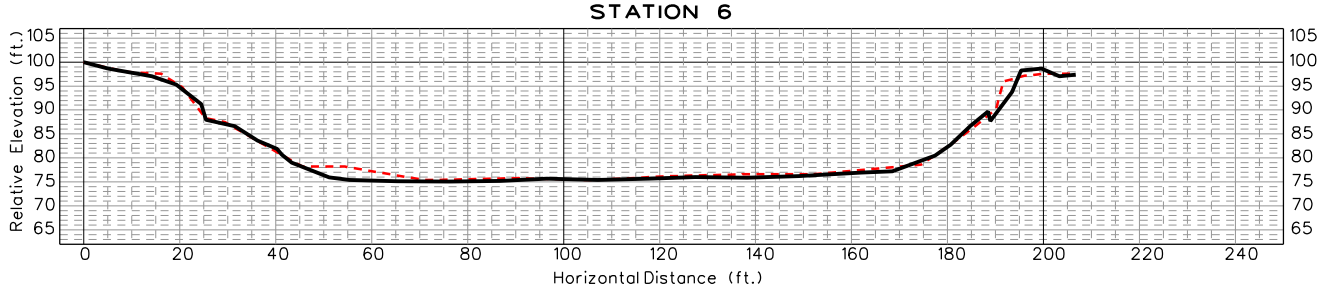

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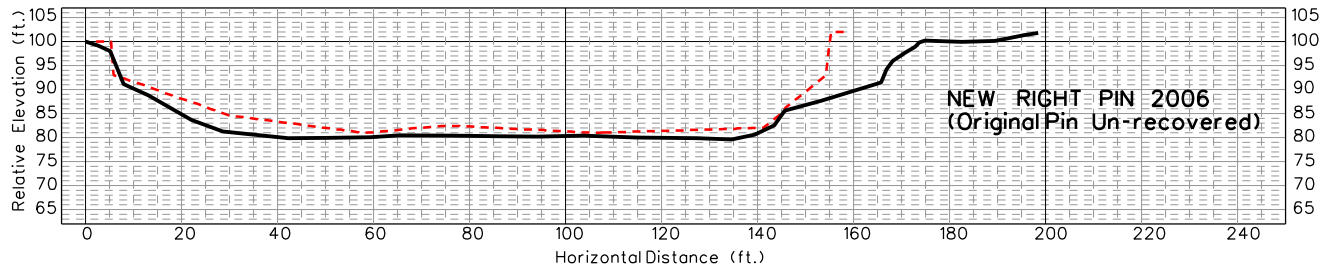

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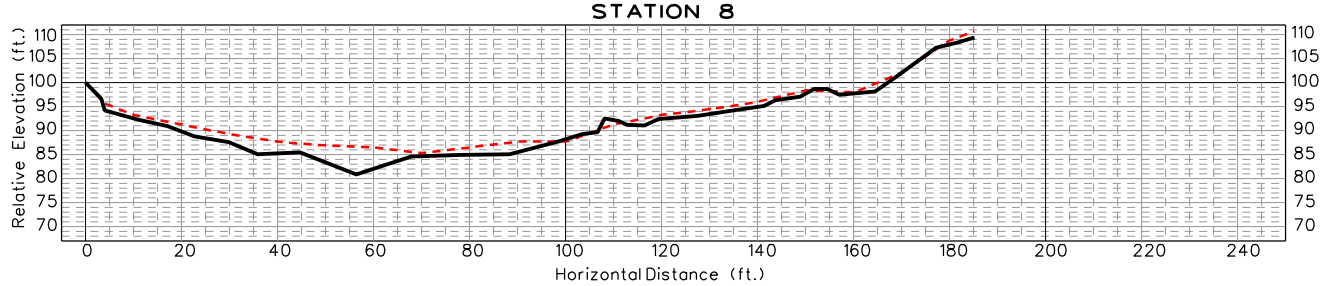

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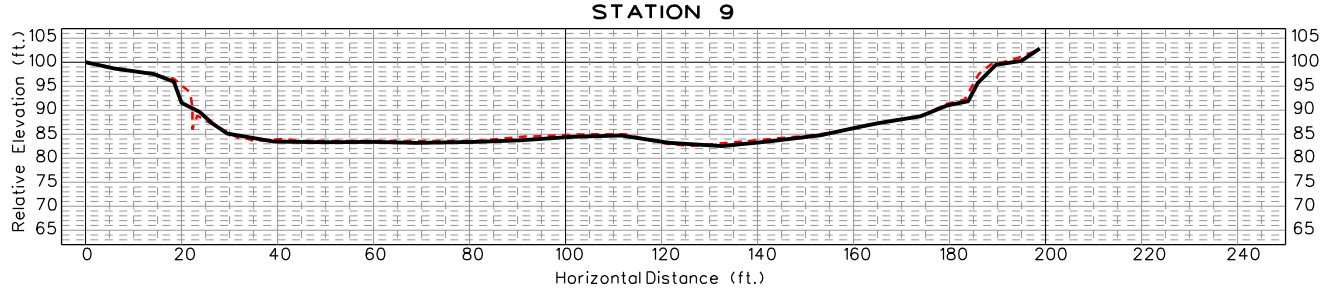

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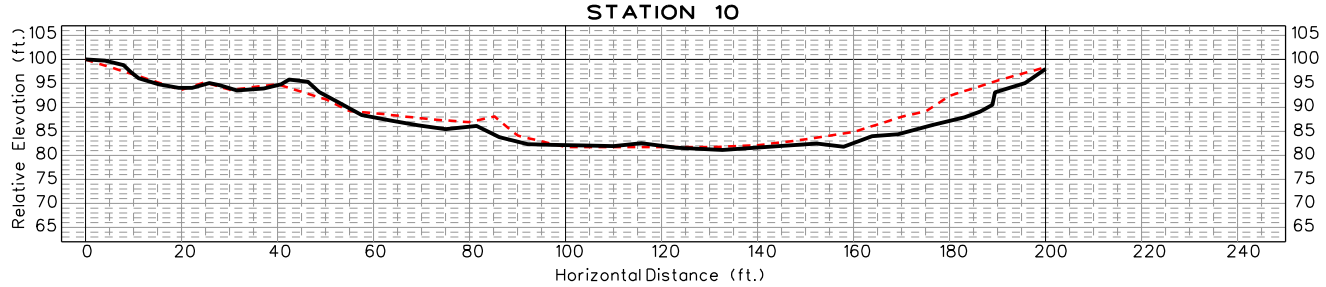

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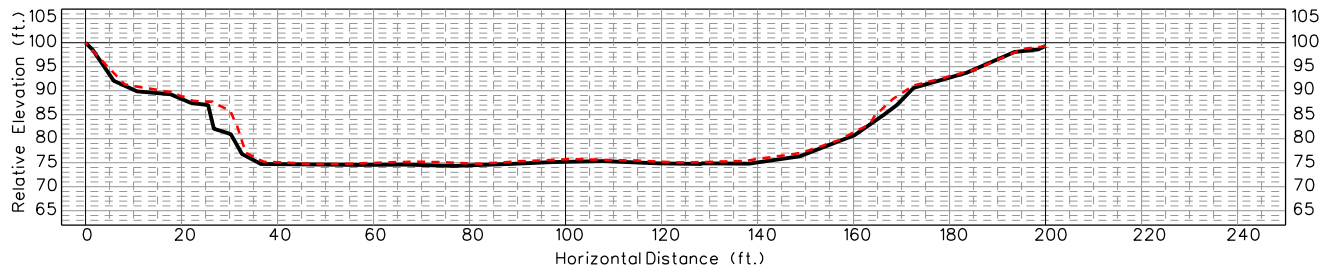

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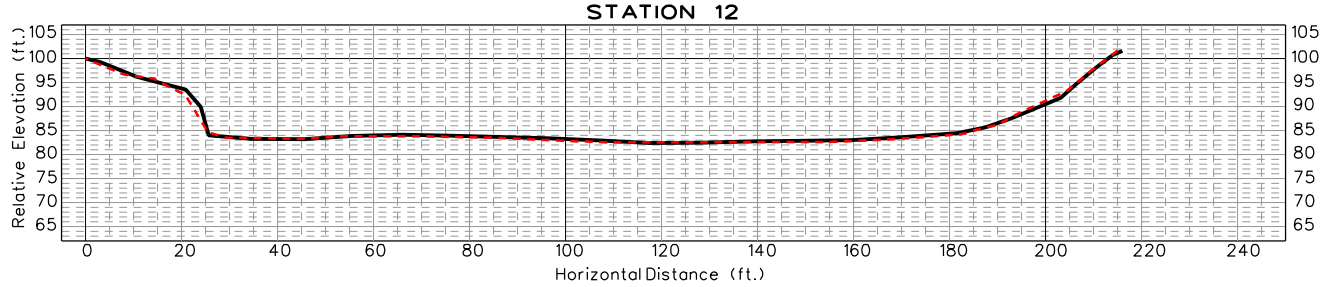

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RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

Client:
Ecosystem Enhancement PROGRAM

LEGEND

- YEAR 2005 PRE-DAM REMOVAL
- YEAR 2006 MONITORING

Project:

CARBONTON DAM–DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

Title:

MONITORING CROSS–SECTIONS

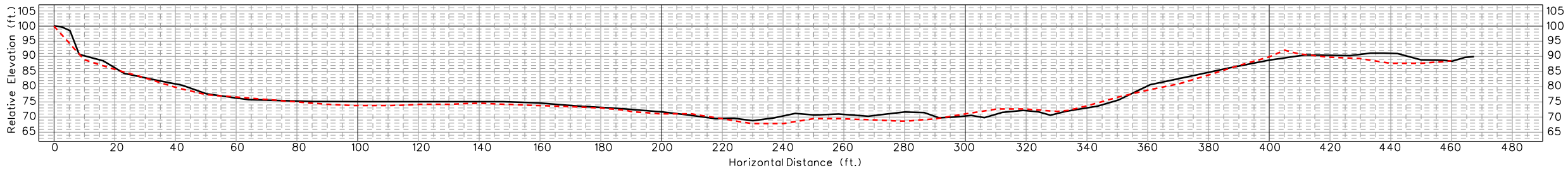
Dwn By:	Date:
MAF	SEPT 2006
Ckd By:	Scale:
MCG	AS SHOWN

ESC Project No.: 06-288

FIGURE

4A

STATION 14



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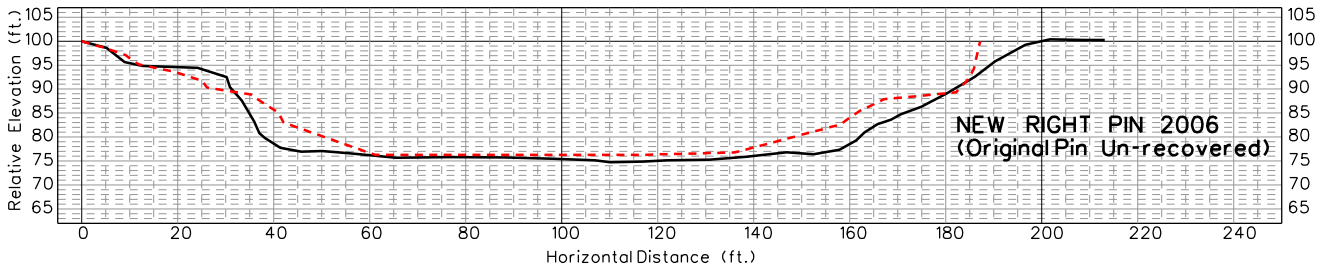

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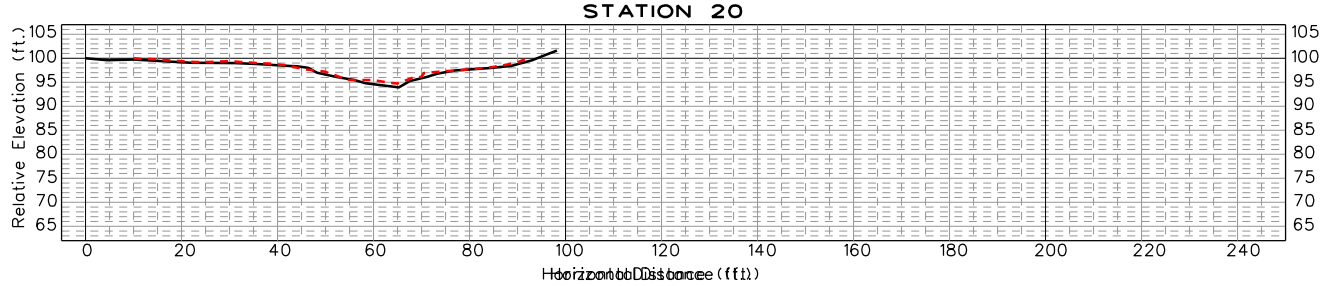

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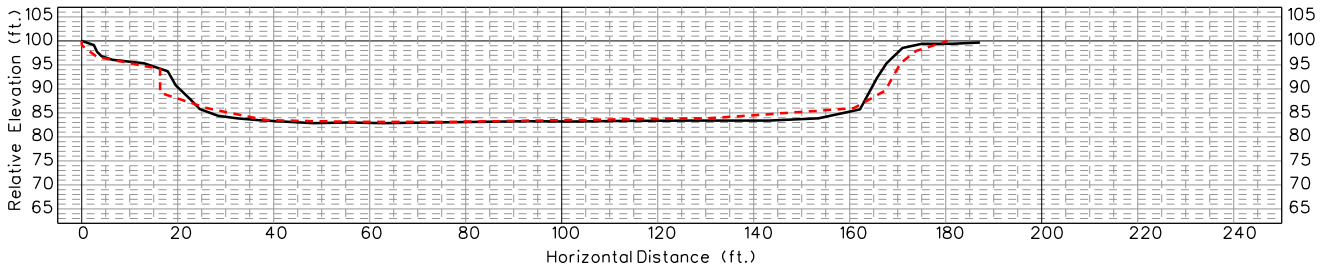

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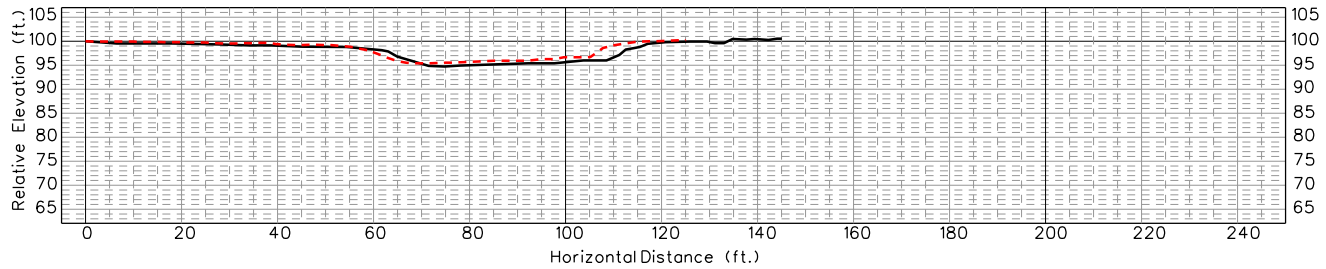

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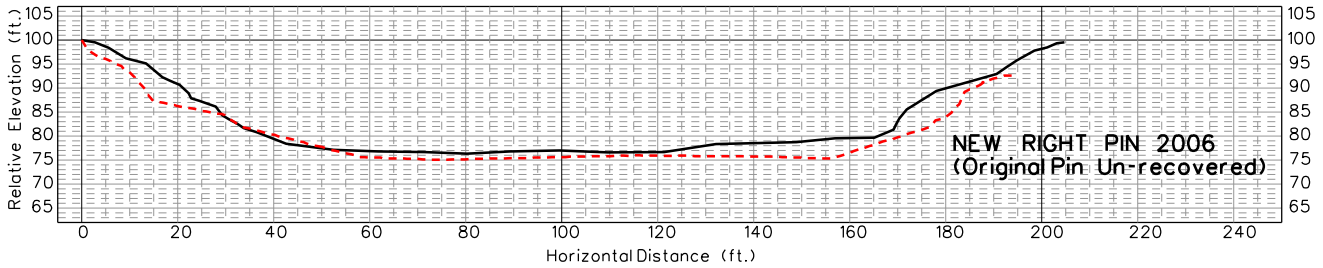

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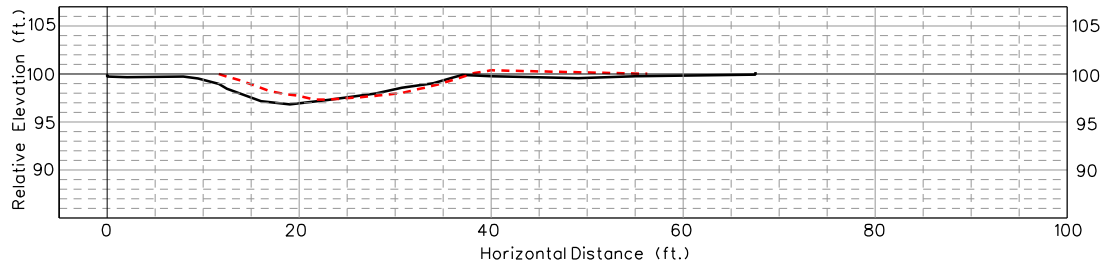

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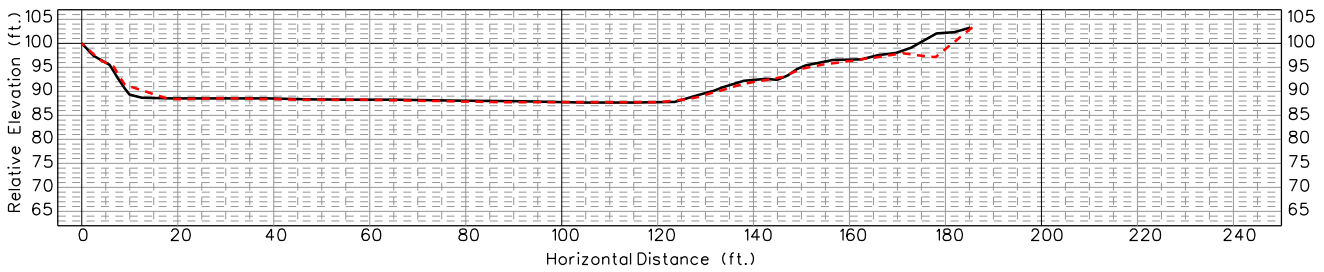

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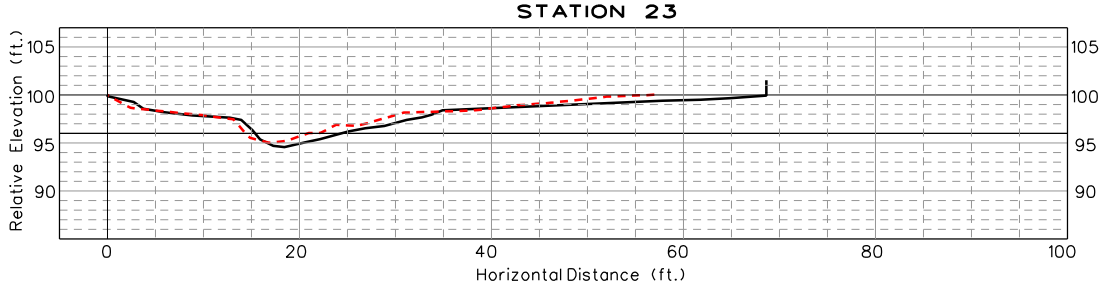

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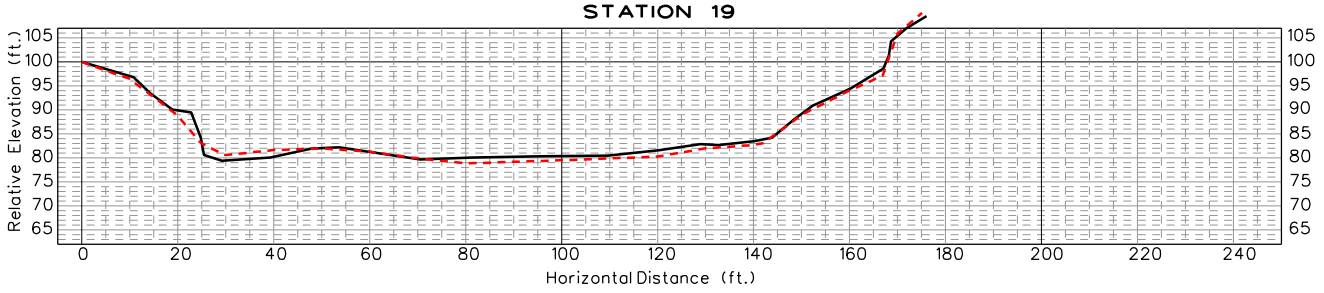

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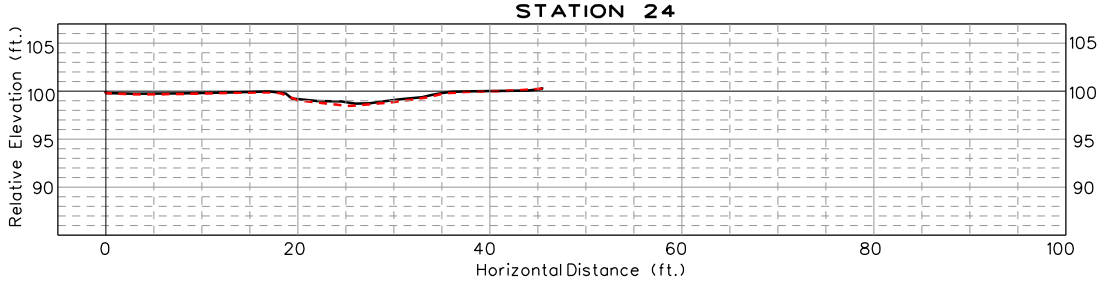

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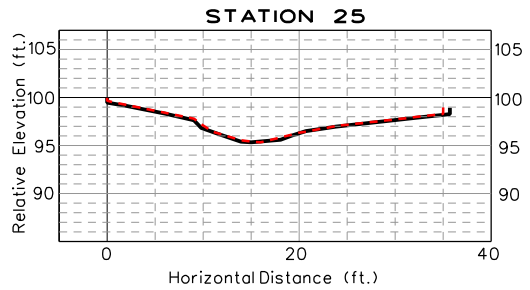
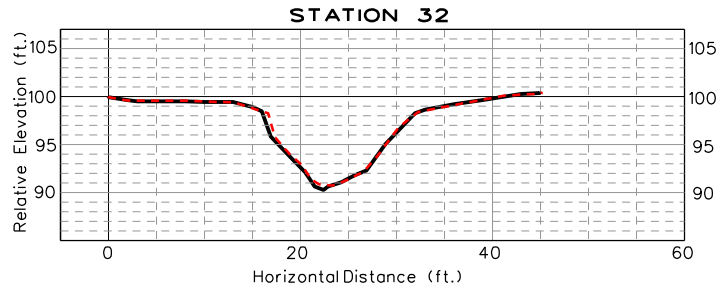
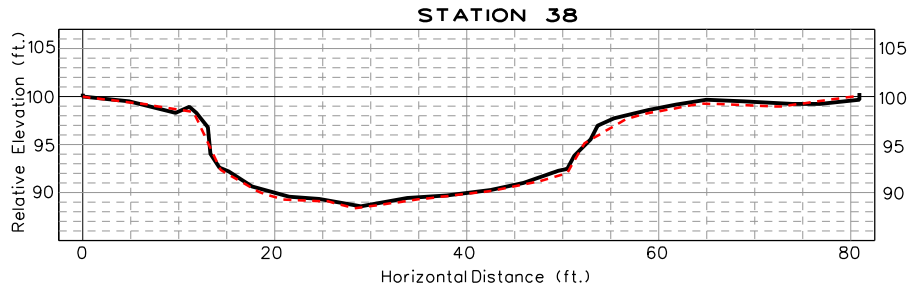
MCG	AS SHOWN

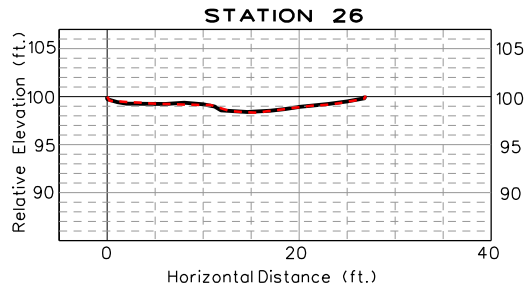
ESC Project No.: 06-288

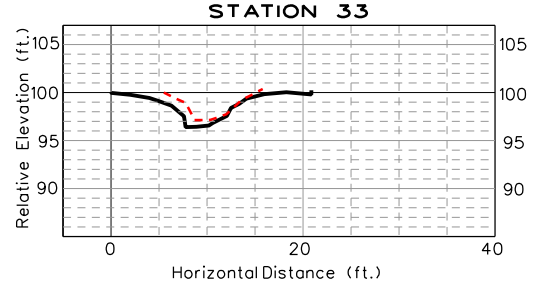
FIGURE
4B

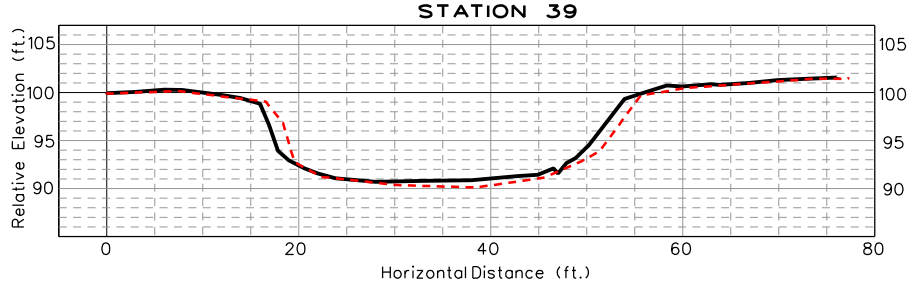


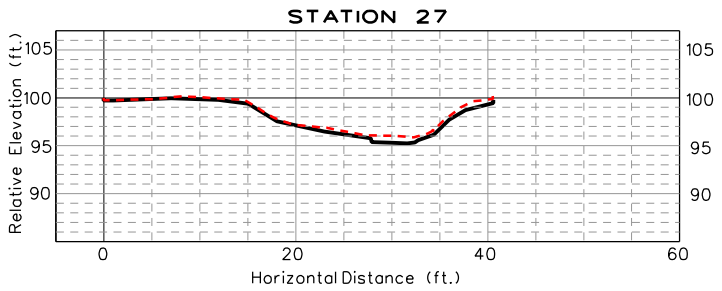


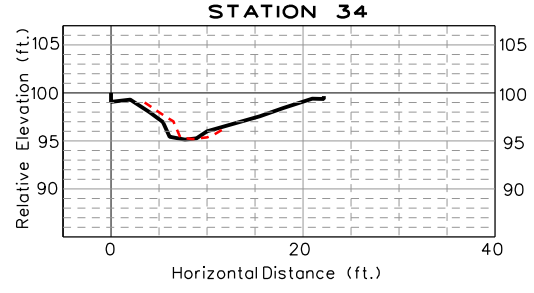


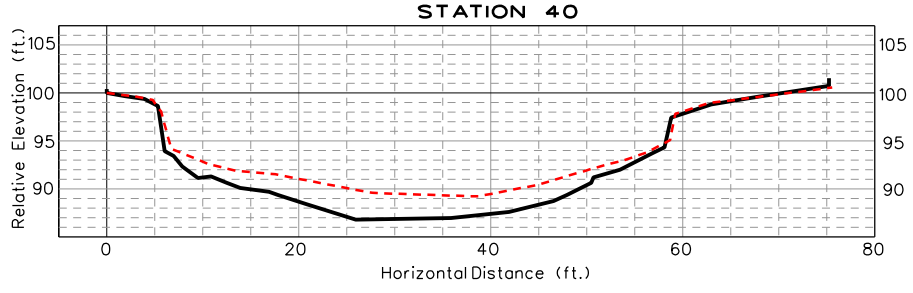


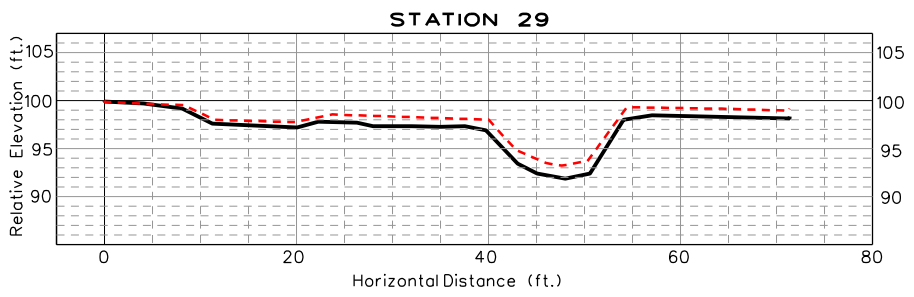


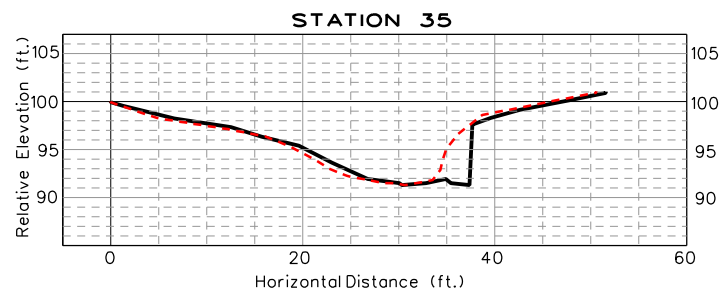


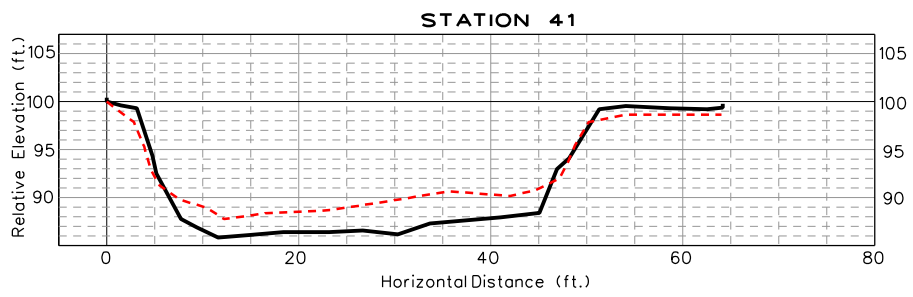


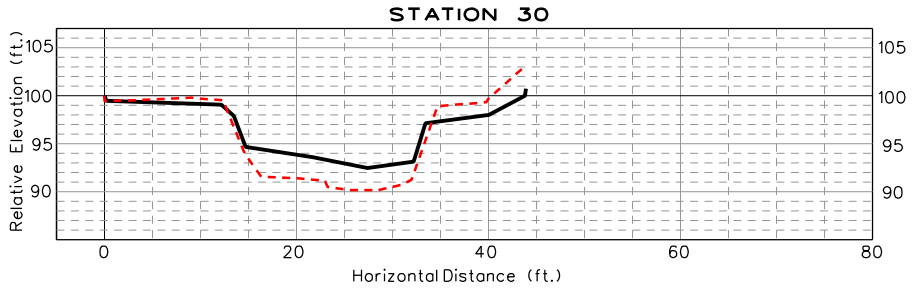


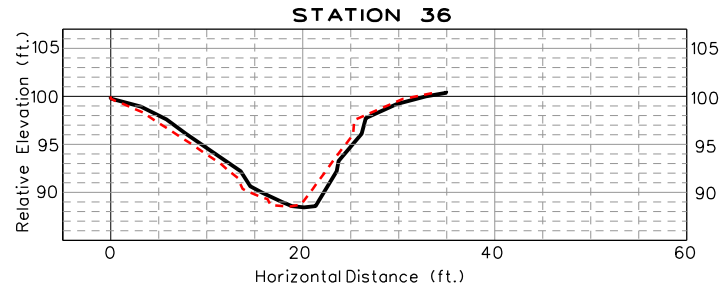


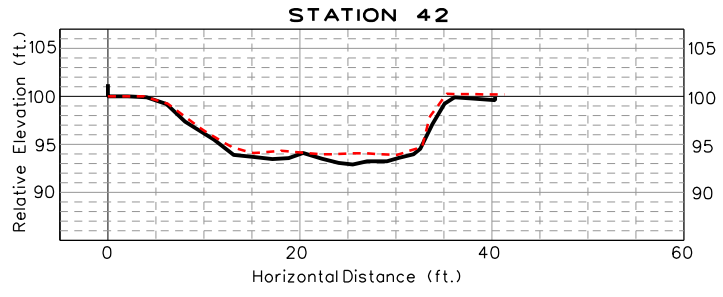


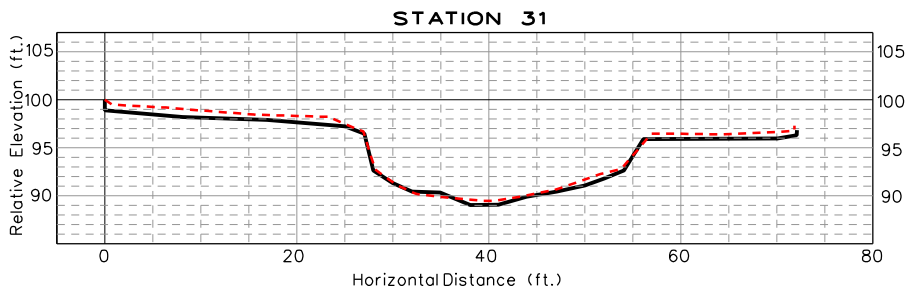


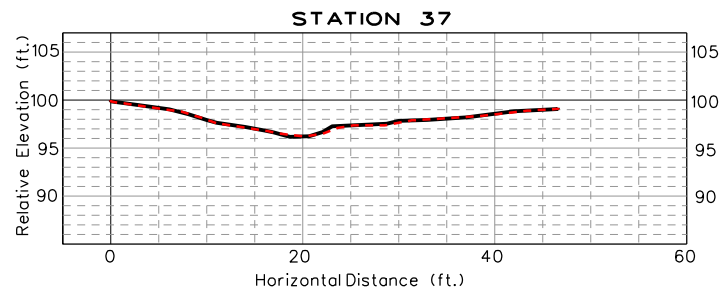


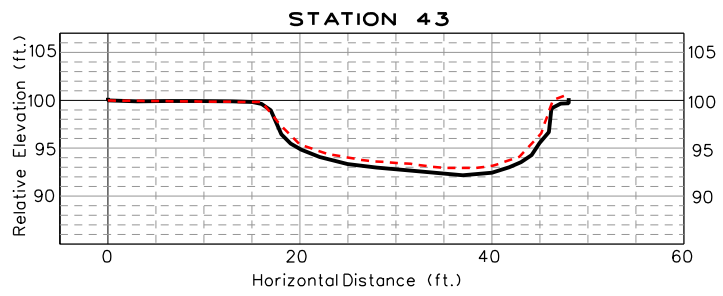












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LEGEND

- YEAR 2005 PRE-DAM REMOVAL
- YEAR 2006 MONITORING

Project:

CARBONTON DAM–DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

Title:

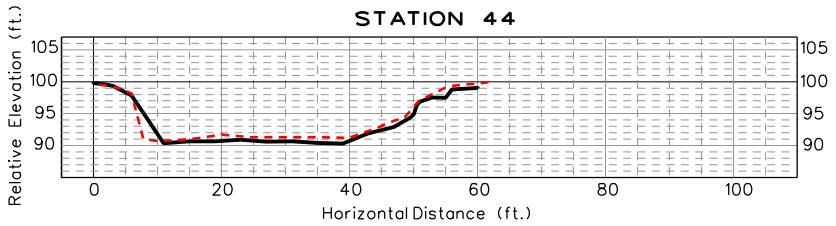
MONITORING CROSS–SECTIONS

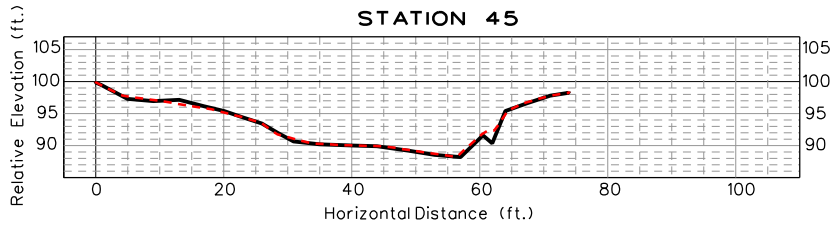
Dwn By:	Date:
MAF	SEPT 2006
Ckd By:	Scale:
MCG	AS SHOWN

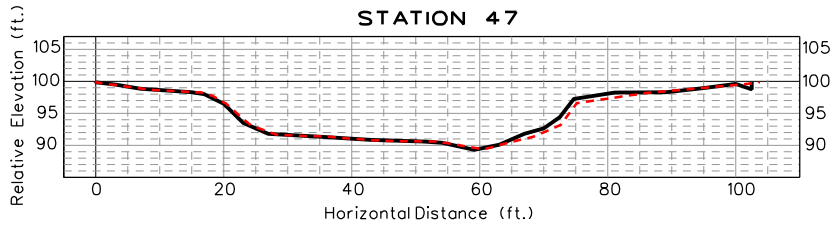
ESC Project No.: 06-288

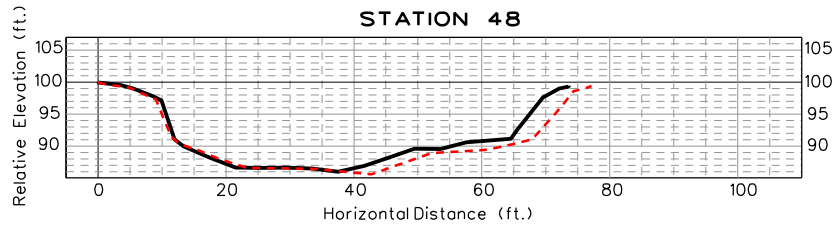
FIGURE

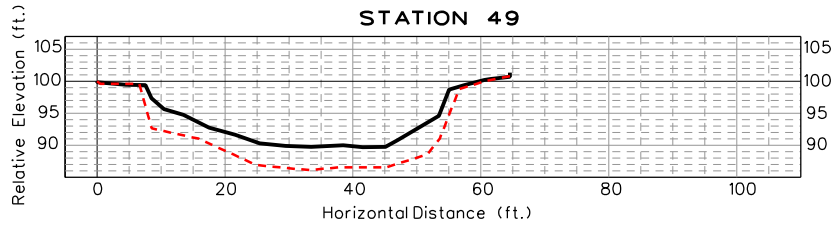
4C

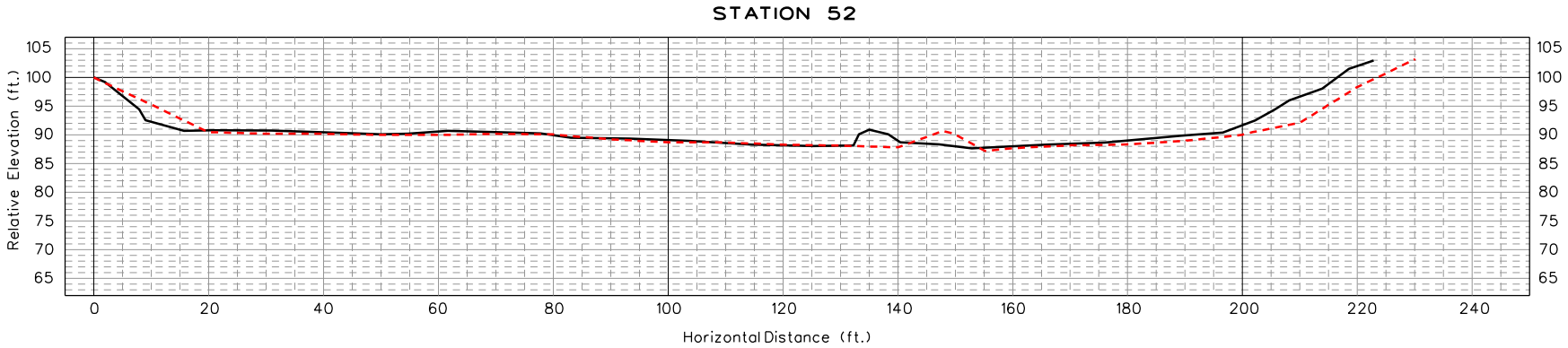


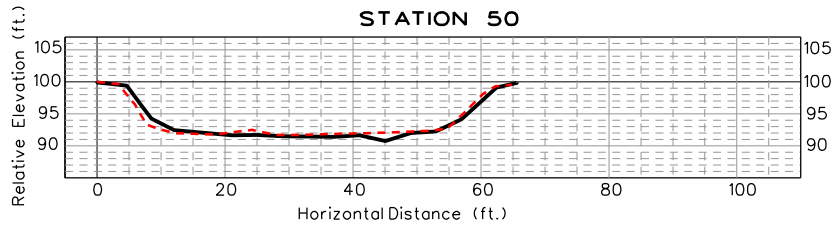


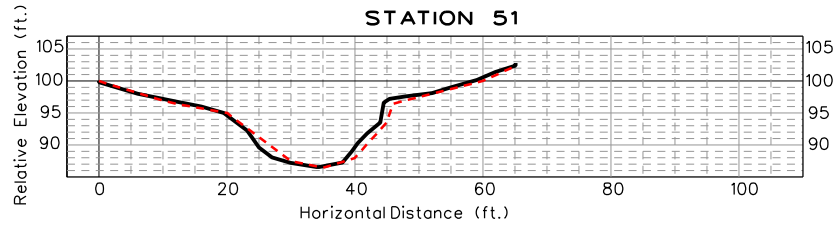


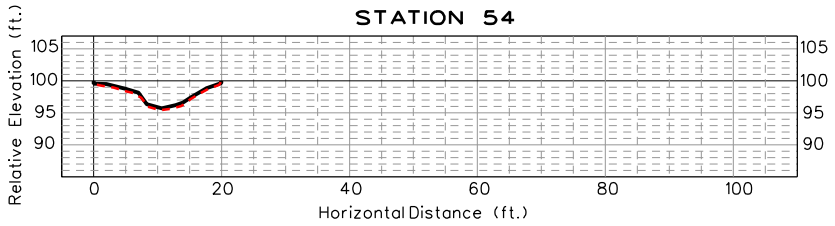


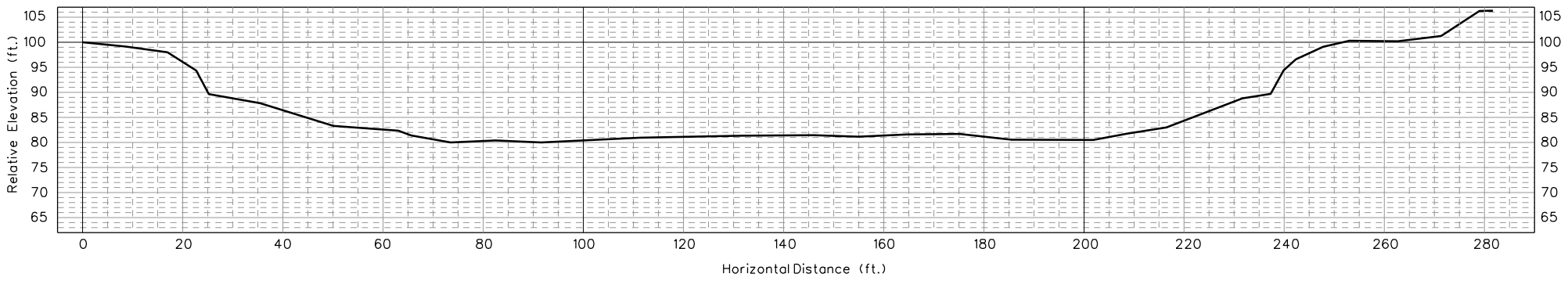












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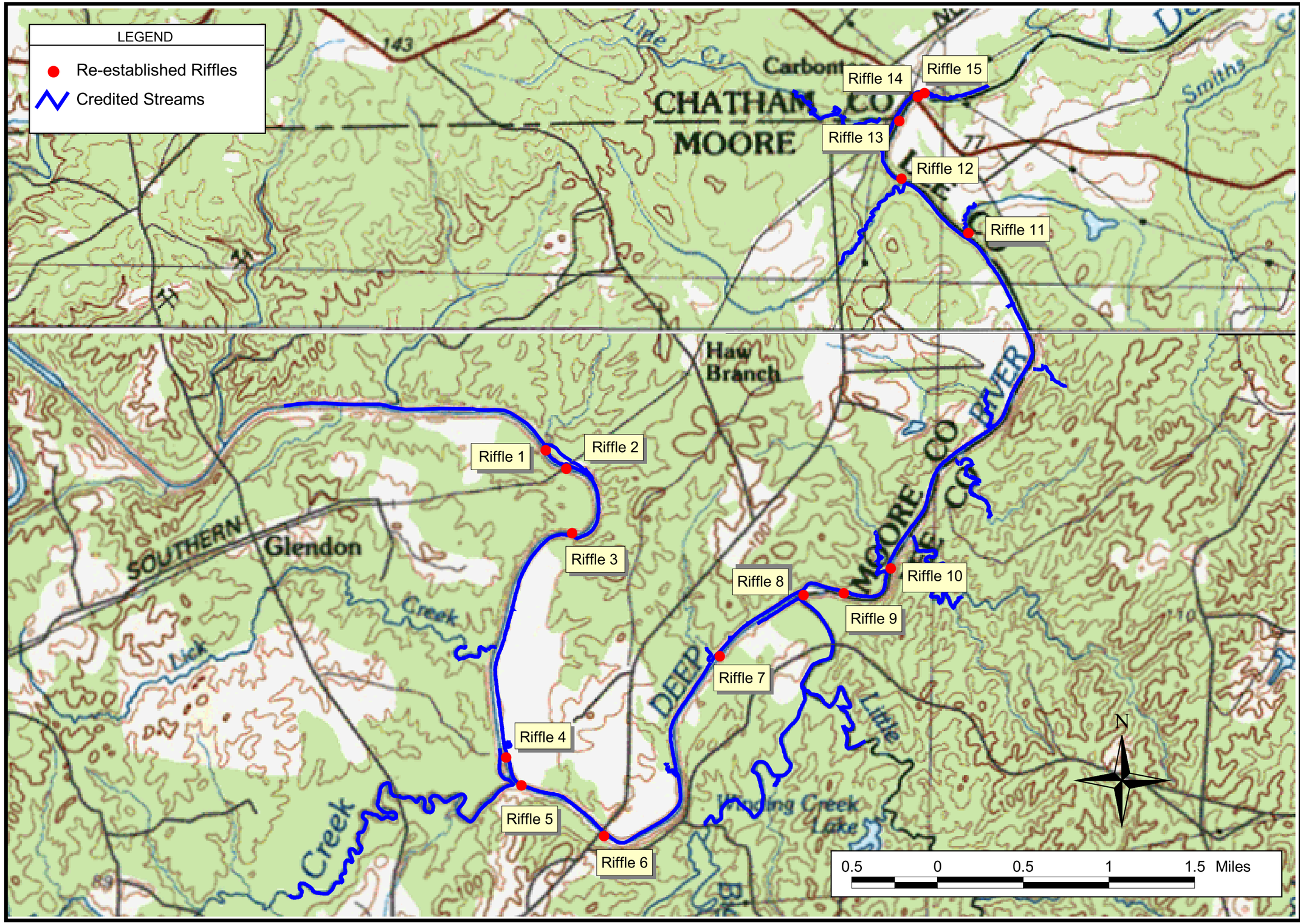
ESC Project No.: 06-288

FIGURE

4D



EcoScience Corporation
Raleigh, North Carolina

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

CLIENT:
Ecosystem Enhancement Program

PROJECT:

CARBONTON DAM-DEEP RIVER WATERSHED RESTORATION SITE

CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

TITLE:

POST DAM REMOVAL RE-ESTABLISHED RIFFLES

Dwn By:	Date:
MCG	SEPT 2006
Ckd By:	Scale:
MTC	AS SHOWN

ESC Project No.: 06-288

FIGURE

5

APPENDIX B: BENTHIC MACROINVERTEBRATE DATA

IMPOUNDED STATIONS												
SPECIES	**T.V.**	**F.F.G.**	**STA. 1**	**STA. 3**	**STA. 5**	**STA. 8**	**STA. 10**	**STA. 40**	**STA. 42**	**STA. 47**	**STA. 51**	**STA. 55**
PLATYHELMINTHES												
Turbellaria												
Tricladida												
Dugesiidae												
Planariidae												
Girardia (Dugesia) tigrina	**7.2**											
NEMATODA	**6**											
MOLLUSCA												
Bivalvia												
Veneroida												
Corbiculidae												
Corbicula fluminea	**6.12**	**FC**								3		
Sphaeriidae	**6.6**	**FC**										
Musculium sp.	**7.5**	**FC**						1				
Pisidium sp.	**6.5**	**FC**								2		
Gastropoda												
Mesogastropoda												
Hydrobiidae	**5.78**	**SC**										
Amnicola limosus	**5.2**	**SC**										
Somatogyrus sp.	**6.4**	**SC**										
Pleuroceridae	**3.4**											
Elimia sp.	**2.46**	**SC**										
Viviparidae												
Campeloma sp.	***7**	**SC**										1
Basommatophora												
Physidae												
Physella sp.	**8.8**	**CG**		1					2	1		1
Planorbidae												
Menetus dilatatus	**8.2**	**SC**								1		
ANNELIDA												
Oligochaeta		**CG**										
Tubificida												
Lumbricidae		**CG**					3		5	5		
Naididae	***8**	**CG**										1
Dero sp.	**10**	**CG**								1		
Tubificidae w.h.c.	**7.1**	**CG**								2		
Tubificidae w.o.h.c.	**7.1**	**CG**							3	1		3
Branchiura sowerbyi	**8.28**	**CG**	2									
Limnodrilus hoffmeisteri	**9.5**	**CG**					1	1				
Lumbriculida												
Lumbriculidae	**7.03**	**CG**							1			
Branchiobdellida												
Hirudinea		**P**							30	1		
Rhynchobdellida												
Glossiphoniidae		**P**										
Helobdella stagnalis	**8.6**	**P**							3			
ARTHROPODA												
Arachnoidea												
Acariformes												
Hygrobatidae												
Atractides sp.	**5.5**					2						

IMPOUNDED STATIONS												
SPECIES	**T.V.**	**F.F.G.**	**STA. 1**	**STA. 3**	**STA. 5**	**STA. 8**	**STA. 10**	**STA. 40**	**STA. 42**	**STA. 47**	**STA. 51**	**STA. 55**
Crustacea												
Ostracoda										1		
Copepoda								1			4	
Cladocera												
Chydoridae						1				1		1
Chydorus sp.							1					
Daphnidae												
Ceriodaphnia sp.											31	
Isopoda												
Asellidae		**SH**										
Caecidotea sp.	**9.1**	**CG**	1					2		4	5	
Amphipoda												
Crangonyctidae												
Crangonyx sp.	**7.9**	**CG**				1	1	2	1		3	
Hyalellidae												
Hyalella azteca	**7.75**	**CG**						2				
Decapoda												
Cambaridae	**7.5**						5	1	4			
Cambarus sp.	**7.62**	**CG**								1		
Orconectes sp.	**2.6**	**SH**										
Procambarus sp.	**7**	**SH**										
Palaemonidae												
Palaemonetes sp.	**7.1**	**CG**										
Insecta												
Collembola								1	1			
Ephemeroptera												
Baetidae		**CG**		1						1		
Baetis intercalaris	**7**	**CG**	4	4	1	1	1					11
Baetis sp.	***4**	**CG**										
Centroptilum sp.	**6.6**	**CG**			2			2				1
Plauditus sp.	***4**	**CG**										7
Pseudocloeon sp.	**4**	**CG**	1	3	1	1	1			5		2
Caenidae		**CG**										
Brachycercus nitidus		**CG**		1								
Caenis sp.	**7.4**	**CG**	7		1							1
Ephemerellidae		**SC**										
Ephemerella sp.	**2.04**	**SC**	1							1		
Eurylophella sp.	**4.34**	**SC**						1		9		
Serratella sp.		**SC**										1
Heptageniidae				1								
Leucrocuta sp.	**2.4**	**SC**	1				4					6
Maccaffertium sp.	***4**	**SC**	10	15	8	3	18					24
Maccaffertium exiguum	**3.8**	**SC**	1				1					3
Maccaffertium modestum	**5.5**	**SC**										
Stenacron interpunctatum	**3.58**	**SC**	2				2			1		
Isonychiidae		**FC**										
Isonychia sp.	**3.5**	**FC**	2				4					7
Leptophlebiidae	***2**	**CG**										
Paraleptophlebia sp.	**0.94**	**CG**										
Potamanthidae		**CG**										
Anthopotamus sp.	**1.5**	**CG**	2									
Anthopotamus myops	**1.5**	**CG**		2								1
Tricorythidae	***4**	**CG**										
Tricorythodes sp.	**5.06**	**CG**		1			1					

IMPOUNDED STATIONS												
SPECIES	**T.V.**	**F.F.G.**	**STA. 1**	**STA. 3**	**STA. 5**	**STA. 8**	**STA. 10**	**STA. 40**	**STA. 42**	**STA. 47**	**STA. 51**	**STA. 55**
Odonata												
Aeshnidae	**5.6**	**P**										
Boyeria vinosa	**5.97**	**P**								1		
Nasiaeschna pentacantha	**8.14**			1								
Coenagrionidae	***9**	**P**										
Argia sp.	**8.17**	**P**	4	1	1		1					
Corduliidae	***5**	**P**										
Macromia sp.	**6.16**	**P**	1							1		
Macromia alleghaniensis	**6.16**	**P**										1
Neurocordulia sp.	**5**			1					1			
Neurocordulia obsoleta	**5.2**											
Gomphidae	***1**	**P**										
Dromogomphus spinosus	**5.1**	**P**	1									
Gomphus sp.	**5.8**	**P**										
Hagenius brevistylus	**4**	**P**										
Progomphus sp.		**P**								1		
Libellulidae	**6.7**	**P**										
Pachydiplax longipennis	**9.9**				1			1				
Perithemis sp.	**9.9**	**P**	1									
Plecoptera												
Perlidae	***1**	**P**										
Acroneuria abnormis	**2.1**	**P**	1	1			2					
Acroneuria mela	**0.9**											
Neoperla sp.	**1.5**	**P**	2	1								
Perlesta placida sp. gp.	**4.7**	**P**	16	2	2	3	17		6	7		61
Perlesta sp.	**4.7**	**P**										
Perlodidae	***2**	**P**										
Isoperla sp.	***2**	**P**								10		1
Hemiptera							1		1			
Belostomatidae												
Belostoma sp.	**9.8**	**P**						1			14	
Corixidae	**9**	**PI**	1					13	1			
Trichocorixa sp.	**9.1**											
Gerridae												
Trepobates sp.											1	
Pleidae								1				
Neoplea sp.							1					
Paraplea sp.												
Naucoridae												
Pelocoris sp.	**7**											
Saldidae												
Veliidae		**P**										
Microvelia sp.		**P**								1		
Rhagovelia sp.		**P**										
Megaloptera												
Corydalidae		**P**										
Chauliodes pectinicornis	**9.6**	**P**				1		1				
Chauliodes sp.	***4**										4	
Sialidae		**P**										
Sialis sp.	**7.17**	**P**										
Trichoptera												
Hydropsychidae	***4**	**FC**		1								
Ceratopsyche sp.	***4**	**FC**										
Cheumatopsyche sp.	**6.2**	**FC**	1	7		2	4					
Hydropsyche sp.	**5**	**FC**	2									
Hydropsyche venularis	**5**	**FC**		13								
Hydroptilidae	***4**	**PI**										

IMPOUNDED STATIONS												
SPECIES	**T.V.**	**F.F.G.**	**STA. 1**	**STA. 3**	**STA. 5**	**STA. 8**	**STA. 10**	**STA. 40**	**STA. 42**	**STA. 47**	**STA. 51**	**STA. 55**
Trichoptera												
Hydroptila sp.	**6.2**	**PI**					1					
Leptoceridae	***4**	**CG**										
Nectopsyche sp.	**2.9**	**SH**										
Triaenodes sp.	**4.46**	**SH**					1					
Philopotamidae		**FC**										
Chimarra obscurus	**2.76**	**FC**										
Chimarra socia	**2.76**	**FC**										1
Lepidoptera												
Coleoptera												
Carabidae					1							2
Dryopidae												
Helichus basalis	***4**	**SC**					1					
Helichus sp.	**4.63**	**SC**										
Dytiscidae		**P**	1	1	1							
Coptotomus sp.	**9.26**						1	1				
Hydroporus sp.	**8.62**	**PI**	1	2	1			76	30	4	3	
Thermonectus sp.		**P**									1	
Elmidae		**CG**										
Ancyronyx variegata	**6.49**	**SC**		1			1			6		
Dubiraphia sp.	**5.93**	**SC**								1		
Dubiraphia vittata	**4.1**	**SC**										
Macronychus glabratus	**4.58**	**SH**				5	2			4		1
Stenelmis sp.	**5.1**	**SC**	2			1	2					2
Gyrinidae		**P**										
Dineutus sp.	**5.54**	**P**								12		
Gyrinus sp.	**6.17**	**P**										
Haliplidae												
Peltodytes sexmaculatus			1		1		1					
Peltodytes sp.	**8.73**	**SH**						2		2		
Hydrophilidae							1	2				1
Berosus sp.	**8.43**	**CG**			1		1					
Helochares sp.	***5**	**P**							1			
Hydrobius sp.	***5**	**P**										
Hydrochus sp.	**6.55**	**SH**						1			9	
Sperchopsis tesselatus	**6.13**	**CG**					1	5		2		
Tropisternus sp.	**9.68**	**P**									2	
Noteridae												
Hydrocanthus sp.							1					
Psephenidae		**SC**										
Ectopria sp.	***4**	**SC**			4							1
Psephenus herricki	**2.35**	**SC**										3
Scirtidae		**SC**					2	20			40	
Staphylinidae		**P**						7				
Diptera												
Ceratopogonidae	***5**	**P**					1			1		
Atrichopogon sp.	**6.49**	**P**		2								
Bezzia/Palpomyia gp.	**6.9**	**P**									1	
Chironomidae												
Ablabesmyia mallochi	**7.2**	**P**	13	11	18		20			5		15
Ablabesmyia rhamphe gp.	**7.2**	**P**	2									
Chironomus sp.	**9.63**	**CG**	56	3				27	5	50		10
Cladotanytarsus sp.	**4.09**	**FC**				4						
Conchapelopia sp.	**8.4**	**P**	2			1		1	1	2		1
Corynoneura sp.	**6.01**	**CG**				2	2	1		9		1
Cricotopus sp.	***7**	**CG**	1			8	22					4

IMPOUNDED STATIONS												
SPECIES	**T.V.**	**F.F.G.**	**STA. 1**	**STA. 3**	**STA. 5**	**STA. 8**	**STA. 10**	**STA. 40**	**STA. 42**	**STA. 47**	**STA. 51**	**STA. 55**
Diptera												
Cricotopus bicinctus	**8.5**	**CG**	6	2	4	13	23		3	45		20
Cricotopus tremulus	***8**	**CG**										
Cricotopus trifascia	**2.8**	**CG**								5		2
Cryptochironomus sp.	**6.4**	**P**								2		
Dicrotendipes sp.	**8.1**	**CG**									5	
Dicrotendipes neomodestus	**8.1**	**CG**	3	6	2	9	16			19		14
Labrundinia sp.	**5.9**	**P**										
Lopescladius sp.	**1.67**											
Nanocladius distinctus	**7.07**	**CG**					2					
Nilotanypus sp.	**3.9**	**P**										
Orthocladius lignicola	**5.4**	**CG**						1				
Paracladopelma sp.	**5.51**	**CG**										
Parakiefferiella sp.	**5.4**	**CG**	1			6	1	6		5		
Parametriocnemus sp.	**3.65**	**CG**					1					
Phaenopsectra punctipes gp.												
Polypedilum fallax	**6.4**	**SH**										
Polypedilum flavum	**4.9**	**SH**	3			8	1		1			24
Polypedilum halterale gp.	**9**	**SH**										1
Polypedilum illinoense	**7.3**	**SH**	6	27			21	3	1		10	8
Potthastia longimana	**9**	**CG**							1	5		
Procladius sp.	**9.1**	**P**	2	1				21		2		1
Rheocricotopus robacki	**7.3**	**CG**				1				2		
Rheotanytarsus sp.	**5.89**	**FC**				1						
Stenochironomus sp.	**6.45**	**SH**								14		
Synorthocladius semivirens	**4.36**	**CG**		1								
Tanytarsus sp.	**6.76**	**FC**	3	3	3	4	1	2	21	31		8
Thienemanniella xena	**5.86**	**CG**				32	7			66		1
Tribelos jucundum	**6.3**		3		1					2		
Tvetenia paucunca	**3.7**	**CG**								2		
Tvetenia vitracies	**3.6**	**CG**		1		1	1					
Zavrelimyia sp.	**9.11**	**P**										
Culicidae		**FC**										
Anopheles sp.	**8.6**	**FC**		1	1			3			3	
Culex sp.	**10**	**FC**						5			11	
Muscidae	**8.4**											2
Phoridae												
Simuliidae	***6**	**FC**										
Simulium sp.	**6**	**FC**	3									2
Tabanidae		**PI**						2				
Chrysops sp.	**6.73**	**PI**										
Tipulidae	***3**	**SH**					1					
Limonia sp.	**9.64**	**SH**										
Pseudolimnophila sp.	**7.22**	**P**							1			
Tipula sp.	**7.33**	**SH**					4	1				
TOTAL NO. OF ORGANISMS			**173**	**119**	**55**	**111**	**209**	**218**	**124**	**360**	**147**	**259**
TOTAL NO. OF TAXA			**40**	**32**	**20**	**24**	**48**	**35**	**23**	**49**	**17**	**42**
EPT INDEX			**15**	**14**	**6**	**5**	**13**	**2**	**1**	**7**	**0**	**14**
BIOTIC INDEX			**7.24**	**6.23**	**6.52**	**6.23**	**6.38**	**8.58**	**7.68**	**6.92**	**8.33**	**5.76**
ASSIGNED BIOTIC INDEX VALUE			**3.51**	**4.04**	**4.42**	**3.35**	**3.62**	**3.39**	**4.27**	**2.59**	**6.37**	**3.14**
EPT ABUNDANCE			**53**	**53**	**15**	**10**	**57**	**3**	**6**	**34**	**0**	**127**

REFERENCE STATIONS										
SPECIES	**T.V.**	**F.F.G.**	**STA. 12**	**STA. 14**	**STA. 18**	**STA. 19**	**STA. 39**	**STA. 45**	**STA. 52**	**STA. 53**
PLATYHELMINTHES										
Turbellaria										
Tricladida										
Dugesiidae			1							
Planariidae										
Girardia (Dugesia) tigrina	**7.2**						1			
NEMATODA	**6**		1							
MOLLUSCA										
Bivalvia										
Veneroida										
Corbiculidae										
Corbicula fluminea	**6.12**	**FC**	4			3		1		
Sphaeriidae	**6.6**	**FC**								
Musculium sp.	**7.5**	**FC**								
Pisidium sp.	**6.5**	**FC**								
Gastropoda										
Mesogastropoda										
Hydrobiidae	**5.78**	**SC**								
Amnicola limosus	**5.2**	**SC**					1			
Somatogyrus sp.	**6.4**	**SC**	10							
Pleuroceridae	**3.4**									
Elimia sp.	**2.46**	**SC**	13							
Viviparidae										
Campeloma sp.	***7**	**SC**					2			
Basommatophora										
Physidae										
Physella sp.	**8.8**	**CG**		1		1	3	1	1	
Planorbidae										
Menetus dilatatus	**8.2**	**SC**								
ANNELIDA										
Oligochaeta		**CG**								
Tubificida										
Lumbricidae		**CG**		1				8		
Naididae	***8**	**CG**								
Dero sp.	**10**	**CG**								
Tubificidae w.h.c.	**7.1**	**CG**						1		
Tubificidae w.o.h.c.	**7.1**	**CG**					1	1		
Branchiura sowerbyi	**8.28**	**CG**	1							
Limnodrilus hoffmeisteri	**9.5**	**CG**						1		
Lumbriculida										
Lumbriculidae	**7.03**	**CG**	5				1		2	1
Branchiobdellida			1		2					
Hirudinea		**P**							3	
Rhynchobdellida										
Glossiphoniidae		**P**								
Helobdella stagnalis	**8.6**	**P**								
ARTHROPODA										
Arachnoidea										
Acariformes										
Hygrobatidae										
Atractides sp.	**5.5**		2							
Crustacea										
Ostracoda			1							
Copepoda							1			
Cladocera										
Chydoridae										

REFERENCE STATIONS										
SPECIES	**T.V.**	**F.F.G.**	**STA. 12**	**STA. 14**	**STA. 18**	**STA. 19**	**STA. 39**	**STA. 45**	**STA. 52**	**STA. 53**
Chydorus sp.										
Daphnidae										
Ceriodaphnia sp.										
Isopoda										
Asellidae		**SH**								
Caecidotea sp.	**9.1**	**CG**		68			6		1	1
Amphipoda										
Crangonyctidae										
Crangonyx sp.	**7.9**	**CG**	2	2			1			1
Hyalellidae										
Hyalella azteca	**7.75**	**CG**				1				
Decapoda										
Cambaridae	**7.5**			1			1	2	4	1
Cambarus sp.	**7.62**	**CG**	3		3					
Orconectes sp.	**2.6**	**SH**		1						
Procambarus sp.	**7**	**SH**		1						
Palaemonidae										
Palaemonetes sp.	**7.1**	**CG**	2		1					
Insecta										
Collembola										
Ephemeroptera										
Baetidae		**CG**		2	1			2		
Baetis intercalaris	**7**	**CG**	12	1	1		1		10	
Baetis sp.	***4**	**CG**								1
Centroptilum sp.	**6.6**	**CG**	1	3	2	1	1		1	1
Plauditus sp.	***4**	**CG**	3	1						1
Pseudocloeon sp.	**4**	**CG**		1	2		7	6	1	
Caenidae		**CG**								
Brachycercus nitidus		**CG**								
Caenis sp.	**7.4**	**CG**	1							1
Ephemerellidae		**SC**								
Ephemerella sp.	**2.04**	**SC**						1	2	
Eurylophella sp.	**4.34**	**SC**						4		
Serratella sp.		**SC**	9	1	1					
Heptageniidae										
Leucrocuta sp.	**2.4**	**SC**	101	2	1				8	3
Maccaffertium (Stenonema) sp.	***4**	**SC**	40	17	19	2	2			
Maccaffertium (Stenonema) exigu	**3.8**	**SC**								
Maccaffertium (Stenonema) mode	**5.5**	**SC**							31	8
Stenacron interpunctatum	**3.58**	**SC**	6						1	1
Isonychiidae		**FC**								
Isonychia sp.	**3.5**	**FC**	10		1				3	
Leptophlebiidae	***2**	**CG**								
Paraleptophlebia sp.	**0.94**	**CG**							1	
Potamanthidae		**CG**								
Anthopotamus (Potamanthus) sp.	**1.5**	**CG**								
Anthopotamus (Potamanthus) myo	**1.5**	**CG**	1	1						
Tricorythidae	***4**	**CG**								
Tricorythodes sp.	**5.06**	**CG**				1			3	2
Odonata										
Aeshnidae	**5.6**	**P**								
Boyeria vinosa	**5.97**	**P**		1	2	1		3	2	
Nasiaeschna pentacantha	**8.14**			1						
Coenagrionidae	***9**	**P**								
Argia sp.	**8.17**	**P**	6		1	18			4	6
Corduliidae	***5**	**P**								
Macromia sp.	**6.16**	**P**	1		1	1			2	

REFERENCE STATIONS										
SPECIES	**T.V.**	**F.F.G.**	**STA. 12**	**STA. 14**	**STA. 18**	**STA. 19**	**STA. 39**	**STA. 45**	**STA. 52**	**STA. 53**
Odonata										
Macromia alleghaniensis	**6.16**	**P**								28
Neurocordulia sp.	**5**									
Neurocordulia obsoleta	**5.2**									2
Gomphidae	***1**	**P**		1	1					
Dromogomphus spinosus	**5.1**	**P**	1							3
Gomphus sp.	**5.8**	**P**	2							
Hagenius brevistylus	**4**	**P**			2				1	
Progomphus sp.		**P**								
Libellulidae	**6.7**	**P**								
Pachydiplax longipennis	**9.9**									
Perithemis sp.	**9.9**	**P**								
Plecoptera										
Perlidae	***1**	**P**	14	1					3	
Acroneuria abnormis	**2.1**	**P**								
Acroneuria mela	**0.9**		3							
Neoperla sp.	**1.5**	**P**	21	1		3			1	3
Perlesta placida sp. gp.	**4.7**	**P**	65	13	6		2	29	49	9
Perlesta sp.	**4.7**	**P**	34						9	
Perlodidae	***2**	**P**								
Isoperla sp.	***2**	**P**				1		6		2
Hemiptera										
Belostomatidae										
Belostoma sp.	**9.8**	**P**								
Corixidae	**9**	**PI**		2		3				
Trichocorixa sp.	**9.1**						3		27	
Gerridae										
Trepobates sp.										
Pleidae										
Neoplea sp.			1							
Paraplea sp.						9				
Naucoridae										
Pelocoris sp.	**7**			1		1				
Saldidae						1				
Veliidae		**P**								
Microvelia sp.		**P**			1					
Rhagovelia sp.		**P**	1							
Megaloptera										
Corydalidae		**P**								
Chauliodes pectinicornis	**9.6**	**P**								
Chauliodes sp.	***4**									
Sialidae		**P**								
Sialis sp.	**7.17**	**P**					6			
Trichoptera										
Hydropsychidae	***4**	**FC**	6	1						
Ceratopsyche sp.	***4**	**FC**	17						16	
Cheumatopsyche sp.	**6.2**	**FC**	23	4	1	1			36	8
Hydropsyche sp.	**5**	**FC**	10			1			4	
Hydropsyche venularis	**5**	**FC**								12
Hydroptilidae	***4**	**PI**								
Hydroptila sp.	**6.2**	**PI**	1	1		1				1
Leptoceridae	***4**	**CG**							1	
Nectopsyche sp.	**2.9**	**SH**			1					
Triaenodes sp.	**4.46**	**SH**				1			1	
Philopotamidae		**FC**								
Chimarra obscurus	**2.76**	**FC**	4							
Chimarra socia	**2.76**	**FC**								

REFERENCE STATIONS										
SPECIES	**T.V.**	**F.F.G.**	**STA. 12**	**STA. 14**	**STA. 18**	**STA. 19**	**STA. 39**	**STA. 45**	**STA. 52**	**STA. 53**
Lepidoptera				1						
Coleoptera										
Carabidae										
Dryopidae										
Helichus basalis	***4**	**SC**								
Helichus sp.	**4.63**	**SC**							2	1
Dytiscidae		**P**			3					
Coptotomus sp.	**9.26**					1				
Hydroporus sp.	**8.62**	**PI**				2	23		1	
Thermonectus sp.		**P**								
Elmidae		**CG**								
Ancyronyx variegata	**6.49**	**SC**	2		3	2		1	1	
Dubiraphia sp.	**5.93**	**SC**						3		
Dubiraphia vittata	**4.1**	**SC**								1
Macronychus glabratus	**4.58**	**SH**	3		6	6		4	1	5
Stenelmis sp.	**5.1**	**SC**	43	4				15	9	
Gyrinidae		**P**								
Dineutus sp.	**5.54**	**P**	1				3	2		
Gyrinus sp.	**6.17**	**P**					3			
Haliplidae										
Peltodytes sexmaculatus										
Peltodytes sp.	**8.73**	**SH**	1	1						
Hydrophilidae										
Berosus sp.	**8.43**	**CG**								
Helochares sp.	***5**	**P**								
Hydrobius sp.	***5**	**P**							1	
Hydrochus sp.	**6.55**	**SH**								
Sperchopsis tesselatus	**6.13**	**CG**				1	1		3	
Tropisternus sp.	**9.68**	**P**								
Noteridae										
Hydrocanthus sp.					1	1				
Psephenidae		**SC**								
Ectopria sp.	***4**	**SC**								
Psephenus herricki	**2.35**	**SC**	1							
Scirtidae		**SC**		1	3	12			2	
Staphylinidae		**P**	3	1	1	1				1
Diptera										
Ceratopogonidae	***5**	**P**				1		1		
Atrichopogon sp.	**6.49**	**P**				13				
Bezzia/Palpomyia gp.	**6.9**	**P**							1	
Chironomidae										
Ablabesmyia mallochi	**7.2**	**P**	12	2	1				15	8
Ablabesmyia rhamphe gp.	**7.2**	**P**								
Chironomus sp.	**9.63**	**CG**		41			7	24	11	
Cladotanytarsus sp.	**4.09**	**FC**								
Conchapelopia sp.	**8.4**	**P**					2		7	
Corynoneura sp.	**6.01**	**CG**	2				3	3	1	
Cricotopus sp.	***7**	**CG**		9	2	1		1		
Cricotopus bicinctus	**8.5**	**CG**	2	7	2			3	16	1
Cricotopus tremulus	***8**	**CG**	1	1						
Cricotopus trifascia	**2.8**	**CG**	1							
Cryptochironomus sp.	**6.4**	**P**								
Dicrotendipes sp.	**8.1**	**CG**								
Dicrotendipes neomodestus	**8.1**	**CG**	1	2	3	2			8	4
Labrundinia sp.	**5.9**	**P**					1			
Lopescladius sp.	**1.67**						1			
Nanocladius distinctus	**7.07**	**CG**					1	1		

REFERENCE STATIONS										
SPECIES	**T.V.**	**F.F.G.**	**STA. 12**	**STA. 14**	**STA. 18**	**STA. 19**	**STA. 39**	**STA. 45**	**STA. 52**	**STA. 53**
Diptera										
Nilotanypus sp.	**3.9**	**P**	2							
Orthocladius lignicola	**5.4**	**CG**								
Paracladopelma sp.	**5.51**	**CG**							1	
Parakiefferiella sp.	**5.4**	**CG**		1				23		
Parametriocnemus sp.	**3.65**	**CG**					4		8	
Phaenopsectra punctipes gp.									1	
Polypedilum fallax	**6.4**	**SH**							1	
Polypedilum flavum (convictum)	**4.9**	**SH**	5	3		1	1		14	3
Polypedilum halterale gp.	**9**	**SH**								
Polypedilum illinoense	**7.3**	**SH**	3	5	11	18	1	1	2	26
Potthastia longimana	**9**	**CG**								
Procladius sp.	**9.1**	**P**		1			3			
Rheocricotopus robacki	**7.3**	**CG**		1			2	2		
Rheotanytarsus sp.	**5.89**	**FC**					2		1	
Stenochironomus sp.	**6.45**	**SH**								1
Synorthocladius semivirens	**4.36**	**CG**								
Tanytarsus sp.	**6.76**	**FC**	1	1			12	2	14	1
Thienemanniella xena	**5.86**	**CG**	14	1	1				12	2
Tribelos jucundum	**6.3**			1			1			
Tvetenia paucunca	**3.7**	**CG**	2					2		
Tvetenia vitracies	**3.6**	**CG**	3		1			1	4	
Zavrelimyia sp.	**9.11**	**P**					1			
Culicidae		**FC**								
Anopheles sp.	**8.6**	**FC**				2		1		
Culex sp.	**10**	**FC**							1	
Muscidae	**8.4**									
Phoridae						1				
Simuliidae	***6**	**FC**								
Simulium sp.	**6**	**FC**	3		1		2	1		2
Tabanidae		**PI**								
Chrysops sp.	**6.73**	**PI**		1						
Tipulidae	***3**	**SH**				1				
Limonia sp.	**9.64**	**SH**				1				
Pseudolimnophila sp.	**7.22**	**P**								
Tipula sp.	**7.33**	**SH**							6	1
TOTAL NO. OF ORGANIMS			**546**	**216**	**89**	**118**	**114**	**157**	**372**	**153**
TOTAL NO. OF TAXA			**61**	**47**	**34**	**37**	**37**	**33**	**56**	**36**
EPT INDEX			**21**	**15**	**11**	**9**	**5**	**6**	**19**	**14**
BIOTIC INDEX			**4.29**	**7.62**	**5.50**	**6.75**	**7.18**	**5.93**	**6.05**	**5.99**
ASSIGNED BIOTIC INDEX VALUE			**2.02**	**2.81**	**4.09**	**4.68**	**4.74**	**3.37**	**3.22**	**3.19**
EPT ABUNDANCE			**382**	**50**	**36**	**12**	**13**	**48**	**181**	**53**

T.V. = tolerance value
F.F.G. = feeding group (see below)

FC = filtering/collector
SC = scraper
CG = collector/gatherer
P = predator
SH = shredder
PI = piercer

APPENDIX C: CARBONTON DAM REMOVAL YEAR-1 FISH MONITORING REPORT PROVIIDED BY THE CATENA GROUP

The Catena Group

410-B Millstone Drive
Hillsborough, NC 27278
(919) 732-1300

CARBONTON DAM REMOVAL YEAR-1 MONITORING REPORT

Deep River Watershed Restoration Site Cape Fear River Basin Catologing Unit 030300003

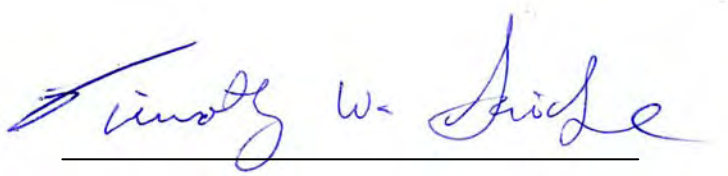
Prepared For:

Restoration Systems LLC

Prepared By:

The Catena Group
Hillsborough, North Carolina

September 06, 2006



Timothy W. Savidge

EXECUTIVE SUMMARY

The Carbonton dam removal project on the Deep River within the Cape Fear River Basin carried out by Restoration Systems LLC (RS) is projected to result in the restoration of more than 9.5 river miles (RM) of the mainstem Deep River, as well as significant portions of three major tributaries, McLendons Creek, Big Governors Creek and Little Governors Creeks, and fifteen smaller tributaries. The project is anticipated to restore significant habitat for the federally Endangered Cape Fear shiner *(Notropis mekistocholas)*, several species of rare mussels, and other riverine aquatic species, in addition to serving as a mitigation bank for future activities within the Cape Fear River Basin.

Based on the restoration success criteria established by the interagency Dam Removal Task Force (DRTF) and the goals of RS, documenting the effectiveness of the restoration initiative required that the aquatic fauna that occurred within the reservoir pool be identified and then monitored for changes in composition after the dam is removed. The Catena Group Inc. (TCG) was retained by RS in 2005 to conduct pre-removal aquatic species surveys at selected locations within the former reservoir pool, as well as at a number of upstream and downstream locations.

A stated goal of the dam removal project is to reconnect the two isolated populations of the Cape Fear shiner in the Deep River by restroing the habitat inbetween. Changes in fish community composition in response to dam removal will also be evaluated as part of the dam removal project. The Cape Fear shiner is the main target species for this study. Other riffle adapted species will serve as surrogate species to demonstrate habitat restoration success. The purpose of the pre-removal surveys was to inventory aquatic communities occurring within the former impounded reach prior to removal, as well as establishing “targeted aquatic communities” (TACs) by sampling locations outside of the impoundment effects. The aquatic fauna sampled include freshwater mussels and clams, aquatic snails and freshwater fish. A total of seventeen sites were sampled during this effort. Based on various habitat features, two TACs were established for the Deep River as well as one each for McLendons Creek and Big Governors Creek. These TACs reflect a desired faunal structure to develop in the restored habitats following dam removal.

A five-year monitoring plan has been initiated to evaluate the success of the dam removal. Molluscan fauna will be monitored beginning in year four post removal when the anticipated recruitment of freshwater mussels into the restored habitats will be visible. Fish community surveys were conducted during the first year following removal. TCG was retained by RS in 2006 to conduct the Year-1 post-removal monitoring studies. This plan involves conducting aquatic species surveys at the six stations within the former reservoir pool that were sampled during the pre-removal surveys, as well as nine other sites selected (based on field observations) during Year-1 monitoring surveys.

The Year-1 monitoring survey effort consisted of two components: 1) habitat reconnaissance of the former impounded reach of the Deep River as well as Big

Governors Creek and McLendons Creek, and 2) fish surveys at the fifteen identified stations. Very brief surveys (≤5 minutes per site) were conducted for freshwater mussels in these newly formed riffle habitats.

General observations of in-stream habitat conditions and bank stability were recorded throughout the former reservoir pool. Fish surveys were conducted in areas in which riffles have formed, or are in the process of forming, and the locations were logged via GPS. These areas, along with the six sites chosen during the pre-removal surveys, will become the permanent survey stations for the five-year monitoring.

A combination of seine netting and hand-held dip netting, visual observations and hook and line methods were used to document fish species. Seine netting was the primary method used to sample fish, as it is the most effective survey method for the targeted Cape Fear shiner.

Based on field observations and fish surveys, it appears that the habitats within the former reservoir pool created by the Carbonton Dam are in the process of reverting to lotic conditions. Riffle/run/pool habitats have formed, or appear to be in the process of forming, at varying intervals throughout the former impounded reaches.

At least 11 substantial riffle habitats have developed within the Deep River, and one within Mclendons Creek. Morphological features at many of these sites have created various hydraulic conditions and in turn, multiple microhabitats which correspond to potentially high quality habitat for aquatic species, including the targeted Cape Fear shiner and various rare mussel species such as the brook floater (*Alasmidonta varicosa*). Cursory surveys for freshwater mussels indicate that mussels are generally absent from the restored riffle habitats, but are present along the banks of the river in areas that are still wetted. This confirms the results of the pre-removal mussel surveys in 2005, which demonstrated presence of mussels in the former reservoir pool primarily in the banks. It is anticipated that mussel recruitment into these areas will occur and should be evident four to five years post removal.

Two fairly long reaches of the river are dominated by relatively homogonous pool habitats of 2.5 kilometers (1.5 miles) and 2.7 kilometers (1.7 miles) respectively in length. It is not clear if riffle habitats will develop in these reaches. These long pools, which offer high quality recreational largemouth bass fishing opportunities, may be natural features of the river in these reaches.

The results of the fish surveys demonstrate that riffle-adapted species have colonized much of the newly restored riffle habitats. Moderate to deep run habitats were also observed at various locations, which are also expected to provide quality habitats for various lotic-adapted fish and freshwater mussel species. A total of twenty fish species were collected at the fifteen sites sampled. The targeted Cape Fears shiner was not located at any of the survey sites during the Year-1 post removal monitoring. However, favorable habitat conditions for this species appear to be developing at least five

locations. Additionally, at least nine of the fifteen sampled sites appear to have fish faunal components approaching those of their respective targeted sites.

The results of the Year-1 monitoring fish survey demonstrate successful restoration of lotic conditions within the former reservoir pool in the Deep River and McLendons Creek. Numerous riffle-adapted species were found in relatively high densities at various localities throughout the surveyed reach. Although these riffle-adapted species serve as surrogate species to demonstrate habitat restoration success, efforts to document recruitment of Cape Fear shiner into these areas, as well as increase in species richness should continue as part of the five-year monitoring plan. Significant riffle habitats are unlikely to develop in Big Governors Creek, and colonization by the Cape Fear shiner is even more unlikely due in part to the natural conditions of this creek. Therefore, restoration success criteria for this stream should not be based on presence of riffle-adapted species, or the Cape Fear shiner. An increase in species diversity overtime is thus a better measure of success with this stream.

TABLE OF CONTENTS

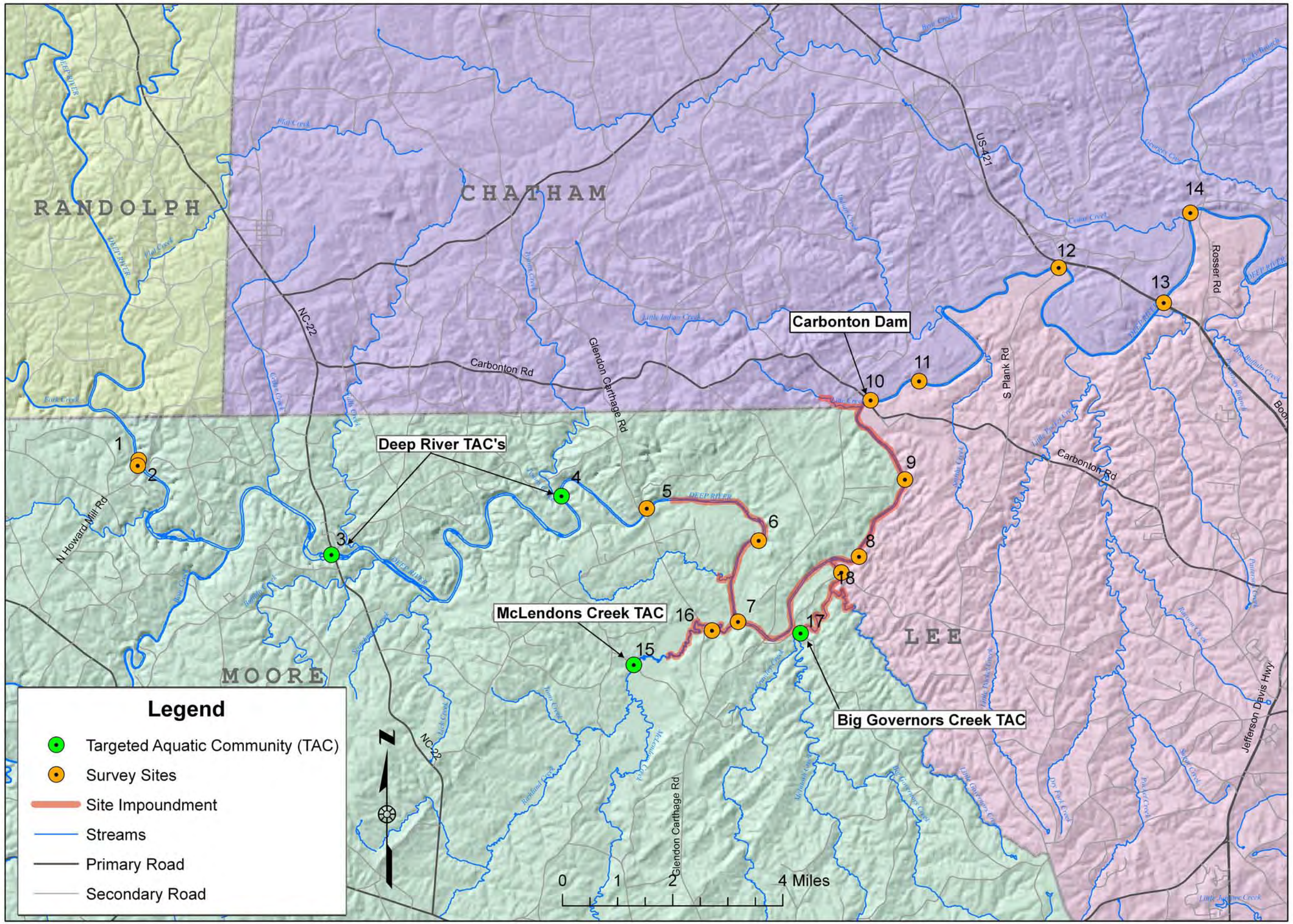
LIST OF TABLES

1.0 INTRODUCTION

The removal of the Carbonton dam on the Deep River by Restoration Systems LLC (RS) is projected to result in the restoration of more than 9.5 river miles (RM) of the mainstem Deep River, as well as significant portions of three major tributaries, McLendons Creek, Big Governors Creek and Little Governors Creeks, and fifteen smaller tributaries within the Cape Fear River Basin. The project is anticipated to restore significant habitat for the federally Endangered Cape Fear shiner *(Notropis mekistocholas)*, several species of rare mussels, and other riverine aquatic species, in addition to serving as a mitigation bank for future activities within the Cape Fear River Basin.

Based on the restoration success criteria established by the interagency Dam Removal Task Force (DRTF) and the goals of RS, documenting the effectiveness of the restoration initiative required that the aquatic fauna within the project area be documented prior to the dam removal and then monitored for changes in composition after the removal. The Catena Group Inc. (TCG) was retained by RS in 2005 to conduct pre-dam removal aquatic species surveys at selected localities in the Deep River within the former reservoir pool created by Carbonton Dam, as well as at upstream and downstream locations. Aquatic fauna sampled included freshwater mussels and clams, aquatic snails, and freshwater fish. The results of the pre-removal surveys were presented in a report submitted to RS on August 07, 2006 (Pre-removal Surveys Report) and included as Appendix A in this report.

A stated goal of the dam removal project is to restore the habitat within the Deep River and its tributaries formerly impounded by the Carbonton dam to lotic conditions, thus reconnecting the two isolated populations of the Cape Fear shiner. Changes in fish community composition in response to dam removal will also be evaluated as part of the dam removal project. The Cape Fear shiner is the main target species for this study. Other riffle adapted species will serve as surrogate species to demonstrate habitat restoration success. The purpose of the pre-removal surveys was to inventory aquatic communities occurring within the former impounded reach prior to removal, as well as establishing “targeted aquatic communities” (TACs) by sampling locations outside of the impoundment effects. A total of seventeen sites were sampled during this effort (Figure 1). Based on various habitat features, two TACs (Site 3 and Site 4) were established for the Deep River (Figure 1), as well as one each for McLendons Creek (Site 15 Figure 1), and Big Governors Creek (Site 17 Figure 1). These TACs reflect a desired faunal structure to develop in the restored habitats following dam removal. The species occurring at these respective TACs are depicted in Tables 1-4 and are discussed in further detail in Section 4.0.



The Catena Group

Date: October 2006

Scale: As Shown

Job No.: 3146

Title:

Carbonton Dam Survey Location Map

Chatham, Moore, and Lee Counties, North Carolina

Client:

Restoration Systems, LLC

Figure

1

Targeted Aquatic Community 1.

This site corresponds to Site 3 in the Pre-removal Surveys Report (Appendix A) and occurs in the vicinity of the NC 22 crossing of the Deep River. The site is characterized by a series of small vegetated islands with multiple channels. Substrate consists of boulders and cobble, with accumulations of gravel in the shallow runs. Large water willow beds are present throughout the site.

Table 1. Targeted Aquatic Community 1 (Pre-removal Surveys Site 3) Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	**~**	**#/CPUE**
Alasmidonta undulate	triangle floater	1 (0.33/hr)
Alasmidonta varicose	brook floater	4 (2/hr)
Elliptio complanata	eastern elliptio	358 (119.33/hr)
Strophitus undulatus	creeper	2 (0.67/hr)
Toxolasma pullus	Savannah liliput	1 (0.33/hr)
Unimoerus carolinianus	Florida pondhorn	7 (2.33/hr)
Villosa delumbis	Eastern creekshell	18 (6.0/hr)
Freshwater Snails and Clams	**~**	**Relative Abundance**
Campeloma decisum	pointed campeloma	Uncommon
Corbicula fluminea	Asian clam	Abundant
Elimia catenaria	gravel elimia	Abundant
Helisoma anceps	two-ridge rams horn	patchy uncommon
Freshwater Fish	**~**	**Relative Abundance**
Ameiurus natalis	yellow bullhead	rare (2)
Etheostoma flabellare	fantail darter	Common
Etheostoma olmstedi	tesseslated darter	Uncommon
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis cyanellus	green sunfish	Uncommon
Lepomis macrochirus	bluegill	Common
Minytrema melanops	spotted sucker	very abundant
Moxostoma pappillosum	V-lip redhorse	rare (1)
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Common
Notropis altipinnis	highfin shiner	Uncommon
Notropis hudsonius	spottail shiner	Common
Notropis mekistocholas	Cape Fear shiner	very abundant (>100)
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Common
Notorus insignis	margined madtom	Common
Percina crassa	Piedmont darter	Common
Scartomyzon sp. nov.	brassy jumprock	rare (1)

Targeted Aquatic Community 2.

This site corresponds to Site 11 in the Pre-removal Surveys Report (Appendix A) and represents the first major riffle/run habitat below the former Carbonton dam. The river is relatively narrow at this site and habitat is dominated primarily by riffle/run habitat with swift flow in shallow to moderate depth. Although habitat complexity at this site is less

than the Targeted Aquatic Community 1 site (Table 1), this habitat type is common throughout the un-impounded portions of the Deep River, and represents an important component of a free-flowing river system. Substrate is dominated by cobble, gravel, and sand with silt-clay banks. Areas of exposed bedrock were also present.

Table 2. Targeted Aquatic Community 2 (Pre-removal Surveys Site 11) Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	~	**#/CPUE**
Elliptio complanata	Eastern elliptio	109 (20.8/hr)
Elliptio icterina	variable spike	2 (0.38/hr)
Elliptio producta	Atlantic spike	5 (0.95/hr)
Elliptio roanokensis	Roanoke slabshell	5 (0.95/hr)
Lampsilis cariosa	yellow lampmussel	1 (0.2/hr)
Elliptio sp.	lanceolate elliptio	6 (1.14/hr)
Uniomerus caroliniana	Florida pondhorn	23 (4.4/hr)
Villosa delumbis	Eastern creekshell	3 (0.57/hr)
Freshwater Snails and Clams	**~**	**Relative Abundance**
Corbicula fluminea	Asian clam	Common
Campeloma decisum	pointed campeloma	Common
Freshwater Fish	~	**Relative Abundance**
Cyprinella nivea	whitefin shiner	Uncommon
Etheostoma olmstedi	tesseslated darter	Uncommon
Lepomis macrochirus	bluegill	Rare
Micropterus salmoides	largemouth bass	Rare
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Common
Notropis altipinnis	highfin shiner	Uncommon
Notropis hudsonius	spottail shiner	Uncommon
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Common
Percina crassa	Piedmont darter	Common

Targeted Aquatic Community 3 (McClendons Creek).

This site corresponds to Site 15 in the Pre-removal Survey Report (Appendix A), and is surrounded by a wide forested floodplain that is easily accessed by the stream. The stream is approximately 10-12 meters wide with very stable, vegetated banks. Substrate is dominated by sand and gravel with an occasional rock outcrop present.

Table 3. Targeted Aquatic Community 3 (Pre-removal Surveys Site 15) Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Elliptio complanata	Eastern elliptio	286 (88.90/hr)
Elliptio icterina	variable spike	3 (0.85/hr)
Elliptio producta	Atlantic spike	2 (0.57/hr)
Uniomerus caroliniana	Florida pondhorn	1 (0.28/hr)
Villosa delumbis	Eastern creekshell	3 (0.85/hr)
Freshwater Snails and Clams	~	**Relative Abundance**

Corbicula fluminea	Asian clam	Common
Sphaerium sp.	a fingernail clam	Common
Freshwater Fish	~	**Relative Abundance**
Etheostoma olmstedi	tesseslated darter	Common
Lepomis macrochirus	bluegill	Rare
Luxilus albeolus	white shiner	Abundant
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Uncommon
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Uncommon
Notropis procne	swallowtail shiner	Abundant
Percina crassa	Piedmont darter	Common

Targeted Aquatic Community 4 (Big Governors Creek).

This site corresponds to Site 17 in the Pre-removal Survey Report (Appendix A). This section of Big Governors Creek occurs in a wide, low-lying floodplain near the Underwood Road crossing. While the site is outside of the recognized former impoundment area, the stream appears as slow moving slackwater, with only one 'riffle' area observed downstream of the road crossing (likely result of construction rip-rap). Substrate is dominated by gravel and mud, with a high concentration of detritus and woody debris. No shiner species were located during the fish surveys; however, fish species typically associated with slow-moving swampy streams, such as the redfin pickerel and sawcheek darter, were found only at this site.

Table 4. Targeted Aquatic Community 4 (Pre-removal Surveys Site 17) Species Found

Scientific Name	Common Name	Abundance/CPUE
Freshwater mussels	~	**CPUE**
Elliptio complanata	Eastern elliptio	40 (17.7/hr)
Elliptio icterina	variable spike	2 (0.89/hr)
Freshwater snails and clams	~	**Relative Abundance**
Corbicula fluminea	Asian clam	Uncommon
Campeloma decisum	pointed campeloma	Common
Hydrobiidae	Hydrobid snail	Rare
Freshwater fish	~	**Relative Abundance**
Esox americanus	redfin pickerel	Common
Etheostoma olmstedi	tesseslated darter	Common
Etheostoma serriferum	Sawcheek darter	Uncommon
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Uncommon
Nocomis leptocephalus	bluehead chub	Common

A five-year monitoring plan has been initiated to evaluate the success of the dam removal. This plan involves conducting aquatic species surveys at the six stations within the former reservoir pool that were sampled during the pre-removal surveys (Table 5, Figure 1), as well as other sites selected (based on field observations) during Year-1 monitoring surveys.

Table 5. Pre-removal Survey Locations within Reservoir Pool-Carbonton Dam

TCG Pre-removal Site #	Site Location	GPS Location
6	Deep River (impoundment)	35.48269ºN, -79.38307ºW
7	Deep River (impoundment)	35.46126ºN, -79.38965ºW
8	Deep River (impoundment)	35.47855ºN, -79.35072ºW
9	Deep River (impoundment)	35.49891ºN, -79.33601ºW
16	McLendons Creek (impoundment)	35.45894ºN, -79.39803ºW
18	Big Governors Creek (impoundment)	35.47434ºN, -79.3564ºW

Survey methodologies used during the monitoring surveys were the same as those used for the pre-removal surveys. Changes in freshwater mussel fauna resulting from dam removal will likely not be evident for at least four years post removal because of their life histories. Thus, these sites will be not be monitored for mussels and other mollusks (snails and clams) until four years post removal when recruitment of freshwater mussels into the restored habitats will be visible. The results of the Year-4 monitoring will determine if future monitoring is warranted. It was determined that fish surveys would be conducted during the first year following removal. Documentation of Cape Fear shiner recruitment into the former impounded reach of the river is a primary measure of restoration success. However, success criteria also includes establishment of similar fish faunal composition between the sampled sites within the former impoundment and their respective assigned TACs following dam removal. Success is not necessarily measured by having the exact species as the assigned TAC, rather to have similar number of species that occupy similar niches (i.e. similar number of darter, shiner and sunfish species). The results of the Year-1 monitoring are presented in this report and will factor into the decision for future monitoring intervals.

2.0 SURVEY EFFORTS

Fish surveys were conducted in August 2006, for the Year-1 monitoring at all of these sites listed in Table 5, with the exception of TCG Site 9 (too deep to adequately survey) by the following personnel from The Catena Group on the listed dates:

Tom Dickinson – August-21, 22
James Freeze* – August-23
Jonathan Hartsell – August-22
Fred C. Rhode Ph.D* – August-21
Daniel Savidge* – August-23
Tim Savidge – August 22, 23
Chris Sheats - August 21
Michael Wood – August 23
*** Contracted by TCG to assist field crew**

In addition to the monitoring stations established during the pre-removal surveys (Table 5), nine additional sites were selected for monitoring during the August 2006 surveys based on presence of habitat conditions that appeared to be most suitable for the targeted Cape Fear shiner. In total, 15 sites (6 selected during pre-removal surveys and 9 selected

during Year-1 monitoring) have been established as permanent monitoring stations (Table 6 and Figure 2).

Table 6. Permanent Monitoring Survey Locations-Carbonton Dam Reservoir Pool

Year-1 Site #	Corresponding TCG Pre-removal Site #	Site Location	GPS Location
1	--	Deep River (impoundment)	35.49298ºN, -79.41518ºW
2	--	Deep River (impoundment)	35.48996ºN, -79.38668ºW
3	6	Deep River (impoundment)	35.48269ºN, -79.38307ºW
4	--	Deep River (impoundment)	35.46404ºN, -79.39042ºW
5	7	Deep River (impoundment)	35.46126ºN, -79.38965ºW
6	--	Deep River (impoundment)	35.45722ºN, -79.38024ºW
7	--	Deep River (impoundment)	35.47221ºN, -79.36856ºW
8	--	Deep River (impoundment)	35.47767ºN, -79.36000ºW
9	8	Deep River (impoundment)	35.47855ºN, -79.35072ºW
10*	9	Deep River (impoundment)	35.49891ºN, -79.33601ºW
11	--	Deep River (impoundment)	35.50792ºN, -79.34282ºW
12	--	Deep River (impoundment)	35.51258ºN, -79.34925ºW
13	--	Deep River (impoundment)	35.51962ºN, -79.34761ºW
14	16	McLendons Creek (impoundment)	35.45894ºN, -79.39803ºW
15	18	Big Governors Creek (impoundment)	35.47434ºN, -79.3564ºW

*not sampled during year-1 monitoring due to water depth
-- No corresponding pre-removal site number

2.1 Methodology

The Year-1 monitoring survey effort consisted of two components: 1) habitat reconnaissance of the former impounded reach of the Deep River as well as Big Governors Creek and McLendons Creek, and 2) fish surveys at the fifteen stations depicted in Figure 2. Very brief surveys (≤5 minutes per site) were conducted for freshwater mussels in these newly formed riffle habitats.

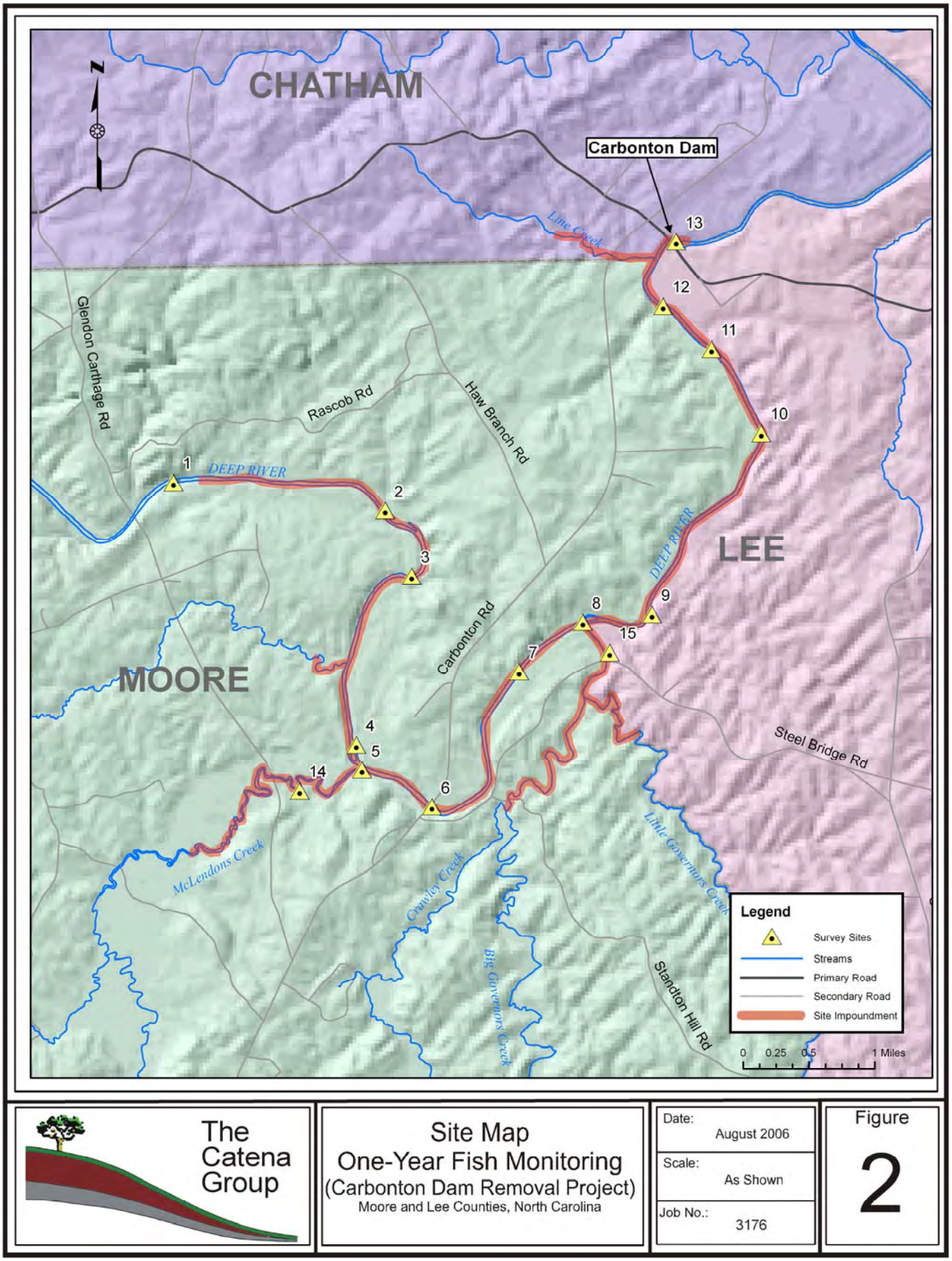
2.1.1 Habitat Reconnaissance

Habitat reconnaissance was conducted in the entire reach of the Deep River within the former reservoir pool by canoeing from the upper limits of the pool downstream to the former dam site. Observations of in-stream habitat conditions and bank stability were recorded. Fish surveys were conducted in areas in which riffles have formed, or are in the process of forming, and the locations were logged via GPS. These areas, along with the six sites chosen during the pre-removal surveys, will become the permanent survey stations for the five-year monitoring protocol (Table 6 and Figure 2).

2.1.2 Fish Sampling

In recognition of the "Collection Sensitive Waters" designation of the Deep River by the North Carolina Wildlife Resources Commission (WRC), electro-fishing methods were not employed. A combination of seine netting and hand-held dip netting, visual observations and hook and line methods were used to document fish species. The survey team began at the downstream point of the survey site and proceeded upstream. Seine netting was the primary method used to sample fish, as it is the most effective survey method for the targeted Cape Fear shiner. Two people pulled the seine net upstream through the survey site, while a third person herded fish into the net by walking downstream towards the seine while kicking the substrate. This process was performed in the middle of the channel and close to each bank in order to survey the entire habitat. This method was effective in riffle and run habitats of shallow to moderate depths as well as shallow pools, but was fairly ineffective in deep runs and wide deep pools. Other sample methods included capturing fish in hand held dip nets against shoreline or bottom structure as well as hook and line surveys.
All captured fish were placed into a water bucket until they could be identified, counted, and released. The length of time necessary to identify, count, and release the fish depended upon the number of fish in the bucket and their condition. Any fish that did not recover from the sampling were preserved in 95% ethanol. Habitat notes were recorded at each collection site. A relative abundance was assigned to each species captured or observed at each site.

Hook and line fishing with artificial baits was also employed at a few locations. This was not a primary method of sampling and was mainly used while conducting habitat reconnaissance and accessing survey sites. It did not produce any species that were not detected using other sampling methods. However, it did demonstrate that high quality recreational fishing opportunities for largemouth bass (*Micropterus salmoides*) and various sunfishes (*Lepomis* spp.) still occur throughout the former reservoir pool.



The Catena Group

Site Map
One-Year Fish Monitoring
(Carbonton Dam Removal Project)
Moore and Lee Counties, North Carolina

Date: August 2006
Scale: As Shown
Job No.: 3176

Figure 2

3.0 RESULTS

Based on field observations and fish surveys, it appears that the habitats within the former reservoir pool created by the Carbonton Dam are in the process of reverting to lotic conditions. Riffle/run/pool habitats have formed, or appear to be in the process of forming, at varying intervals throughout the former impounded reaches. Fifteen of these areas were selected as sampling sites.

3.1 Habitat Reconnaissance

General habitat reconnaissance of the Deep River and McLendons Creek indicate that riffle/run habitats have developed, or are in the process of developing within the former reservoir pool. It is unclear whether riffles will form at sites 9 and 10 (Figure 2) within the Deep River, and at Site 15 in Big Governors Creek. Currently sites 9 and 10 can be characterized as deep runs with substantial flow over rocky substrate. Numerous other areas with similar characteristics (deep rocky runs) were also observed throughout the Deep River, but were not marked, or recorded, as the intent of the habitat reconnaissance was to mark the riffle areas.

Currently habitat at Site 15 and throughout Big Governors Creek is predominately composed of slack-water pools, deep-moderate runs with sluggish flow, and very limited riffle habitat. Similar habitat conditions were observed during the pre-removal surveys conducted in 2005 in Big Governors Creek upstream of the reservoir pool (Site 17 in the Pre-removal Survey Report/Appendix A), suggesting that Big Governors Creek is naturally a sluggish stream with limited riffle habitats.

Cursory surveys for freshwater mussels indicate that mussels are generally absent from the restored riffle habitats, but are present along the banks of the river in areas that are still wetted. This confirms the results of the pre-removal mussel surveys in 2005, which demonstrated presence of mussels in the former reservoir pool primarily in the banks (Appendix A).

Two fairly long reaches of the river are dominated by relatively homogonous pool habitats. These occur between sites 3 and 4 and sites 9 and 10 (Figure 2) and are 2.5 kilometers (1.5 miles) and 2.7 kilometers (1.7 miles) respectively in length. Several largemouth bass were captured using hook and line while canoeing through this section of river. Additionally, numerous longnose gar (*Lepisosteus osseus*), various sunfishes, gizzard shad (*Dorosoma cepedianum*) and large schools of large-bodied redhorse (*Moxostoma* spp.) were observed in these reaches.

In general, vegetation has colonized the newly exposed river banks fairly quickly following dam removal and overall the banks appear to be stable with very little scour and erosion noted. The exception to this occurs in the lower reach of the former impoundment between sites 12 and 13 (Figure 2) in the general vicinity of WRC boat landing where patches of moderate stream-bank erosion and scour were observed.

3.2 Fish Surveys

A total of twenty fish species were collected at the fifteen sites sampled. Relative abundance for fish were estimated using the following criteria:

- Very abundant: > 30 collected at survey station
- Abundant: 15-30 collected at survey station
- Common: 6-15 collected at survey station
- Uncommon: 3-5 collected at survey station
- Rare: 1-2 collected at survey station

It should be noted that relative abundances of particular species can be affected by the survey methodologies, and thus some species, particularly those that are found in deeper pools and runs, and those that can seek cover quickly may be underrepresented at a sample site. Survey results for each site are further described below.

3.2.1 Site 1 (Deep River-Impoundment):

This sampling station occurs near an apparent old mill site. Some of the material (rock and timbers) from the old dam remain in the river, and a riffle run sequence of approximately 30 meters (98 feet) in length has formed. The substrate is dominated by rock (from the dam) and cobble. Coarse sand and gravel have accumulated in the shallow areas at the head and base of the riffle. A small cobble-gravel bar has formed between the center of the channel and the right descending bank creating a hydraulic break, and is beginning to be colonized by various species of herbaceous and woody vegetation. The spottail shiner (*Notropis hudsonius*) and sandbar shiner (*N. scepticus*) were very abundant in the swift current of the riffle, and largemouth bass were abundant in the pool above the riffle and in the run at the base of the riffle. Although some of the habitat complexity present at this site is of artificial origin (mill dam), over time, the anticipated aquatic community is expected to develop and be similar to the TAC 1 (Table 1).

Table 7. Site 1: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesselated darter	Uncommon
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Abundant
Notropis altipinnis	highfin shiner	Uncommon
Notropis hudsonius	spottail shiner	Very Abundant
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Common

A total of nine species were found at this site compared to eighteen found at the target site (TAC 1), suggesting that this site needs to develop further to meet the targeted fish

fauna. However, many lotic species such as highfin shiner, Piedmont darter, sandbar shiner, spottail shiner and swallowtail shiner have colonized this site. Seven species, bluegill, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner and tessellated darter are shared with the TAC 1 site. Species richness is expected to increase at this location over time as the habitat continues to develop.

3.2.2 Site 2 (Deep River-Impoundment):

This site is situated within a long riffle/pool/riffle run sequence, with a rocky/cobble island bar being formed near the center of the river creating a side channel along the right descending bank. The substrate is dominated by cobble and gravel overlain with coarse sand. A variety of habitat conditions occur at this site which was one of the most species rich sites sampled during this effort. Eastern mosquitofish (*Gambusia hollbrokii*) and speckled killifish (*Fundulus rathbuni*) were common in the shallow pools formed on the island bar, four shiner species, two darter species, one chub and one redhorse species were captured in the riffles, and largemouth bass, longnose gar, and two sunfish species were captured and/or observed in the pool habitats present. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 1 (Table 1).

Table 8. Site 2: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesseslated darter	Uncommon
Fundulus rathbuni	speckled killifish	Common
Gambusia holbrookii	Eastern mosquitofish	Common
Lepiostteus osseus	longnose gar	Uncommon
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Common
Moxostoma pappillosum	V-lip redhorse	Common
Nocomis leptocephalus	bluehead chub	Common
Notropis altipinnis	highfin shiner	Common
Notropis amoenus	comely shiner	Rare
Notropis hudsonius	spottail shiner	Uncommon
Notropis scepticus	sandbar shiner	Abundant
Percina crassa	Piedmont darter	Common

A total of fourteen species were found at this site compared to eighteen found at the target site (TAC 1), suggesting that this site is transitioning toward the targeted fish fauna. Many lotic species such as bluehead chub, comely shiner, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, and V-lip redhorse have colonized this site. Nine species, bluegill, bluehead chub, Eastern mosquitofish, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, tessellated darter and V-lip redhorse are shared with the TAC 1 site.

3.2.3 Site 3 (Deep River-Impoundment):

This site corresponds to Site 6 (Deep River Impoundment 1) sampled during the pre-removal surveys in 2005 (Appendix A). The site was selected prior to dam removal due

to the presence of large rock outcroppings. Since dam removal, much more of the rock outcropping is exposed and small riffles with accumulated gravel and cobble over bedrock less than 6 meters (20 feet) in length have formed. However, much of the site is currently characterized as a moderate to deep run with swift flow over rock and gravel and could not be adequately sampled by seine. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 2 (Table 2).

Table 9. Site 3: Fish Species Collected

Scientific Name	Common Name	Abundance
Dorosoma cepedianum	gizzard shad	Common
Etheostoma olmstedi	tesseslated darter	Uncommon
Lepiostteus osseus	longnose gar	Uncommon
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Common
Notropis scepticus	sandbar shiner	Abundant

A total of seven species were found at this site compared to nine found at the Target site (TAC 2). Bluegill, largemouth bass, sandbar shiner and tessellated darter are shared with the TAC 2 site.

3.2.4 Site 4 (Deep River-Impoundment):

This site is situated within a long, riffle/run/pool sequence that is essentially contiguous with Site 5. The substrate is dominated by cobble and gravel overlain with coarse sand. Six species of shiner were collected in the riffle. Approximately 30 meters (98 feet) of the riffle/run and shallow pool sequence was sampled. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 1 (Table 1).

Table 10. Site 4: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesseslated darter	Uncommon
Fundulus rathbuni	speckled killifish	Uncommon
Gambusia holbrookii	Eastern mosquitofish	Uncommon
Luxilus albeolus	white shiner	Abundant
Micropterus salmoides	largemouth bass	Rare
Moxostoma pappillosum	V-lip redhorse	Common
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis altipinnis	highfin shiner	Common
Notropis amoenus	comely shiner	Uncommon
Notropis hudsonius	spottail shiner	Common
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Abundant
Percina crassa	Piedmont darter	Common

A total of thirteen species were found at this site compared to eighteen found at the target site (TAC 1), suggesting that this site is transitioning toward the targeted fish fauna. Many lotic species such as bluehead chub, comely shiner, highfin shiner, Piedmont

darter, sandbar shiner, spottail shiner, swallowtail shiner, V-lip redhorse and white shiner have colonized this site. Nine species, bluehead chub, Eastern mosquitofish, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, tessellated darter and V-lip redhorse are shared by these two sites.

3.2.5 Site 5 (Deep River-Impoundment):

This site corresponds to Site 7 (Deep River Impoundment 2) sampled during the pre-removal surveys in 2005 (Appendix A) and was selected prior to dam removal due to the presence of large boulder and bedrock rock outcroppings. Since dam removal, much more of the rock outcropping is exposed. The channel is becoming braided around several of the large boulders creating hydraulic breaks where sediments are accumulating that are being colonized by herbaceous vegetation in some areas. This station is one of the most habitat complex sites selected for monitoring, as a variety of substrate and hydraulic conditions are present. This site is essentially contiguous with Site 4. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 1 (Table 1).

Table 11 Site 5: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesseslated darter	Uncommon
Fundulus rathbuni	speckled killifish	Rare
Gambusia holbrookii	Eastern mosquitofish	Rare
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Common
Moxostoma pappillosum	V-lip redhorse	Common
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis altipinnis	highfin shiner	Common
Notropis amoenus	comely shiner	Uncommon
Notropis hudsonius	spottail shiner	Very Abundant
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Common
Scartomyzon sp. nov.	brassy jumprock	Uncommon

A total of fourteen species were found at this site compared to eighteen found at the target site (TAC 1), suggesting that this site is transitioning toward the targeted fish fauna. Many lotic species such as bluehead chub, brassy jumprock, comely shiner, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner and white shiner have colonized this site. Ten species, bluegill, bluehead chub, brassy jumprock, Eastern mosquitofish, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner and tessellated darter are shared with the TAC 1 site.

3.2.6 Site 6 (Deep River-Impoundment):

This sampling station occurs in a small (10 meter/ 33 feet) riffle/pool sequence just below the SR 1621 (Carbonton Road) bridge. Large accumulations of woody debris have been trapped at the bridge creating this small riffle in an otherwise homogonous pool section

of the Deep River. If riffle habitat continues to form in this location, the aquatic community anticipated to develop at this site is expected to be similar to the TAC 2 (Table 2), but may be less diverse due to less amount of riffle habitat.

Table 12. Site 6: Fish Species Collected

Scientific Name	Common Name	Abundance
Fundulus rathbuni	speckled killifish	Uncommon
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Common
Percina crassa	Piedmont darter	Rare

Only five species were found at this site, compared to the nine at the target site (TAC 2). The fish species captured are more indicative of pooled habitats; however, the lotic Piedmont darter was captured. If this riffle continues to form additional lotic species are expected to colonize this area.

3.2.7 Site 7 (Deep River-Impoundment):

This site is characterized by a gravel/sand bar island in the center of the channel approximately 20 meters (66 feet) in length that has created a shallow riffle along the right descending bank and a riffle/ run of moderate depth along the left descending bank. The island is being colonized by herbaceous and woody vegetation and several small depressions on the island appear to retain water during low flows. Large numbers of eastern mosquitofish and speckled killifish were captured in these shallow depressions. This station is one of the most habitat complex sites selected for monitoring, as a variety of substrate and hydraulic conditions are present. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 1 (Table 1).

Table 13. Site 7: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesselated darter	Uncommon
Fundulus rathbuni	speckled killifish	Common
Gambusia holbrookii	Eastern mosquitofish	Abundant
Lepomis macrochirus	bluegill	Common
Luxilus albeolus	white shiner	Common
Micropterus salmoides	largemouth bass	Common
Moxostoma pappillosum	V-lip redhorse	Common
Nocomis leptocephalus	bluehead chub	Common
Notropis altipinnis	highfin shiner	Uncommon
Notropis amoenus	comely shiner	Common
Notropis hudsonius	spottail shiner	Common
Notropis procne	swallowtail shiner	Rare
Notropis scepticus	sandbar shiner	Abundant
Percina crassa	Piedmont darter	Common
Scartomyzon sp. nov.	brassy jumprock	Common

A total of fifteen species were found at this site compared to eighteen found at the target site (TAC 1), suggesting that this site is transitioning toward the targeted fish fauna. Many lotic species such as bluehead chub, brassy jumprock, comely shiner, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, V-lip redhorse and white shiner have colonized this site. Eleven species, bluegill, bluehead chub, brassy jumprock, Eastern mosquitofish, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, tessellated darter and V-lip redhorse are shared with the TAC 1 site.

3.2.8 Site 8 (Deep River-Impoundment):

This site occurs at the mouth of Big Governors Creek and is dominated by a shallow sand/gravel riffle approximately 15 meters (49 feet) long riffle/run/pool sequence. A point bar appears to be forming at the confluence. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 1 (Table 1).

Table 14. Site 8: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesseslated darter	Uncommon
Lepomis auritus	redbreast sunfish	Uncommon
Luxilus albeolus	white shiner	Abundant
Micropterus salmoides	largemouth bass	Rare
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis hudsonius	spottail shiner	Common
Notropis petersoni	coastal shiner	Rare
Notropis scepticus	sandbar shiner	Abundant
Percina crassa	Piedmont darter	Common

A total of nine species were found at this site compared to eighteen found at the target site (TAC 1), suggesting that this site needs to develop further to meet the targeted fish fauna. However, many lotic species such as bluehead chub, coastal shiner, Piedmont darter, sandbar shiner, spottail shiner and white shiner have colonized this site. Five species, bluehead chub, Piedmont darter, sandbar shiner, spottail shiner and tessellated darter are shared with the TAC 1 site.

3.2.9 Site 9 (Deep River-Impoundment):

This site corresponds to Site 8 (Deep River Impoundment 3) sampled during the pre-removal surveys in 2005 (Appendix A) and was selected due to the presence of large boulder and bedrock rock outcroppings just upstream. Prior to dam removal water depth was between 3-6 meters (10-20 feet). Since dam removal much more of the rock outcropping is exposed, however substantial shallow riffle habitat has not formed. Accumulations of gravel and sand are evident in some areas, but it is unclear whether riffle habitat will form in this area. Two very small (3 meter/10 feet) shallow areas were sampled with the seine net; however few fish were captured. Longnose gar was observed at the water surface in this area. If riffle habitats continue to form, the aquatic community anticipated to develop at this site is expected to be similar to the "Targeted Aquatic Community" 2 (Table 2).

Table 15. Site 9: Fish Species Collected

Scientific Name	Common Name	Abundance
Lepiostteus osseus	longnose gar	Rare
Lepomis macrochirus	bluegill	Uncommon
Luxilus albeolus	white shiner	Uncommon
Micropterus salmoides	largemouth bass	Uncommon
Notropis scepticus	sandbar shiner	Uncommon

A total of five species were found with limited sampling effort at this site compared to nine found at the Target site (TAC 2). Bluegill, largemouth bass and sandbar shiner are shared with the TAC 2 site.

3.2.10 Site 10 (Deep River-Impoundment):

This site corresponds to Site 9 (Deep River Impoundment 4) sampled during the pre-removal surveys in 2005 (Appendix A) and was selected due to the presence of large boulder and bedrock rock outcroppings. Prior to dam removal, flow was virtually nonexistent and the rocky substrate was covered with large accumulations of fine sediments. Since dam removal, much more of the rock outcropping is exposed, however substantial shallow riffle habitat has not formed and water depths precluded the use of seine netting. It appears that most of the fine sediments have been flushed from this site, and accumulations of gravel and sand are evident in some areas, but it is unclear whether riffle habitat will form. Fish sampling was not conducted at this site; however, longnose gar, bluegill and largemouth bass were observed. The "Targeted Aquatic Community" 2 (Table 2) has been assigned as the anticipated community for this site, however, it is unclear if the habitat conditions associated with this community will develop at this site over time.

Table 16. Site 10: Fish Species Observed

Scientific Name	Common Name	Abundance
Lepiostteus osseus	longnose gar	~
Lepomis macrochirus	bluegill	~
Micropterus salmoides	largemouth bass	~

Surveys were not conducted at this site, however two of the nine species occurring at the target site (TAC 2), the bluegill and largemouth bass were observed at this site.

3.2.11 Site 11 (Deep River-Impoundment):

This site occurs in a long straight reach of the Deep River and is characterized by a gravel/cobble riffle/run of moderate depth and swift flow. Approximately 30 meters (98 feet) of the riffle/run was sampled. Species diversity is fairly low, likely a reflection of habitat homogeneity; however, shiners, particularly sandbar shiner, are abundant. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 2 (Table 2).

Table 17. Site 11: Fish Species Collected

Scientific Name	Common Name	Abundance
Luxilus albeolus	white shiner	Common
Moxostoma pappillosum	V-lip redhorse	Uncommon
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis altipinnis	highfin shiner	Common
Notropis hudsonius	spottail shiner	Common
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Very Abundant
Scartomyzon sp. nov.	Brassy jumprock	Common

A total of eight species were found at this site compared to nine found at the Target site (TAC 2). Bluehead chub, highfin shiner, sandbar shiner, spottail shiner and swallowtail shiner are shared with the TAC 2 site.

3.2.12 Site 12 (Deep River-Impoundment):

Like Site 11, this site occurs in a long straight reach of the Deep River and is characterized by a gravel/cobble riffle/run of moderate depth and swift flow. Approximately 30 meters (98 feet) of the riffle/run was sampled. Species diversity is fairly low, likely a reflection of habitat homogeneity; however, shiners, particularly white shiner and sandbar shiner are abundant. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 2 (Table 2).

Table 18. Site 12: Fish Species Collected

Scientific Name	Common Name	Abundance
Cyprinella niveus	whitefin shiner	Rare
Luxilus albeolus	white shiner	Abundant
Moxostoma pappillosum	V-lip redhorse	Uncommon
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Rare
Notropis scepticus	sandbar shiner	Very Abundant

A total of six species were found at this site compared to nine found at the Target site (TAC 2). Highfin shiner, sandbar shiner, spottail shiner and whitefin shiner are shared with the TAC 2 site.

3.2.13 Site 13 (Deep River-Impoundment/Dam Site):

This site occurs in a shallow riffle consisting of shifting sand and gravel at the location of the former Carbonton dam. The riffle was sampled from the former dam site to a point approximately 20 meters (66 feet) upstream. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 2 (Table 2).

Table 19. Site 13: Fish Species Collected

Scientific Name	Common Name	Abundance
Etheostoma olmstedi	tesselated darter	Rare
Gambusia holbrookii	Eastern mosquitofish	Common

Lepomis macrochirus	Bluegill	Common
Luxilus albeolus	white shiner	Common
Micropterus salmoides	largemouth bass	Uncommon
Nocomis leptocephalus	bluehead chub	Rare
Notropis amoenus	comely shiner	Common
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant

A total of seven species were found at this site compared to eleven found at the target site (TAC 2). Bluegill, bluehead chub, largemouth bass, swallowtail shiner, sandbar shiner and tesseleated darter are shared by these two sites.

3.2.14 Site 14 (McLendons Creek-Impoundment):

This site corresponds to Site 16 (McLendons Creek Impoundment) sampled during the pre-removal surveys in 2005 (Appendix A). Prior to dam removal, flow was virtually nonexistent and large accumulations of fine sediments, detritus and woody debris were evident. Since dam removal, it appears that natural riffle/run/pool sequences are being formed with pea gravel over hard clay substrate. Much of the fine sediments appear to have been flushed from the site; however a large amount of woody debris still remains in the channel. An approximately 150 meter (492 feet) reach of the creek was sampled. The aquatic community anticipated to develop at this site is expected to be similar to the TAC 3 (Table 3), which occurs in the upstream reaches of McClendons Creek.

Table 20. Site 14: Fish Species Collected

Scientific Name	Common Name	Abundance
Hybognathus regius	Eastern silvery minnow	Rare
Lepomis macrochirus	Bluegill	Common
Luxilus albeolus	white shiner	Abundant
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis hudsonius	spottail shiner	Rare
Notropis petersoni	coastal shiner	Rare
Notropis scepticus	sandbar shiner	Very Abundant

A total of seven species were found at this site compared to nine found at the Target site (TAC 3). Bluegill, white shiner bluehead chub and spottail shiner are shared by these two sites.

3.2.15 Site 15 (Big Governors Creek-Impoundment):

This site corresponds to Site 18 (Big Governors Creek Impoundment) sampled during the pre-removal, surveys in 2005 (Appendix A). Prior to dam removal flow was virtually nonexistent and large accumulations of fine sediments, detritus, and woody debris were evident. Since dam removal, it appears that limited sandy riffles are being formed in places; however, much of the stream is characterized by slack-water pools with large amounts of woody debris. An approximately 50 meter (164 feet) reach of the creek was able to be sampled. The aquatic community anticipated to develop at this site is expected

to be similar to the TAC 4 (Table 4), which occurs in the upstream reaches of Big Governors Creek.

Table 21. Site 15: Fish Species Collected

Scientific Name	Common Name	Abundance
Lepomis macrochirus	Bluegill	Uncommon
Luxilus albeolus	white shiner	Uncommon
Micropterus salmoides	largemouth bass	Uncommon
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis petersoni	coastal shiner	Rare
Notropis scepticus	sandbar shiner	Abundant

A total of six species were found at this site, the same number as found at the target site (TAC 4) upstream. Bluegill, largemouth bass and bluehead chub are shared by these two sites.

4.0 DISCUSSION/CONCLUSIONS

Qualitative surveys for various freshwater fish were conducted at 15 specific locations in areas formerly impounded by Carbonton dam to document establishment of lotic habitats and associated fish communities.

4.1 Habitat Reconnaissance

At least 11 substantial riffle habitats have developed within the Deep River, and one within Mclendons Creek. Morphological features at many of these sites (2, 4, 5, 7, and possibly 8) have created various hydraulic conditions and in turn, multiple microhabitats which correspond to potentially high quality habitat for aquatic species, including the targeted Cape Fear shiner and various rare mussel species such as the brook floater (*Alasmidonta varicosa*). It is anticipated that mussel recruitment into these areas will occur and should be evident four to five years post removal. The results of the fish surveys demonstrate that riffle-adapted species have colonized the newly restored riffle habitats (Section 3.2). Moderate to deep run habitats as those observed at sites 9 and 10 are also expected to provide quality habitats for various lotic-adapted fish and freshwater mussel species.

As discussed above, two long pools occur in the Deep River between sites 3 and 4 and sites 9 and 10, respectively. It is not clear if riffle habitats will develop in these reaches. These long pools may be natural features of the river in these reaches.

4.2 Fish Surveys

As discussed above (Section 2.2.1) as well as in the pre-removal report (Appendix A), electro-fishing was not used during the Carbonton Dam Removal studies, in recognition of the “Collection Sensitive Waters” designation of the Deep River by the NCWRC. A more comprehensive survey effort conducted at various times throughout the year and using multiple sampling methodologies (boat electro-fishing, backpack electro-fishing,

seine netting etc.) is needed, particularly in the deeper habitats, to obtain a complete list of all fish species occurring in the Deep River and its tributaries. However, the methods used and the data collected is adequate for establishing fish fauna targeting the Cape Fear shiner, the main target species for this study. Other riffle adapted species will serve as surrogate species to demonstrate habitat restoration success. These methods will also allow for the monitoring of changes in riffle-adapted species composition over time in response to dam removal.

The results of the habitat reconnaissance and fish surveys demonstrate re-establishment of lotic conditions within the former reservoir pool. The targeted Cape Fears shiner was not located at any of the survey sites during the Year-1 post removal monitoring. However, favorable habitat conditions for this species appear to be developing at many locations, particularly at sites 2, 4, 5 and 7 and possibly 8. As was demonstrated at upstream and downstream locations during the pre-removal surveys in 2005, habitat complexity was directly correlated with species richness (Carbonton Pre-removal Surveys Report). This is further documented with the Year-1 monitoring fish surveys as sites 2, 4, 5 and 7 had the highest species diversity (14, 13, 14 and 15 species respectively). A total of 18 fish species, including the Cape Fear shiner were recorded at the respective target site (TAC 1), thus it is apparent that species diversity at these four locations (Sites 2, 4, 5 and 7) is approaching the desired fish fauna assemblage, as many of the shiner, darter, chub and sucker species present at the TAC 1 site also occur at sites 2, 4, 5 and 7, as they share 9, 9, 10 and 11 species respectively with the TAC 1 site. Additionally, habitat complexity should further develop at Site 1 and Site 8 once the channel and substrate stabilize.

In addition to the habitat-complex sites that are forming in the river following dam removal (Sites 2, 4, 5, 7), a number of shallow riffle/run sites are also forming. Similarly these sites, sites 11, 12 and 13 had comparable fish species diversity and composition to their respective assigned TAC (TAC 2), sharing 5, 4 and 6 species respectively with the targeted site.

There do not appear to be any obstructions that would prevent recruitment of Cape Fear shiner into these Deep River habitats from either upstream, or downstream populations and colonization is expected to occur over time. Utilization of tributaries by the Cape Fear shiner is poorly understood. Of the two tributaries surveyed during this effort, McLendons Creek appears to have more potential than Big Governors Creek to support this species.

4.3 Future Fish Survey Monitoring

The results of the Year-1 monitoring fish survey demonstrate successful restoration of lotic conditions within the former reservoir pool in the Deep River and McLendons Creek. Numerous riffle-adapted species were found in relatively high densities at various localities throughout the surveyed reach. Although these riffle-adapted species serve as surrogate species to demonstrate habitat restoration success, efforts to document recruitment of Cape Fear shiner into these areas, as well as increase in species richness

should continue as part of the five-year monitoring plan. As discussed above, significant riffle habitats are unlikely to develop in Big Governors Creek, and colonization by the Cape Fear shiner is even more unlikely due in part to the natural conditions of this creek. Therefore, restoration success criteria for this stream should not be based on presence of riffle-adapted species. An increase in species diversity overtime is thus a better measure of success with this stream.

APPENDIX A

Pre-Removal Surveys Report

1.0 INTRODUCTION

The impacts to aquatic fauna from artificial impoundments are well documented. Dams have been shown to result in declines in fish biodiversity and fisheries (Nehlsen et al. 1991, Martinez et al. 1994, Moyle and Leidy 1992, LaRoe et al. 1995, Quinn and Kwak 2003, Santucci et al. 2005; and others) and are identified as a major factor in the decline of freshwater mussels (Williams et al., 1993 Bogan 1993, Neves 1993). The construction of dams can indirectly impact freshwater mussel species, which require fish hosts to complete their life cycles, by posing a barrier to fish migration. The construction of the Petitcodiac River Causeway in 1968, resulted in the extirpation of the dwarf wedgemussel (*Alasmidonta heterodon*) from Canada, because the causeway restricted the migration of the diadromous Inner Bay of Fundy stock of Atlantic salmon (*Salmo salar*), which serves as the fish host for the dwarf wedgemussel in this region (Locke et al. 2003). Fish populations can also be greatly impacted by dam construction reducing both numbers and biodiversity (Nehlsen et al. 1991, Moyle and Leidy 1992 LaRoe et al. 1995, Santucci et al. 2005). Dam construction on the Cape Fear River system has been identified as the most significant factor causing the decline of the federally endangered Cape Fear shiner *(Notropis mekistocholas)* and has resulted in isolation of the remaining populations (USFWS 1988). Morita and Yokota (2002) showed that damming of waterways in Japan created population isolation of many fish species including the white-spotted char (*Salvelinus leucomaenis*) and that most of the small fragmented populations were not viable.

Restoration Systems, LLC (RS) is coordinating the demolition and removal of Carbonton Dam, a hydro facility located on the Deep River along the Chatham/Lee/Moore county line, with the goal of restoring the impounded stretch of the Deep River and its tributaries to pre-impoundment conditions. The existing dam currently separates two populations of the Cape Fear shiner. The removal of Carbonton dam is projected to result in the restoration of more than 9.5 river miles (RM) of the mainstem Deep River; significant portions of three major tributaries, McLendons Creek, Big and Little Governors Creeks; as well as fifteen smaller tributaries within the Cape Fear River Basin. The dam removal project is anticipated to restore significant additional, habitat for the federally endangered Cape Fear shiner, several species of rare mussels, and other riverine aquatic species. The project is expected to serve as a mitigation bank for future activities within the Cape Fear River Basin.

Based on the restoration success criteria recommended by the U.S. Fish and Wildlife Service (FWS), the expectations of the interagency dam removal task force, and the goals of RS, documenting the effectiveness of the restoration initiative requires that a baseline of existing aquatic fauna within the project area be established and then monitored for changes in composition after the dam is removed. Meeting this goal involves two phases:

Phase I. Pre-dam removal surveys in order to establish a baseline of fish, mussels, and macro-snails present in impounded and nearby free-flowing reaches.

Phase II. Post-dam removal surveys in the restored reaches to detect/document changes in fish, mussel, and macro-snail composition for a five-year period.

The Catena Group, Inc. (TCG) was contracted by RS to complete the Phase I aquatic fauna surveys for the project. This report provides a detailed summary of the survey efforts undertaken for this project.

2.0 TARGETED RARE AND PROTECTED SPECIES DESCRIPTIONS

Since rare and protected species restoration is one of the criteria that may be used to determine the success of dam removal, the following rare species with the potential to occur within the Cape Fear River Basin, were targeted for this study (Table 1). Descriptions of these federally protected, Federal Species of Concern (FSC), and North Carolina-state listed species are provided below.

Table 1. Rare Aquatic Species Documented from Upper Cape Fear River Basin

Scientific Name	Common Name	Taxa Group	Federal Status*	NC Status*
Alasmidonta undulata	triangle floater	Mussel	~	T
Alasmidonta varicosa	brook floater	Mussel	FSC	E
*Amboplites cavifrons***	Roanoke bass	Fish	FSC	SR
Elliptio roanokensis	Roanoke slabshell	Mussel	~	T
Etheostoma collis	Carolina darter	Fish	FSC	SC
Fusconaia masoni	Atlantic pigtoe	Mussel	FSC	E
Lampsilis cariosa	yellow lampmussel	Mussel	FSC	E
Lasmigona subviridis	green floater	Mussel	FSC	E
Moxostoma sp. 3	Carolina redhorse	Fish	FSC	PE
Strophitus undulatus	creeper	Mussel	~	T
Toxolasma pullus	Savannah liliput	Mussel	FSC	E
Villosa constricta	notched rainbow	Mussel	~	SC
Villosa delumbis	Eastern creekshell	Mussel	~	SR
Villosa vaughniana	Carolina creekshell	Mussel	FSC	E

* Federal and North Carolina status defined in Appendix A

****** Not native to basin

2.1 Targeted Federally Protected Species

***Notropis mekistocholas* (Cape Fear shiner)**
Status: Endangered
Listed: September 26, 1987

Characteristics

The Cape Fear shiner is a small, moderately stocky Cyprinid described by Snelson (1971). The fish's body is flushed, pale, silvery, yellow, with a black band running along the side. The fins are yellowish and somewhat pointed. The upper lip is black and the lower lip bears a thin black bar along its margin.

The Cape Fear shiner is distinguished from all other *Notropis* by having an elongated alimentary tract with two convolutions crossing the intestinal bulb. This is believed to be an adaptation for herbivorous feeding (Snelson 1971, USFWS 1988).

Distribution and Habitat Requirements

Current distribution of the Cape Fear shiner is limited mainly to small stretches of the Deep, Haw, and Rocky rivers of the Cape Fear River basin. It is possible that it has always been rare and restricted in range; however a reduction in the historical range has been demonstrated (USFWS 1988). Approximately 17 RM of the Deep, Haw, and Rocky Rivers have been designated as federal Critical Habitat for the Cape Fear shiner (50 CFR Vol. 52 No. 186).

Typical habitat for the Cape Fear shiner has been described as slow pools, riffles, and slow runs over gravel, cobble, and boulder substrates (Snelson 1971, Pottern and Huish 1985). It has been suggested that essential spawning habitat for this species is associated with water willow (*Justicia americana*) beds, as Catch per Unit Effort (CPUE) were higher in water willow beds (NCWRC 1995), however recent micro-habitat studies did not support an association with water willow during the spawning season (Howard 2003). Water willow may still provide protection from predators as well as water velocity refugia for depositing eggs (Howard 2003).

Threats to the Species

The restricted range and small population sizes make this species vulnerable to catastrophic events, such as toxic chemical spills (USFWS 1988). Inundation of habitat and restriction of flow regimes, which have resulted from multiple dam construction projects in the Cape Fear system, is likely the most significant factor that contributed to the species decline (USFWS 1988). Sedimentation of habitat, particularly that of water willow beds, also threatens the species.

2.2 Targeted Federal Species of Concern

Federal Species of Concern (FSC) are defined as species that are under consideration for listing as Threatened and Endangered, but for which there is insufficient information to support the listing. FSCs are not afforded protection under the Endangered Species Act and are not subject to any of its provisions, including Section 7, until they are formally proposed or listed as Threatened or Endangered. However, since the status of these species is subject to change, FSCs should be included for consideration during the planning process of a project in the event that they become listed.

2.2.1 Alasmidonta varicosa (brook floater)

Federal Status: Federal Species of Concern
State Status: Endangered

Characteristics

Shells of the brook floater are long and rhomboid in outline with a yellowish to greenish, smooth perisotracum. Shell surfaces are partly to completely covered with dark, greenish rays which become obscured with age. The posterior slope of the shell is flattened and slightly concave with numerous, low corrugations or varicose ridges.

Distribution and Habitat Requirements

Described by Lamarck (1819) from the Schuylkill River in Philadelphia County, Pennsylvania, this species ranges from the lower St. Laurence River basin, south to the Atlantic drainages of South Carolina. It is found in riffle habitats in small streams to moderate-sized rivers, usually associated with gravel/cobble substrate in strong current.

Threats to Species

While still common in some areas, the species has experienced significant declines throughout its range. Like with many freshwater mussel species, the cumulative effects of several factors, including sedimentation, point and non-point discharge, and stream modifications (impoundments, channelization, etc.) have contributed to the decline of this species throughout its range. This species is listed as Endangered[1] in North Carolina

***2.2.2 Ambloplites cavifrons* (Roanoke bass) Cope 1868**
Federal Status: Federal Species of Concern
State Status: Significantly Rare

Characteristics

This member of the sunfish family (Centrachidae) was described from the head waters of the Roanoke River, in Virginia by Cope (1868). Along with the similar rock bass (*Ambloplites rupestris*), it is often referred to as "redeye bass, or "goggle eye", as it has a large red eye. The Roanoke bass has large terminal mouth with a short (150-235 SL), robust body, that is dark olive brown in color, with many dark spots and lateral stripes that are silvery to pale-green. It has five to six (usually six) anal spines (most centrachids have three), and a rounded pectoral fin. It is a popular "game" fish in some areas of its range.

Distribution and Habitat Requirements

This species has a relatively small native range, being known from the Chowan and Roanoke River Basins in Virginia south through the Tar-Pamlico and Neuse River Basin in North Carolina (Lee et al. 1980). This species was stocked into the upper Cape Fear

[1] **North Carolina Listed Endangered (E)** defined as a species that is in danger of extinction throughout all or a significant portion of its range

River Basin between 1973, and 1975, by the NCWRC (Menhinick 1991). Although stocking was discontinued, a reproducing population persists in the Deep River (Menhenick and Braswell 1997). It occurs in medium size streams to large rivers, but has experienced major declines throughout much of its range and has been extirpated from the upper Roanoke.

Threats to Species

The decrease in range and population numbers of this species has been attributed to impoundments, pollution, and siltation of habitats (Jenkins and Burkhead 1993). The extirpation from the upper Roanoke is suggested to be attributable to the introduction of the rock bass into this area (Jenkins and Burkhead 1993). It is considered Significantly Rare in North Carolina.

2.2.3 Etheostoma collis (Hubbs and Cannon 1935) pop 2 (Carolina darter-eastern Piedmont population)

Federal Status: Federal Species of Concern
State Status: Special Concern

Characteristics

The Carolina darter (a small fish) was described in South Carolina (Hubbs and Cannon 1935). Three allopatric taxa have been recognized in the *E. collis* group (Collette 1962): *E. collis lepidinion* in the Roanoke, Neuse, and Cape Fear drainages, *E. c. collis* in the Pee Dee drainage and the Catawba system of the Santee drainage; and *E. saludae* from the Saluda system of the Santee drainage. Jenkins and Burkhead (1993) noted that no populations from individual drainages exhibit distinctive taxonomic characters, and thus, use the name *E. collis* for the broadened species. In North Carolina, two populations are recognized (LeGrand et al. 2004): population 1 (central Piedmont population), which corresponds to *E. c. collis* and population 2 (eastern Piedmont population), which corresponds to *E. c. lepidinion*.

The Carolina darter is a small (31-60 mm) nondescript darter that has a yellow-brown body covered in eight to fourteen dark blotches along the midside, with a yellowish white venter. Its eyes are nearly on the top of its head and it has a rounded caudal fin with three dark blotches at the base.

Distribution and Habitat Requirements

This population of the Carolina darter (eastern Piedmont) ranges from the Roanoke River Basin south to the Cape Fear River Basin in North Carolina. It inhabits small to moderate size streams and small rivers, in areas of low current velocity. Preferred substrate is usually characterized as sand or mud, usually in or near aquatic vegetation (Rhode et al. 1994).

Threats to Species

Geographic isolation in addition to threats from development, water quality impacts, and habitat alterations (channelization, impoundments, etc.) has been identified as threats to this species (Warren et al. 2000). This species is of Special Concern in North Carolina.

***2.2.4 Fusconaia masoni* (Atlantic pigtoe)** Conrad 1834
Federal Status: Federal Species of Concern
State Status: Endangered

Characteristics

The Atlantic pigtoe (a mussel) was described by Conrad (1834) from the Savannah River in Augusta, Georgia. Shells of the Atlantic pigtoe are subrhomboidal in outline, with a parchment-like yellow to dark brown periostracum. The posterior ridge is very distinct, and the umbos extend well above the dorsal margin.

The Atlantic pigtoe is a tachytictic (short-term) breeder, brooding young and releasing glochidia in early summer. The bluegill (*Lepomis macrochirus*) and shield darter (*Percina peltata*) have been identified as potential fish hosts for this species (O'Dee and Waters 2000).

Distribution and Habitat Requirements

The Atlantic pigtoe ranges from the Ogeechee River Basin in Georgia north to the James River Basin in Virginia. It occurs in medium size streams to large rivers, but has experienced major declines throughout its entire range. The preferred habitat for this species is a substrate composed of gravel and coarse sand, usually at the base of riffles; however, it can be found in a variety of other substrates and habitat conditions (personal observations).

Threats to Species

Threats to this and many other freshwater mussel species are similar to those described above for the brook floater. Williams et al. (1993) list this species as Endangered. There appears to be sufficient data to warrant elevation of the Atlantic pigtoe to Candidate status in the very near future (John Fridell, Recovery Biologist USFWS, Personal Communication). It is listed as Endangered in North Carolina.

***2.2.5 Lampsilis cariosa* (yellow lampmussel)** Say 1817
Federal Status: Federal Species of Concern
State Status: Endangered

Characteristics

The yellow lampmussel (a mussel) was described by Say (1817) from the Schuykill River near Philadelphia, Pennsylvania (Say 1817). The waxy-yellow shell is obovate in outline, with a rounded anterior margin and slightly curved posterior margin and is rarely rayed. Like other members of this genus, this species is sexually dimorphic, with the shell of the male being more elongate and the female more rounded, particularly in the posterior margin.

Distribution and Habitat Requirements

The yellow lampmussel extends from the Ogeechee River in Georgia north to Nova Scotia, Canada, and westward in the St. Lawrence River Basin to the lower Ottawa River and Madawaska River drainages, Canada (Johnson 1970). It occurs in small size streams to large rivers, but has experienced major declines throughout its entire range. The preferred habitat for this species is a substrate composed of sand and gravel, but it may also occur in substrates of silt, cobble, and bedrock crevices.

Threats to Species

Threats to this and many other freshwater mussel species are similar to those described above for the brook floater. Williams et al. (1993) list this species as Endangered throughout its range. It is listed as Endangered in North Carolina.

***2.2.6 Lasmigona subviridis* (green floater)** Conrad 1835
Federal Status: Federal Species of Concern
State Status: Endangered

Characteristics

The green floater (a mussel) was described by Conrad (1835) from the Schuykill River in Lancaster County Pennsylvania. The small mussel species has a thin slightly inflated subovate shell that is narrower in front, higher behind. The dorsal margin forms a blunt angle with the posterior margin. The shell is dull yellow or tan to brownish green, usually with concentrations of dark green rays.

Distribution and Habitat Requirements

The green floater occurs along the Atlantic slope from the Savannah River in Georgia north to the Hudson River in New York, as well as in the "interior" basins (New, Kanawah, and Wataugua Rivers) of the Tennessee River basin. It occurs in small size streams to large rivers, in quiet waters or pools, or eddies, with gravel and sand substrates. It has experienced major declines throughout its entire range.

Threats to Species

Threats to this and many other freshwater mussel species are similar to those described above for the brook floater. Williams et al. (1993) list this species as Threatened. It is listed as Endangered in North Carolina.

2.2.7 Moxostoma sp 3 (Carolina redhorse)

Federal Status: Federal Species of Concern
State Status: Proposed Endangered

Characteristics

This undescribed species of sucker is most closely related to the golden redhorse (*Moxostoma erythrurum*). Like other members of the genus it has a large horizontal mouth with fleshy lips, with 12 rows of scales around the caudal peduncle. It has a long slender body, with light orange pectoral, anal and pelvic fins. The taxonomy and life history of this species is being studied by R.E. Jenkins of Roanoke College.

Distribution and Habitat Requirements

The Carolina redhorse appears to be restricted to a relatively short reach of the Great Pee Dee River in North Carolina and South Carolina and the Deep River of the Cape Fear River Basin in North Carolina. Very little is known of its habitat requirements other than it is found in medium-sized rivers with moderate gradient, usually in deep pools.

Threats to Species

Given its limited natural distribution, and the degree of habitat modification that has taken place in the Pee Dee and Cape Fear River basins, the Carolina redhorse is highly vulnerable to extinction (Wayne Starnes NCSM, personal communication). This species is considered a G1 species (Globally Imperiled) and warrants federal protection (NatureServe 2006).

The undescribed Carolina redhorse is known from the Yadkin-Pee Dee and Cape Fear River basins in North Carolina. Comparative studies are being conducted by Robert Jenkins of Roanoke College and Wayne Starnes of the North Carolina State Museum of Natural Sciences (NCSM) in order to formally describe this species (R.E. Jenkins and Wayne Starnes, personal communication). Currently, the best known population is from the Deep River near the project area. Based on its apparent restricted range and current threats, the Carolina redhorse merits endangered status (John Fridell USFWS personal communication). The Carolina redhorse is currently considered State Rare (Proposed Endangered) in North Carolina.

2.2.8 Toxolasma pullus (Savannah liliput)

Federal Status: Federal Species of Concern
State Status: Endangered

Characteristics

This species was described by Conrad (1838) from the Watree River, South Carolina (Johnson 1970). This very small mussel reaches a maximum size of 35 mm TL. Like other members of this genus, this species is sexually dimorphic, with the shell of the male being more elongate and pointed, and the female more rounded and truncate in the posterior margin. The ventral margin is generally straight in males, and rounded in females. The periostracum is usually blackish, or olivish with obscure fine green rays. The nacre of the shell is bluish white with a purplish iridescence.

Distribution and Habitat Requirements

The Savannah liliput ranges from the Altamaha River Basin in Georgia to the Neuse River Basin in North Carolina. It may be extirpated from the Neuse River Basin (Bogan 2002). This species is typically found near the banks of streams and ponds in mud or sandy substrate.

Threats to Species

Threats to this and many other freshwater mussel species are similar to those described above for the brook floater. Williams et al. (1993) lists this species as Threatened. It is considered Endangered in North Carolina.

2.2.9 Villosa vaughniana (Carolina creekshell)

Federal Status: Federal Species of Concern
State Status: Endangered

Characteristics

This species was described from Swaney's Creek near Camden, South Carolina (Lea 1838). Like other members of this genus, this species is sexually dimorphic, with the shell of the male being more elongate, and the female more inflated and rounded in the posterior margin. The periostracum is usually dark yellow brown with many green, unbroken rays. The shell of this species is generally thicker, with more prominent pseudocardinal teeth than the similar eastern creekshell.

Distribution and Habitat Requirements

The Carolina creekshell ranges from the Santee River Basin in South Carolina north to the Cape Fear River Basin in North Carolina. This species is typically found near the banks in shaded shallow pools of small streams and in muddy or silty gravel (Bogan and Alderman 2004).

Threats to Species

Threats to this and many other freshwater mussel species are similar to those described above for the brook floater. Williams et al. (1993) lists this species as Special Concern. It is considered Endangered in North Carolina.

2.3 Targeted State Listed and Rare Species

North Carolina Endangered, Threatened and Special Concern species have legal protection status in North Carolina under the State Endangered Species Act administered and enforced by the North Carolina Wildlife Resources Commission. Species listed as Significantly Rare and Watch List species are not afforded any protection.

Alasmidonta undulata (triangle floater)-This mussel species was described from the Schuykill River near Philadelphia (Say 1817). Its range extends from the Catawba River in North Carolina north to the lower St. Lawrence River. The shell shape is subtriangular to ovate and inflated. The anterior and ventral shell margins are rounded. The periostracum is yellowish green with broad green or black rays. This species is considered Special Concern throughout its range (Williams et al. 1993). It is considered Threatened in North Carolina.

Elliptio roanokensis (Roanoke slabshell)-The Roanoke slabshell was described from the Roanoke River (exact location unknown) by Lea (1838). The reported range of this mussel species extends from the Connecticut River in Massachusetts south to the Savannah River in Georgia (Walter 1954). Based on shell morphologies, Johnson (1970) synonimized this and 100 other species into the *Elliptio complanata* complex, however it is now widely recognized as being a valid species. The periostracum is generally very smooth, often with placations (furrows), and reddish yellow in color. Shells of this species reach lengths exceeding 150 mm. This species is listed as Threatened in North Carolina. Williams et al. (1993) list this species as Special Concern.

Strophitus undulatus (creeper)-This mussel species was described from the Schuykill River near Philadelphia (Say 1817). Its range extends from throughout much of the Interior River Basin and Atlantic Slope regions. The shell is elliptical to rhomboid in outlined and somewhat inflated. The anterior end is rounded and the posterior end is bluntly pointed. The periostracum is yellowish green to brown, with dark green rays. Williams et al. (1993) consider this species to be Stable; however it is considered Threatened in North Carolina.

Villosa constricta (notched rainbow)-This mussel species was described by Conrad (1838) from the North River in Rockbridge County Virginia. It is reported to occur from the James River Basin in Virginia south to the Catawba River Basin in North Carolina (Johnson 1970). The shell is fairly small and short, and sub elliptical in outline. The beaks are generally not elevated. The periostracum is shiny yellowish green to black occasionally having dark green rays. Like other members of the genus, the notched rainbow is sexually dimorphic, however the marsupial swelling of the females is

generally small compared to other species. Williams et al. (1993) lists this species as special concern. It is also considered Special Concern in North Carolina.

Villosa delumbis (eastern creekshell)- This mussel species, described by Conrad (1834) from small streams near the Cooper River, South Carolina, ranges from Ocmulgee River, Georgia north to the Cape Fear River in North Carolina. It has a generally thin shell that is ovate in outline. Like other members of this genus, this species is sexually dimorphic, with the shell of the male being more elongate, and the female more rounded and swollen, particularly in the posterior margin. The periostracum is yellow with numerous green rays that are broken along the prominent growth lines. Williams et al. (1993) consider this species to be stable; however it is considered Significantly Rare in North Carolina.

3.0 SURVEY EFFORTS

Pre Survey Investigation

Prior to conducting field surveys, a review was conducted of previous surveys in the project area. The North Carolina Natural Heritage Program (NCNHP) systematic inventory (database) of rare plant and animal species, NCWRC database of North Carolina fauna, and other available biological inventories conducted within the project area were consulted.

The pre-survey database search revealed records of Cape Fear shiner, Carolina redhorse, yellow lampmussel, and notched rainbow in the Deep River both upstream and downstream of the Carbonton dam. The Carolina redhorse has also been documented within the impounded portion of the Deep River, and the Atlantic pigtoe has been recorded upstream of the impoundment.

Aquatic Surveys

Surveys for freshwater mussels, fish, and snails were conducted April-October, 2005, by the following personnel from The Catena Group on the listed dates:

Tom Dickinson – 4-20, 4-22, 5-5, 5-25, 6-1, 8-25, 8-26
Tim Savidge – 4-20, 4-22, 5-5, 5-25, 10-20, 10-22
Shay Garriock – 5-5, 6-1, 8-25, 8-26
Michael Wood – 6-1
Sharon Snider – 4-20
Kate Montieth – 4-22, 8-25, 8-26
Steve Melin – 5-25, 10-20
Alex Adams – 10-20
Chris Sheats -10-22

The surveys were conducted at 18 sampling locations (listed in Table 2 by general site location, survey date, survey type, and GPS location). Figure 1 shows the approximate midpoints of each survey location listed in Table 2.

Table 2. Pre Dam Removal Survey Locations

TCG Site #	Site Location	Survey Type*	Survey Date(s)	GPS Location
1	Deep River-upstream-1 (Howard Mill Rd)	M, F, S	8/25/2005, 10/20/2005	35.50311ºN, -79.58303ºW
2	Deep River-upstream-2 (Island Channel/Howard Mill Rd)	F	10/20/2005	35.50162ºN, -79.58331ºW
3	Deep River-upstream-3 (NC 22)	M, F, S	8/25/2005, 10/20/2005	35.47842ºN, -79.52077ºW
4	Deep River-upstream-4 (Tyson's Creek)	M, F, S	8/25/2005, 10/20/2005	35.49417ºN, -79.44673ºW
5	Deep River-upstream-5 (Glendon-Carthage Rd)	M, F, S	4/20/2005	35.49102ºN, -79.41919ºW
6	Deep River-impoundment-1	M, S	4/22/2005	35.48269ºN, -79.38307ºW
7	Deep River-impoundment-2	M, S	4/22/2005	35.46126ºN, -79.38965ºW
8	Deep River-impoundment-3	M, S	4/22/2005	35.47855ºN, -79.35072ºW
9	Deep River-impoundment-4	M, S	4/22/2005	35.49891ºN, -79.33601ºW
10	Deep River-downstream-1 (Tailrace)	F	5/25/2005	35.5198ºN, -79.34719ºW
11	Deep River-downstream-2	M, F, S	5/25/2005	35.52488ºN, -79.33158ºW
12	Deep River-downstream 3 (Plank Road)	M,F,S	8/26/2005, 10/22/2005	35.55487ºN, -79.28666ºW
13	Deep River-downstream 4 (US 421)	M,F,S	8/26/2005, 10/22/2005	35.54573ºN, -79.25275ºW
14	Deep River-downstream 5 (Rosser/Cummock Rd)	M,F,S	8/26/2005, 10/22/2005	35.56945ºN, -79.24425ºW
15	McLendons Creek-upstream (Cool Springs Rd)	M, F, S	5/5/2005	35.44977ºN, -79.42318ºW
16	McLendons Creek-impoundment	M, S	6/1/2005	35.45894ºN, -79.39803ºW
17	Big Governors Creek-upstream (Underwood Rd)	M, F, S	5/5/2005	35.4583ºN, -79.36951ºW
18	Big Governors Creek-impoundment	M, S	6/1/2005	35.47434ºN, -79.3564ºW

*M (mussel survey), F (Qualitative fish assessment), S (snail survey)

Survey site locations were correlated with pre-selected data collection sites identified by RS, when possible, although time and accessibility constraints influenced survey locations in some instances. Most importantly, survey site locations were chosen in the field in areas with physical characteristics that represented the best available habitat for the target fauna. In impounded reaches, site selection was based on the presence of rock outcrops or other indicators suggesting good habitat conditions for the target species prior to impoundment. These sites will be established as post-removal monitoring stations.

4.0 METHODOLOGY

Aquatic species surveys were conducted at 18 sites:

- Four sites within the current reservoir pool in the Deep River created by Carbonton Dam (Sites 6-9)
- Four sites upstream of the reservoir pool in the Deep River (Sites 1-4)
- Five sites downstream of the dam in the Deep River (Sites 10-14)
- One site within the current reservoir pool in McLendons Creek
- One site above the reservoir pool in McLendons Creek
- One site within the current reservoir pool in Big Governors Creek
- One site above the reservoir pool in Big Governors Creek (Figure 1).

Power boat and canoe were used to access many of the sites, while the other sites were accessed via bridge crossings or other access points (e.g. public park access, dam site). Typically a three-person survey team was used to perform the aquatic inventories at each site. The visual survey component (primarily mussel/snails) of the inventory surveys was conducted first at each site, followed by the active capture (fishes) component.

The length of each survey site was approximately 200-300 feet, with the exception of Site 10, which occurred in a 30 feet length of the tailrace immediately below the dam, in very swift current. Due to the high water velocity only active capture (fish) surveys were conducted at this site. The midpoints of each survey site were recorded using a hand-held Garmin etrex Vista GPS unit.

4.1 Visual (SCUBA, Mask/Snorkle and Bathyscope) Methods

Specific visual searches were conducted for freshwater mussels, fish, and freshwater snails. The survey team spread out across the stream into survey lanes to provide total width coverage as they ascended the stream. All appropriate habitat types within a given survey reach were searched thoroughly via visual surveys using primarily mask/snorkel, and occasionally glass bottom buckets (bathyscopes) in the shallow water habitats and SCUBA at the sites in the impounded reach (Sites 6-9, 16,18). Tactile methods were also employed when appropriate. Where SCUBA was used, one of the three person survey team members provided surface support to the divers.

All species of freshwater bivalves were recorded and returned to the substrate. Searches were also conducted for relict shells. The presence of a shell was equated with presence of that species, but not factored into the Catch per Unit Effort (CPUE), which is defined as the number of individuals found per person hour of search time. All species that are monitored by the NC Natural Heritage Program (NCNHP) were measured (total length). Snails were hand picked from rocks and woody debris. Dip nets were used, where appropriate, to sift through leaf packs. Following each timed search, collected snails were identified to the species level and each species was assigned a relative abundance rating to correspond to the survey site.

Active searches for mussels and snails were also conducted by turning over rocks and lifting submerged rootmats. Each person conducting visual surveys also used small hand-held dip nets, or mesh bags to capture species. All fish species captured or observed using these methods were identified and recorded with notes made regarding their relative abundances.

4.2 Active Capture (Seine Netting/Dip Netting/Hook and Line) Methods

After visual surveys were completed, a combination of seine netting and hand-held dip netting was used to capture fish. These methods were used at each of the upstream and downstream survey sites (Sites 1-5, 10-15, 17). Active capture fish surveys were not conducted within the impounded locations, as water depths were too deep to employ similar methodologies as those used at the other sites. Additionally, it was determined in conjunction with USFWS that these lentic areas contain a predictable suite of impoundment-adapted species and therefore would not require an initial inventory. Fish species observed while conducting visual surveys within the impounded sites were recorded and assigned a relative abundance based on the number of individuals seen at the site.

As with the visual surveys, the survey team began at the downstream point of the survey site and proceeded upstream. Seine netting was the primary method used to sample fish, as it is the most effective survey method for the targeted Cape Fear shiner. Seine netting is an effective method in shallow riffles and runs, as well as shallow pools; generally the preferred habitat of the Cape Fear shiner. This method is not as effective in deeper pools or riffles with a very strong current, therefore fish species preferring these habitats were not effectively sampled. Other sample methods included capturing fish in hand held dip nets against shoreline or bottom structure as well as visual census surveys. Visual survey census methods using mask/snorkel were also employed. These methods often provide more accurate estimates on abundance of some species than more traditional methods, such as mark recapture and depletion (Hankin and Reeves 1988, personal observations).

All habitat types present in each survey reach were sampled using the following method, surveyors moving upstream at 3-4 meter intervals until the entire length of the habitat type (riffle/run, pool) was sampled. This process was performed in the middle of the channel and close to each bank, in order to survey the entire habitat. This method was effective in riffle and run habitats of shallow to moderate depths, but was fairly ineffective in deep runs, and wide deep pools.

All captured fish were placed into a water bucket until they could be identified, counted, and released. The length of time necessary to identify, count, and release the fish depended upon the number of fish in the bucket and their condition. Any fish that did not recover from the sampling were preserved in 95% ethanol. Habitat notes were recorded at each collection site. A relative abundance was assigned to each species captured or observed at each site.

Hook and line fishing with spinner baits was also employed at a few locations. This was not a primary method of sampling and mainly used for recreation while accessing survey sites and during the time between Visual and Active Capture Methods. It did not produce any species that were not detected using other sampling methods.

5.0 RESULTS

A total of 32 fish species, at least 16 freshwater mussel species, 4 aquatic snail species, and 2 freshwater clam species were located during the combined survey efforts (Table 3). Mussels were found at all sites that were surveyed for mussels except the impounded section of Big Governors Creek (Site 18). Mussel surveys were not conducted at the Tailrace site (Site 10) or the Deep River Island Channel-upstream (Site 2); however, relict shells of mussels were observed at these two sites. The Cape Fear shiner, was located at two upstream sites in the Deep River (Sites 1 and 3) and two sites in the Deep River downstream of the dam (Sites, 10 and 13).

Table 3. Aquatic Species Found in Carbonton Dam Pre-Removal Surveys

Scientific Name	Common Name	Sites
Freshwater Mussels	~	~
Alasmidonta undulata	triangle floater	3,5,7,12
Alasmidonta varicosa	brook floater	1,3,5,
Elliptio angustata	Carolina lance	14
*Elliptio complanata**	Eastern elliptio	1-17
*Elliptio icterina**	variable spike	3,5,11,14,15,17
Elliptio producta	Atlantic spike	5,6,11,15
Elliptio roanokensis	Roanoke slabshell	6,11,12
Elliptio sp.	lanceolate elliptio	6,11,12
Elliptio spp.*	elliptio mussels	14
Lampsilis cariosa	yellow lampmussel	1,4,5,6,11,14
Pyganadon cataracta	Eastern floater	7,9
Strophitus undulatus	Creeper	1,3,4,5,
Toxolasma pullus	Savannah liliput	3
Uniomerus carolinianus	Florida pondhorn	3,6,7,8,9,11,14,15
Utterbackia imbecillis	paper pondshell	9
Villosa delumbis	Eastern creekshell	1,2,3,11,12,13,14,15
Villosa vaughniana	Carolina creekshell	12
Freshwater Snails and clams	~	**Sites**
Campeloma decisum	pointed campeloma	1,3,4,6,7,8,11,13,17
Corbicula fluminea	Asian clam	All
Elimia catenaria	gravel elimia	1,3,4,5,14
Helisoma anceps	Two-ridge rams-horn	3,4
Hydrobidae	Hydrobiade snail	4,17
Psidium sp.	A fingernail clam	15
Freshwater Fish	~	**Sites**
Ameiurus natalis	yellow bullhead	3
Amboplites cavifrons	Roanoke bass	1
Cyprinella analostanus	satinfin shiner	1,10
Cyprinella nivea	whitefin shiner	1,10,11,12

Dorosoma cepedianum	gizzard shad	10
Erimyzon oblongus	creek chubsucker	2
Esox americanus	redfin pickerel	17
Etheostoma flabellare	fantail darter	3,4,
Etheostoma olmstedi	tesseslated darter	1,2,3,4,6,11,12,13,14,15,17
Etheostoma serriferum	sawcheek darter	17
Fundulus rathbuni	speckled killifish	12,13,14
Gambusia holbrookii	eastern mosquitofish	1,2,3,4,5,12,13,14
Ictaluridae	Catfish	6,7
Lepomis auritus	redbreast sunfish	2,4,5
Lepomis cyanellus	green sunfish	2,3,4
Lepomis macrochirus	Bluegill	1,2,3,4,5,6,7,8,11,13,15,17
Luxilus albeolus	white shiner	1,2,15
Micropterus salmoides	largemouth bass	5,6,8,9,11,13,17
Minytrema melanops	spotted sucker	2,3,4
Moxostoma pappillosum	V-lip redhorse	2,3,4
Nocomis leptocephalus	bluehead chub	2,3,10,11,15,17
Notemigonus crysoleucas	golden shiner	10
Notropis alborus	whitemouth shiner	3,4,5,10,11,12,13,14,15
Notropis altipinnis	highfin shiner	1,3,4,10,11,15
Notropis amoenus	comely shiner	10
Notropis hudsonius	spottail shiner	1,2,3,4,5,10,11,12,13,14,15
Notropis mekistocholas	Cape Fear shiner	1,3,10,13
Notropis procne	swallowtail shiner	1,2,3,4,5,10,11,12,13,14,15
Notropis scepticus	sandbar shiner	1,2,3,4,5,10,11,12,13,14
Noturus insignis	margined madtom	3,5,
Percina crassa	Piedmont darter	1,3,5,6,11,12,15
Scartomyzon sp. nov.	brassy jumprock	2,3
Semotilus atromaculatus	creek chub	2

* Referred to collectively as *Elliptio* spp. at Site 14

Relative abundance for fish, freshwater snails, and freshwater clam species were estimated using the following criteria:

- Very abundant: > 30 collected at survey station
- Abundant: 15-30 collected at survey station
- Common: 6-15 collected at survey station
- Uncommon: 3-5 collected at survey station
- Rare: 1-2 collected at survey station
- Patchy: indicates an uneven distribution of the species within the sampled site.

CPUE was calculated for each freshwater mussel species located per site and refers to the number of individuals of that species found per one person hour of survey time. Survey results for each site are further described below.

Site 1 (Deep River-upstream-1):
This site occurs upstream of Howard Mill Road (SR 1456) in a series of boulder and cobble dominated riffles and runs, with small pools formed on the upstream of large boulders. Moderate sized beds of water willow (*Justichia americana*) occur in much of

the surveyed site. Timed mussel searches were conducted for 5 person hours and fish were sampled until no new species were collected (approximately 1.5 hours). The targeted Cape Fear shiner (1 individual) and Roanoke bass (1 individual) were collected at this site.

Table 4. Site 1: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels *	~	#/CPUE
Alasmidonta undulata	triangle floater	1 shell
Alasmidonta varicosa	brook floater	1 (0.20/hr)
Elliptio complanata	eastern elliptio	210 (42.0/hr)
Elliptio icterina	variable spike	Shells
Lampsilis cariosa	yellow lampmussel	7 (1.40/hr)
Strophitus undulatus	Creeper	2 (0.40/hr)
Villosa delumbis	Eastern creekshell	4 (0.80/hr)
Freshwater Snails and Clams	~	**Relative Abundance**
Campeloma decisum	pointed campeloma	patchy uncommon
Corbicula fluminea	Asian clam	Abundant
Elimia catenaria	gravel elimia	Abundant
Helisoma anceps	two-ridge rams horn	Common
Hydrobiidae	Hydrobiide snail	Uncommon
Freshwater Fish	~	**Relative Abundance**
Amboplites cavifrons	Roanoke bass	rare (2)
Cyprinella analostanus	satinfin shiner	Uncommon
Cyprinella nivea	whitefin shiner	Uncommon
Etheostoma olmstedi	tesselated darter	Common
Gambusia holbrookii	Eastern mosquitofish	Uncommon
Lepomis macrochirus	Bluegill	Common
Luxilus albeolus	white shiner	Common
Notropis altipinnis	highfin shiner	Common
Notropis hudsonius	spottail shiner	Common
Notropis mekistocholas	Cape Fear shiner	rare (1)
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Common
Percina crassa	Piedmont darter	Common

* The notched rainbow *(Villosa constricta)* recorded at this site in 1997 (Personal observations)

Site 2 (Deep River-upstream-2-(Island Channel/Howard Mill Road):
This site occurs within an overflow channel formed along the right descending bank of the Deep River just upstream of Howard Mill Road (SR 1456) at approximately 35.5051°N, 79.5847°W. The site is connected with Site 1; however, it was treated as a separate site due to the different characteristics than the main river channel. The island channel receives significant flows during high water periods, but also appears to receive a small amount of flow from the river during low flow. In addition, a small intermittent stream joins the channel in mid course. Habitat in the channel consists of shallow riffles and small pools of moderate (3 feet) depth. Gravel, sand, and cobble dominate the substrate, and multiple sand/gravel bars occur throughout the channel. This is the only location that the creek chubsucker and the creek chub were found during this survey effort. Live freshwater mussels were not observed in this channel, however shells of the

eastern elliptio and the eastern creekshell were found. The Asian clam is fairly common in the channel.

Table 5. Site 2: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	**~**	**#/CPUE**
Elliptio complanata	Eastern elliptio	Shells
Villosa delumbis	Eastern creekshell	1 shell
Freshwater Snails and Clams	~	**Relative Abundance**
Campeloma decisum	pointed campeloma	Uncommon
Corbicula fluminea	Asian clam	Common
Freshwater Fish	~	**Relative Abundance**
Erimyzon oblongus	creek chubsucker	rare (2)
Etheostoma olmstedi	tesseslated darter	Common
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis auritus	redbreast sunfish	rare (1)
Lepomis cyanellus	green sunfish	rare (1)
Lepomis macrochirus	bluegill	rare (2)
Luxilus albeolus	white shiner	Common
Minytrema melanops	spotted sucker	Common
Moxostoma pappillosum	V-lip redhorse	rare (1)
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis hudsonius	spottail shiner	Common
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Uncommon
Scartomyzon sp. nov.	brassy jumprock	Common
Semotilus atromaculatus	creek chub	very abundant

Site 3 (Deep River-upstream-3):
This site occurs in the vicinity of the NC 22 crossing of the Deep River and is characterized by a series of small vegetated islands with multiple channels. Substrate consists of boulders and cobble, with accumulations of gravel in the shallow runs. Large water willow beds are present throughout the site. Timed mussel searches were conducted for 3 person hours and fish were sampled using seine netting and dipnetting for approximately 1 hour. The targeted Cape Fear shiner was abundant in every seine haul and the decision was made to cease survey activities at this site, to limit disturbance to this species.

Table 6. Site 3: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	**~**	**#/CPUE**
Alasmidonta undulata	triangle floater	1 (0.33/hr)
Alasmidonta varicosa	brook floater	4 (2/hr)
Elliptio complanata	eastern elliptio	358 (119.33/hr)
Strophitus undulatus	creeper	2 (0.67/hr)
Toxolasma pullus	Savannah liliput	1 (0.33/hr)
Unimoerus carolinianus	Florida pondhorn	7 (2.33/hr)
Villosa delumbis	Eastern creekshell	18 (6.0/hr)
Freshwater Snails and Clams	~	**Relative Abundance**
Campeloma decisum	pointed campeloma	Uncommon
Corbicula fluminea	Asian clam	Abundant
Elimia catenaria	gravel elimia	Abundant
Helisoma anceps	Two-ridge rams horn	patchy uncommon
Freshwater Fish	~	**Relative Abundance**
Ameiurus natalis	yellow bullhead	rare (2)
Etheostoma flabellare	fantail darter	Common
Etheostoma olmstedi	tesseslated darter	Uncommon
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis cyanellus	green sunfish	Uncommon
Lepomis macrochirus	Bluegill	Common
Minytrema melanops	spotted sucker	very abundant
Moxostoma pappillosum	V-lip redhorse	rare (1)
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Common
Notropis altipinnis	highfin shiner	Uncommon
Notropis hudsonius	spottail shiner	Common
Notropis mekistocholas	Cape Fear shiner	very abundant (>100)
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Common
Notorus insignis	margined madtom	Common
Percina crassa	Piedmont darter	Common
Scartomyzon sp. nov.	brassy jumprock	rare (1)

Site 4 (Deep River-upstream-4):
This site occurs below the mouth of Tyson's Creek and is characterized as a swift, gravel/cobble dominated, run of moderate depth on the left descending side of the river, with a small depositional island creating a shallow sand dominated run/riffle and pool channel along the right descending bank. A large amount of coarse sand was being carried through the site during the site visits. Timed mussel searches were conducted for 2.5 person hours and fish were sampled until no new species were collected (approximately 1.5 hours).

Table 7. Site 4: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	**~**	**#/CPUE**
Elliptio complanata	eastern elliptio	63 (25.2/hr)
Lampsilis cariosa	yellow lampmussel	1 (0.5/hr)
Strophitus undulatus	creeper	2 (0.8/hr)
Freshwater Snails and Clams	~	**Relative Abundance**
Campeloma decisum	pointed campeloma	patchy uncommon
Corbicula fluminea	Asian clam	Abundant
Elimia catenaria	gravel elimia	Abundant
Helisoma anceps	two-ridge rams horn	patchy uncommon
Hydrobiidae	Hydrobiid snail	Abundant
Freshwater Fish	~	**Relative Abundance**
Etheostoma flabellare	fantail darter	Uncommon
Etheostoma olmstedi	tesseslated darter	Common
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis auritus	redbreast sunfish	rare (1)
Lepomis cyanellus	green sunfish	Uncommon
Lepomis macrochirus	bluegill	Common
Minytrema melanops	spotted sucker	Common
Moxostoma pappillosum	V-lip redhorse	rare (1)
Notropis alborus	whitemouth shiner	Common
Notropis altipinnis	highfin shiner	Uncommon
Notropis hudsonius	spottail shiner	Common
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Uncommon

Site 5 (Deep River-upstream-5):
This site included one of the first riffles upstream of the impoundment effects of the Carbonton dam and is located in the vicinity of Glendon Carthage Road (SR 1006). The area searched consisted of a riffle and flows into a slow moving pool of moderate depth. Depths sampled ranged from less than one foot to approximately five feet in the pool, however SCUBA was not necessary to effectively survey for the target mussel species. Substrates were dominated by sand and gravel, although cobble areas were common in the riffle. Silt-clay banks overlain with gravel and cobble were vegetated and mostly stable, providing some of the best mussel habitat in the surveyed reach. A series of small vegetated sand bar islands occurred in the river at this site near the left descending side of the river. Timed mussel searches were conducted for 4.5 person hours and fish were sampled until no new species were collected (approximately 1.5 hours).

Table 8. Site 5: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels *	**~**	**#/CPUE**
Alasmidonta undulata	triangle floater	2 (0.44/hr)
Alasmidonta varicosa	brook floater	2 0.44/hr)
Elliptio complanata	eastern elliptio	153 (34.0/hr)
Elliptio icterina	variable spike	23 (5.1/hr)
Elliptio producta	Atlantic spike	5 (1.1/hr)
Lampsilis cariosa	Yellow lampmussel	1 (0.22/hr)
Strophitus undulatus	Creeper	2 (0.44/hr)
Freshwater Snails and clams	**~**	**Relative Abundance**
Corbicula fluminea	Asian clam	common
Elimia catenaria	gravel elimia	patchy common
Freshwater Fish	**~**	**Relative Abundance**
Etheostoma flabellare	fantail darter	common
Etheostoma olmstedi	tesseslated darter	common
Gambusia holbrookii	Eastern mosquitofish	rare
Lepomis auritus	redbreast sunfish	rare
Lepomis macrochirus	bluegill	common
Micropterus salmoides	largemouth bass	rare
Notropis alborus	whitemouth shiner	common
Notropis hudsonius	spottail shiner	common
Notropis procne	swallowtail shiner	abundant
Notropis scepticus	sandbar shiner	common
Noturus insignis	margined madtom	common
Percina crassa	Piedmont darter	common

* The Atlantic pigtoe (*Fusconaia masoni*) has been recorded at this general location (Site 5 - near Glendon Carthage Road) in the early 1990s (NCNHP database search).

Site 6 (Deep River, impoundment-1):

This was the furthest upstream site within the Carbonton impoundment. Mussel surveys were conducted near a large rock outcrop on the left descending side of the river. Substrates were dominated by gravel/cobble and were interspersed with large boulders. Visual surveys were conducted using SCUBA at depths averaging 6 feet (maximum 12 feet) for 1.17 person hours. This site had the highest mussel diversity and abundance of the impounded sites. Fish surveys were not conducted at this site; however, a number of fish species were observed and noted during the mussel surveys.

Table 9. Site 6: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Elliptio complanata	eastern elliptio	75 (64.0/hr)
Elliptio producta	Atlantic spike	5 (4.3/hr)
Elliptio sp.	lanceolate elliptio	5/ (4.3/hr)
Elliptio roanokensis	Roanoke slabshell	1/ (0.85/hr)
Uniomerus caroliniana	Florida pondhorn	8/ (4.4/hr)
Lampsilis cariosa	yellow lampmussel	1 shell
Freshwater Snails and Clams	~	**Relative Abundance**
Corbicula fluminea	Asian clam	common
Campeloma decisum	Pointed campeloma	common
Freshwater Fish	~	**Relative Abundance**
Etheostoma olmstedi	tesseslated darter	present*
Lepomis macrochirus	Bluegill	present*
Micropterus salmoides	largemouth bass	present*
Percina crassa	Piedmont darter	present*
Ictaluridae	Catfish	present*

* Species was observed at site, but relative abundance could not be estimated due to poor conditions for visual surveys

Site 7 (Deep River, impoundment-2):

This impoundment site was located downstream of an island that divided the channel, just below the confluence of McLendons Creek. The substrate consisted of a gravel/sand bar below the surface covered with scattered large cobbles and boulders. Depths searched averaged approximately 6 feet (maximum depth 11 feet). SCUBA surveys were conducted for 1.17 person hours. Fish surveys were not conducted at this site; however, a few fish species were observed and noted during the mussel surveys. The eastern elliptio was the most abundant mussel found with the Florida pondhorn next in abundance. An individual eastern floater, a species well adapted to lentic conditions, was also found.

Table 10. Site 7: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Alasmidonta undulata	Triangle floater	1 (0.44/hr)
Elliptio complanata	eastern elliptio	57 (46/hr)
Pyganadon cataracta	eastern floater	2 (0.88/hr)
Uniomerus caroliniana	Florida pondhorn	8 (4.40/hr)
Freshwater Snails and Clams	~	**Relative Abundance**
Corbicula fluminea	Asian clam	Common
Campeloma decisum	pointed campeloma	Common
Freshwater Fish	~	**Relative Abundance**
Lepomis macrochirus	bluegill	present*
Ictaluridae	catfish	present*

* Species was observed at site, but relative abundance could not be estimated due to poor conditions for visual surveys

Site 8 (Deep River, impoundment-3):
This site was located just downstream of a large, nearly 180º bend in the river near a significant rock outcrop. Average search depths were approximately 10 feet (maximum depth 20 feet). Substrates were dominated by sand and gravel with some cobble and silty areas present. Only two mussel species were found. SCUBA searches were conducted for 1 person hour. Fish surveys were not conducted at this site; and few fish were observed during the mussel survey, which was likely due to the poor water clarity.

Table 11. Site 8: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Elliptio complanata	eastern elliptio	24 (24/hr)
Uniomerus caroliniana	Florida pondhorn	10 (10/hr)
Freshwater Snails and Clams	~	**Relative Abundance**
Campeloma decisum	pointed campeloma	Rare
Corbicula fluminea	Asian clam	Common
Freshwater Fish	~	**Relative Abundance**
Lepomis macrochirus	bluegill	present*
Micropterus salmoides	largemouth bass	present*

* Species was observed at site, but relative abundance could not be estimated due to poor conditions for visual surveys

Site 9 (Deep River, impoundment-4):
This site is less than two RMs upstream of the Carbonton dam. Flow was virtually non-existent when compared to the other impoundment sites, and an accumulation of silt covered most substrates, including rock outcrops. Average search depth was approximately 11 feet (maximum depth 15 feet). Mussel searches were conducted for 0.83 person hours. Fish surveys were not conducted at this site; and few fish were observed during the mussel survey, which was likely due to the poor water clarity. Fairly large numbers of Florida pondhorn were located at this survey site along with the only occurrence of paper pondshell found during the survey effort. The majority of mussels found at this site occurred along the sloping clay banks just below the water's edge.

Table 12. Site 9: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	**~**	**#/CPUE**
Elliptio complanata	eastern elliptio	2 (2.4/hr)
Pyganadon cataracta	eastern floater	3 (3.6/hr)
Uniomerus caroliniana	Florida pondhorn	20 (24.1/hr)
Utterbackia imbecillis	paper pondshell	1 (1.2/hr)
Freshwater Fish	~	**Relative Abundance**
Micropterus salmoides	largemouth bass	present*

* Species was observed at site, but relative abundance could not be estimated due to poor conditions for visual surveys

Site 10 (Deep River, downstream-1):
This site was located within the tailrace directly below the Carbonton dam. The area consists primarily of bedrock adjacent to the dam and shallow gravel shoals and bars, with sparse patches of water willow present. The site was seined for fish, but due to high water velocity, mussel surveys were not able to be conducted. Seine hauls were conducted up to the dam over the bedrock areas. This site contained several lotic-adapted shiner species, including eight Cape Fear shiner. These individuals were captured along a sand bar in moderate current.

Table 13. Site 10: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Elliptio complanata	eastern elliptio	Shells
Freshwater Snails and Clams	~	**Relative Abundance**
Corbicula fluminea	Asian clam	Common
Freshwater Fish	~	**Relative Abundance**
Cyprinella analostana	satinfin shiner	Uncommon
Cyprinella nivea	whitefin shiner	Uncommon
Dorosoma cepedianum	gizzard shad	Uncommon
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis alborus	whitemouth shiner	Common
Notropis altipinnis	highfin shiner	Common
Notropis amoenus	comely shiner	Rare
Notropis hudsonius	spottail shiner	Uncommon
Notropis mekistocholas	Cape Fear shiner	common (8)
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Common
Notemigonus crysoleucas	golden shiner	Common

Site 11 (Deep River, downstream-2):
This site represents the first major riffle/run habitat below Carbonton dam. Searches were concentrated within this relatively shallow riffle and run ranging from less than 1 foot to 3 feet deep. Substrate was dominated by cobble, gravel, and sand with silt-clay banks. Areas of exposed bedrock were also present. Fairly high accumulations of silt were observed on the substrate throughout much of the site. Timed mussel searches were conducted for 5.25 person hours and fish were sampled until no new species were collected (approximately 1.0 hours).

Table 14. Site 11: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	~	**#/CPUE**
Elliptio complanata	eastern elliptio	109 (20.8/hr)
Elliptio icterina	variable spike	2 (0.38/hr)
Elliptio producta	Atlantic spike	5 (0.95/hr)
Elliptio roanokensis	Roanoke slabshell	5 (0.95/hr)
Lampsilis cariosa	yellow lampmussel	1 (0.2/hr)
Elliptio sp.	lanceolate elliptio	6 (1.14/hr)
Uniomerus caroliniana	Florida pondhorn	23 (4.4/hr)
Villosa delumbis	eastern creekshell	3 (0.57/hr)
Freshwater Snails and Clams	**~**	**Relative Abundance**
Corbicula fluminea	Asian clam	Common
Campeloma decisum	pointed campeloma	Common
Freshwater Fish	~	**Relative Abundance**
Cyprinella nivea	whitefin shiner	Uncommon
Etheostoma olmstedi	tesseslated darter	Uncommon
Lepomis macrochirus	bluegill	Rare
Micropterus salmoides	largemouth bass	Rare
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Common
Notropis altipinnis	highfin shiner	Uncommon
Notropis hudsonius	spottail shiner	Uncommon
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Common
Percina crassa	Piedmont darter	Common

Site 12 (Deep River-downstream-3):

This site occurs in the vicinity of the Plank Road (SR 1007) crossing of the Deep River, and was accessed via the Triangle Lands canoe access. A moderately deep (3 feet) run occurs along the left descending bank and a vegetated island forms a shallow riffle/run channel along the right bank. A large pooled area occurs at the head of the island. The substrate in the runs is predominately sand and gravel. Cobble and gravel, with deposits of silt, occur in the pooled areas. Timed mussel searches were conducted for 3.75 person hours and fish were sampled until no new species were collected (approximately 1.5 hours).

Table 15. Site 12: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels *	~	**#/CPUE**
Alasmidonta undulata	triangle floater	1 (0.27/hr)
Elliptio complanata	Eastern elliptio	152 (40.53/hr)
Elliptio roanokensis	Roanoke slabshell	1 shell
Lampsilis cariosa	yellow lampmussel	0.2
Elliptio sp.	lanceolate elliptio	1 shell
Villosa delumbis	eastern creekshell	2 (0.53/hr)
Villosa vaughniana	Carolina creekshell	1 (0.27/hr)
Freshwater Snails and Clams	**~**	**Relative Abundance**
Corbicula fluminea	Asian clam	Common
Freshwater Fish	~	**Relative Abundance**
Cyprinella nivea	whitefin shiner	Common
Etheostoma olmstedi	tesseslated darter	Uncommon
Fundulus rathbuni	speckled killifish	rare (2)
Gambusia holbrookii	Eastern mosquitofish	Common
Notropis alborus	whitemouth shiner	Common
Notropis hudsonius	spottail shiner	Common
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Uncommon
Percina crassa	Piedmont darter	Uncommon

*The notched rainbow (*Villosa constricta*) has also been reported from this site (Johnson 1970).

Site 13 (Deep River-downstream-4):

This site occurs in the vicinity of the US 421 crossing of the Deep River. Large amounts of woody debris have accumulated throughout the river in this location, creating numerous sand bars within the channel. The majority of the substrate in this area is dominated by unconsolidated sands; however, gravel troughs occur at the base of the clay banks on both sides of the river, which provide the most suitable habitat for mussels in this section of river. Timed mussel searches were conducted for 3.0 person hours and fish were sampled until no new species were collected (approximately 1 hour).
One well worn (frayed fins) Cape Fear shiner was captured at this location.

Table 16. Site 13: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	~	**#/CPUE**
Elliptio complanata	Eastern elliptio	61 (20.33/hr)
Villosa delumbis	eastern creekshell	1 (0.33/hr)
Freshwater Snails and Clams	**~**	**Relative Abundance**
Campeloma decisum	pointed campeloma	patchy uncommon
Corbicula fluminea	Asian clam	Common
Freshwater Fish	~	**Relative Abundance**
Etheostoma olmstedi	tesseslated darter	Common
Fundulus rathbuni	speckled killifish	Common
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	uncommon
Notropis alborus	whitemouth shiner	Abundant
Notropis hudsonius	spottail shiner	Abundant
Notropis mekistocholas	Cape Fear shiner	rare (1)
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Common

Site 14 (Deep River-downstream-5):

This site occurs upstream of the Roser/Cummock Road (SR 2153/1400) crossing of the Deep River, and was accessed from the County park. The site is characterized by a long boulder/cobble dominated riffle with very swift flow, and a long gravel and sand run of moderate depth (2-3 feet). Small pools have formed upstream of woody debris accumulated along the clay banks. Timed mussel searches were conducted for 3.0 person hours and fish were sampled until no new species were collected (approximately 2 hours).

Table 17. Site 14: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater Mussels	~	**#/CPUE**
Elliptio angustata	Carolina lance	1 (0.33/hr)
Elliptio complanata	Eastern elliptio	140 (46.67/hr)
Lampsilis cariosa	yellow lampmussel	1 shell
Uniomerus carolinianus	Florida pondhorn	2 (0.67/hr)
Villosa delumbis	eastern creekshell	3 (1.0/hr)
Freshwater Snails and Clams	**~**	**Relative Abundance**
Campeloma decisum	pointed campeloma	patchy uncommon
Corbicula fluminea	Asian clam	Abundant
Elimia catenaria	gravel elimia	patchy uncommon
Freshwater Fish	~	**Relative Abundance**
Etheostoma olmstedi	tesseslated darter	Common
Fundulus rathbuni	speckled killifish	Uncommon
Gambusia holbrookii	Eastern mosquitofish	Common
Notropis alborus	whitemouth shiner	Abundant
Notropis hudsonius	spottail shiner	Abundant
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Abundant

Site 15 (McLendons Creek, upstream):
This site was located on the largest of the Deep River tributaries impounded by the Carbonton dam. It was sampled for fish, mussels, and snails upstream of the impoundment effect (near the Cool Springs Road crossing). The wide floodplain surrounding the site is forested and natural. The stream is approximately 10-12 meters wide with very stable, vegetated banks. Substrate is dominated by sand and gravel with an occasional rock outcrop present. Gravel runs provided excellent mussel habitat. Mussel searches were conducted more than 200 meters below Cool Spring Road to a point just above the road crossing. Fish were collected in a riffle pool area above the road crossing. Survey depths averaged 1.5 feet deep with a maximum depth of 3 feet. Mussel searches were conducted for 3.5 person hours and fish were sampled until no new species were collected. Five species of mussels were collected, including the state rare eastern creekshell. Two freshwater clam species, the Asian clam, and a native pea clam (*Sphaerium sp.*) were common at this site. Fish species collected included six species of shiner.

Table 18. Site 15: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Elliptio complanata	eastern elliptio	286 (88.90/hr)
Elliptio icterina	variable spike	3 (0.85/hr)
Elliptio producta	Atlantic spike	2 (0.57/hr)
Uniomerus caroliniana	Florida pondhorn	1 (0.28/hr)
Villosa delumbis	Eastern creekshell	3 (0.85/hr)
Freshwater Snails and Clams	~	**Relative Abundance**
Corbicula fluminea	Asian clam	Common
Sphaerium sp.	a fingernail clam	Common
Freshwater Fish	~	**Relative Abundance**
Etheostoma olmstedi	tesseslated darter	Common
Lepomis macrochirus	bluegill	Rare
Luxilus albeolus	white shiner	Abundant
Nocomis leptocephalus	bluehead chub	Common
Notropis alborus	whitemouth shiner	Uncommon
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Uncommon
Notropis procne	swallowtail shiner	Abundant
Percina crassa	Piedmont darter	Common

Site 16 (McLendons Creek, impoundment):
This site is impounded and was surveyed for mussels downstream of the Glendon-Carthage Road crossing. The channel is approximately 10 meters wide and has a wide, natural floodplain. Substrate in this portion of McLendons Creek is dominated by thick accumulations of silt and detritus with sloping clay banks, although some areas of gravel were searched. Woody debris was heavy throughout the surveyed reach. Depths averaged 4 feet, with 8 feet being the maximum depth reached. Mussel habitat was marginal. One eastern elliptio was located during 1.33 person hours of SCUBA search time. Fish surveys were not conducted at this site, and no fish species were observed during the visual (mussel) surveys. The Asian clam was observed to be rare at this site.

Table 19. Site 16: Aquatic Species Found

Scientific Name	Common Name	Abundance
Freshwater mussels	~	**#/CPUE**
Elliptio complanata	Eastern elliptio	1 (0.75/hr)
Freshwater Snails and clams	**~**	**Relative Abundance**
Corbicula fluminea	Asian clam	Rare

Site 17 (Big Governors Creek, upstream):
This section of Big Governors Creek occurs in a wide, low-lying floodplain near the Underwood Road crossing. While the site is outside of the recognized impoundment area, the stream appears as slow moving slackwater, with only one 'riffle' area observed downstream of the road crossing (likely result of construction rip-rap). Mussel surveys were conducted for more than 200 meters, starting downstream of the road and ending upstream near the confluence of Crawley Creek. Substrate was dominated by gravel and

mud, with a high concentration of detritus and woody debris. Mussel searches were conducted for 2.25 person hours, with two species being found. Fish surveys were conducted using seine netting and dip netting until no new species were collected (approximately 1 hour). No shiner species were located during the fish surveys; however, fish species typically associated with slow-moving swampy streams, such as the redfin pickerel and sawcheek darter, were found only at this site.

Table 20. Site 17: Aquatic Species Found

Scientific Name	Common Name	Abundance/CPUE
Freshwater mussels	~	**CPUE**
Elliptio complanata	eastern elliptio	40 (17.7/hr)
Elliptio icterina	variable spike	2 (0.89/hr)
Freshwater snails and clams	~	**Relative Abundance**
Corbicula fluminea	Asian clam	Uncommon
Campeloma decisum	pointed campeloma	Common
Hydrobiidae	Hydrobid snail	Rare
Freshwater fish	~	**Relative Abundance**
Esox americanus	redfin pickerel	Common
Etheostoma olmstedi	tesseslated darter	Common
Etheostoma serriferum	sawcheek darter	Uncommon
Lepomis macrochirus	Bluegill	Common
Micropterus salmoides	largemouth bass	Uncommon
Nocomis leptocephalus	bluehead chub	Common

Site 18 (Big Governors Creek, impoundment):
This impounded site was surveyed for mussels downstream of Steel Bridge Road (SR 1625) crossing. The approximately 8 meter wide channel is surrounded by a low lying, swampy floodplain. Substrate is dominated by silt and detritus and there are large accumulations of woody debris within the channel. Depths reached 12 feet, but averaged less than 5 feet. SCUBA searches were conducted for 1.5 person hours and no freshwater mussels were found. Fish surveys were not conducted at this site, and no fish species were observed during the visual (mussel) surveys. A few relict Asian clam shells were observed; however no live individuals were recorded.

6.0 DISCUSSION

Qualitative surveys for various targeted aquatic species were conducted to provide a baseline for the presence/absence of fish, freshwater bivalve and aquatic snail species at specific locations in the section of the Deep River (and its tributaries) impounded by Carbonton dam and those same water bodies in the immediate area above or below the impounded reaches. Changes in faunal community composition should be monitored over time following dam removal.

6.1 Freshwater Mussels

More species of freshwater mussels have been reported from the Cape Fear River Basin (29) than any other river basin in North Carolina (Bogan 2002). Although no federally

protected mussel species are included in this fauna, as discussed above, several rare and state listed species are known from the basin. At least 16 species of freshwater mussels were found during this survey effort, including eight of the twelve targeted freshwater mussel species.

With the exception of Site 18 (Big Governors Creek, impoundment), freshwater mussels were found at all of the surveyed sites. The eastern elliptio was the most commonly encountered species at all of but one of the sites (Site 9 Deep River impoundment-4), where the Florida pondhorn was most common. Relative abundance (estimated by CPUE) for the eastern elliptio was highest at Site 3 (Deep River-upstream-3) with 119.33 individuals located per hour of survey time, followed by Site 15 (McLendons Creek, upstream) and Site 6 (Deep River impoundment-1), with 88.9 and 64.0 individuals located per hour of survey time, respectively.

Eight of the eleven targeted mussel species listed in Table 1 were found during this survey effort. The three targeted species not found are the Atlantic pigtoe, green floater and notched rainbow. However, in the past, the notched rainbow has been found in the vicinity of Site 1 and Site 12, and the Atlantic pigtoe has been found near Site 5. The fact that these species were not detected during this survey effort, confirms their rarity in the Deep River, and may even suggest possible extirpation from the river, as both species are usually easily detectable where they occur (personal observations). The green floater has never been reported in the Deep River, is known from only a few locations in the Cape Fear River Basin, and has not been reported in recent years.

The survey results indicate that the un-impounded reaches of the Deep River generally contained the highest species richness. Eight mussel species were found at Site 11 (Deep River-downstream-2), followed by seven species at Site 3 (Deep River-upstream-3), Site 5 (Deep River-upstream-5) and Site 12 (Deep River, downstream-3), respectively. The eight targeted “rare” mussel species were found primarily at un-impounded sites within the Deep River (Table 21).

Table 21. Relative Abundance and diversity of mussels per survey site

Site	CPUE all mussels	# mussels species*	# rare mussel species	# fish species
1: Deep River-upstream-1 (Howard Mill Rd)	44.8/hr	5	4	13
2: Deep River-upstream-2 (Island Channel/Howard Mill Rd) and Site 10 Deep River-downstream-1 (Tailrace)	not sampled for mussels			
3: Deep River-upstream-3 (NC 22)	130.33/hr	7	5	18
4: Deep River-upstream-4 (Tyson's Creek)	26.4/hr	3	2	13
5: Deep River-upstream-5 (Glendon-Carthage Rd)	41.77/hr	7	4	12
6: Deep River-impoundment-1	81.19/hr	6	2	5*
7: Deep River impoundment-2	58.12/hr	4	1	2*
8: Deep River impoundment-3	34.0/hr	2	0	2*
9: Deep River impoundment-4	31.32/hr	4	0	1*
10: Deep River downstream-1	not sampled for mussels			
11: Deep River downstream-2	29.33/hr	8	3	11
12: Deep River-downstream-3 (Plank Road)	41.86/hr	7	5	9
13: Deep River-downstream-4 (US 421)	20.67/hr	2	1	10
14: Deep River-downstream-5 (Rosser/Cummock Rd)	48.67/hr	5	2	7
15: McLendons Creek-upstream (Cool Springs Rd)	84.28/hr	5	1	9
16: McLendons Creek impoundment	0.75/hr	1	0	0*
17: Big Governors Creek-upstream (Underwood Rd)	18.67/hr	2	0	6
18: Big Governors Creek-impoundment	0.0/hr	0	0	0*

The brook floater and creeper were found at three and four sites, respectively, upstream of the reservoir pool (Sites 1, 3, and 5 and Sites 1, 3, 4 and 5). All of these sites are characterized as having a significant amount of habitat complexity. The absence of these species at the survey sites downstream of Carbonton Dam is most likely a reflection of the rarity of these species in the Deep River, and the limited amount of habitat complexity at some of the sampled downstream sites. Both of these species likely occur in low numbers at scattered locales in the Deep River below Carbonton Dam. The restoration of habitat within the reservoir pool may provide more potential habitat for these species in the river.

The eastern creekshell was found at the majority of the un-impounded sites (Sites 1-3, and 11-15) usually associated with shallow low velocity areas near the banks. Likewise, the yellow lampmussel was found at a number of upstream and downstream sites (Sites 1, 4, 5, 6, 11, and 14). The occurrence at Site 6, within the impoundment is represented by 1 very weathered relict shell, indicating that this species may occur in low numbers in the upper limits of the reservoir pool, where the lentic effect is diminished.

The state endangered Carolina creekshell and Savannah liliput were each represented by only one individual during the entire survey effort. The occurrence of the Carolina creekshell at Site 12 is somewhat of an oddity as this species is usually associated with smaller water bodies. This species likely occurs at various locales in the Deep River in low numbers, but is more likely to occur in larger numbers in tributaries to the river. The removal of Carbonton Dam may provide potential habitat for this species in the restored reaches of Big Governors Creek and McLendons Creek. The Savannah liliput was found at Site 3. This is only the second individual of this species reported from the entire Deep River subbasin. This species has only been reported at one other location in the Deep River (Art Bogan, personal communication). The Savannah liliput is more commonly associated with shallow water habitats with fine sediments and little to no current. Although Site 3 is characterized as a swift flowing riffle/run habitat, the numerous beds of water willow provide some hydraulic refugia and thus accumulate finer sediments, providing suitable habitat for this species. This species is likely very rare in the Deep River; however, it may be under sampled due to its diminutive size. If areas within the impounded reach develop similar characteristics as those present at Site 3 following dam removal, the Savannah liliput may be able to establish itself in these areas.

The impounded sites contain a less diverse, more lentic adapted mussel fauna than the un-impounded sites. The eastern floater and paper pondshell most often associated with lentic habitats were found only within the impounded portion of the Deep River. Species richness and mussel abundance within the impounded portion of the river increased with increasing distance upstream of the dam, suggesting a diminished lentic effect in the upstream limits of the impoundment. Mussels found within the lower limits of the impoundment Site 8 (Deep River, impoundment-3) and Site 9 (Deep River, impoundment-4) respectively were found primarily along the banks just below the waters edge, as the deeper habitats were heavily silted. In contrast the bottom substrates at the upstream sites within the impoundment, Site 6 (Deep River, impoundment-1), and Site 7 (Deep River, impoundment-2) were relatively free of fine sediments and supported comparatively high numbers of the eastern elliptio.

Noteworthy within the impoundment was the presence of a relatively old Roanoke slabshell individual at Site 6. This marks the furthest upstream occurrence of this species in the Cape Fear River Basin. The species was also found in low numbers downstream of the dam at Sites 11 and 12. The Roanoke slabshell, considered Threatened in North Carolina, is believed to have an anadromous fish host. The few individuals found during this survey effort may be senescent individuals that existed in this reach before construction of the many dams on the Cape Fear River, including the Carbonton dam, as

many mussel species are long-lived organisms. It may also be possible that a population of this species is able to persist in very low numbers, by either using a less suitable fish species as a host (resulting in lower transformation), or by using direct transformation (bypassing the obligate fish host). Direct transformation has been reported in some mussel species, but never within the genus elliptio.

6.2 Aquatic Snails and Freshwater Clams

The pointed campeloma was the most common aquatic snail found during the survey efforts, being present at 9 of the 18 sites sampled. This species tolerates a wide range of habitat conditions, including lentic habitats. The gravel elimia, a lotic riffle adapted species was found exclusively in riffle habitats dominated by rocky substrates (Sites 1,3,4,5,14). Its apparent absence from the riffle habitat of Site 11 (Deep River, downstream-2) may be attributed to the relatively high silt loads observed at this site. The removal of the Carbonton dam will likely result in an increase of habitats occupied by this species within the Deep River as some areas revert to riffle conditions.

Two clam species were found during the pre-removal surveys, the invasive and ubiquitous Asian clam and a native fingernail clam. The Asian clam was found, usually in large numbers, at all of the sites surveyed with the exception of Site 18 (Big Governors Creek-impoundment), however, a few relict shells of this species were observed at this site. Native fingernail clams were found only at Site 15 (McLendons Creek-upstream). The apparent absence of fingernail clams at the other sites is more likely the result of not being detected rather than being absent, as fingernail clams are fairly difficult to detect without survey methods utilizing excavation of sediment.

6.3 Fish

At least 70 species of freshwater fish, including the federally endangered Cape Fear shiner have been reported from the Upper (above the fall line) Cape Fear River Basin (Menhenick 1991); at least ten of these are not native to the basin. The Carbonton dam currently separates two populations of the Cape Fear shiner in the Deep River. A stated goal of the dam removal project is to restore the habitat within the Deep River and its tributaries impounded by the Carbonton dam to lotic conditions, thus reconnecting the two isolated populations. Changes in fish community composition in response to dam removal will be evaluated as part of the proposed removal. The Cape Fear shiner is the main target species for this study. Other riffle adapted species will serve as surrogate species to demonstrate habitat restoration success.

The impounded portions of the Deep River and its tributaries contain a predictable suite of impoundment-adapted species and thus fish surveys were not conducted within the impounded reaches. Additionally, the target species, the Cape Fear shiner is not found in impounded reaches (Howard 2003).

As expected, shallow lotic species that exhibit affinities for rocky riffle/run habitats were located at the un-impounded survey stations. Survey sites that contained the greatest

amount of habitat complexity (Sites 1-4) yielded the highest number of fish species (13, 15, 18 and 13 respectively. If Sites 1 and 2 are considered collectively as 1 site, fish species number is 21. The fish composition between the un-impounded upstream and downstream sites on the Deep River is fairly comparable, with the differences in species composition likely attributable to differences in habitat complexity between sites.

Although fish surveys were not conducted in the impounded reaches, many of the species found in the lotic habitats are not expected to occur, nor were they observed within the impounded sites. The one exception to this was the presence of the Piedmont darter within Site 6 (Deep River impoundment-1), the most upstream site within the impoundment. The presence of this species which is more often associated with lotic conditions, suggests a decreasing lentic effect at the upper limits of the impoundment. Results from the mussel surveys further support this theory.

The targeted Cape Fear shiner was found at two sites upstream of the dam (Sites 1 and 3) and two sites downstream of the dam (Sites 10 and 13). The two upstream sites are characterized as habitats typically associated with Cape Fear shiner. This species was found in great numbers at Site 3. Although the tailrace site (Site 10) differs from typical habitats supporting Cape Fear shiner, the high velocities over rocky substrate created by water being released from the dam mimic the rocky riffle habitats where this species is usually found. The occurrence of this species at Site 13 is unusual given the lack of flow and poor habitat conditions present at this site. The one individual found was in poor condition (worn fins) and was possibly a vagrant from a congregation occurring in more suitable habitat nearby.

The tailrace site (Site 10, Deep River downstream-1) contained the high numbers of shiner species (10), including the Cape Fear shiner. However, the bluehead chub and gizzard shad were the only other species captured at this site. Three individual gizzard shad were collected immediately below the dam. This species is more often found within impoundments, and its presence in the tailrace may be the result of individuals washing over the dam. The shiner species occupy similar niches (within the water column), and their large congregations below the dam may indicate that food resources (zooplankton) are suspended and concentrated by the action of water coming over the dam. The lack of other fish species at this site is consistent with reported reductions in species diversity below impoundments (Quinn and Kwak 2003) and may be a function of high velocities and scour. However, more demersal (having a close affinity to the bottom) species (sunfishes, catfish, bass etc.), likely occur in this habitat, but were not detected during this survey effort, as they are difficult to detect in these conditions exclusively using seine netting methodologies, because they are able to seek cover under boulders in the channel.

The differences in fish abundance between Site 15 McLendons Creek, upstream) and site 17 (Big Governors Creek, upstream), is likely attributable to a higher diversity of microhabitats in McLendons Creek. The habitat and fish fauna present in the surveyed portion of Big Governors Creek are more indicative of slow-moving swampy streams than faster flowing rocky streams of the Piedmont.

The Roanoke bass was captured in low numbers at Site 1. This species is fairly intolerant and has experienced declines throughout its natural range; however, the Deep River population is a result of introduction efforts by the NCWRC in the 1970's and carries no conservation status. Although established in the Deep River, little is known of the population in the Deep River, but it appears to be limited in numbers in the reach near Carbonton Dam (Wayne Starnes, personal communication).

The targeted Carolina darter and Carolina redhorse were not found during this survey effort. The Carolina darter is more commonly associated with smaller water bodies with sandy substrates and was not expected to be found during this effort. The capture methodologies used during this study are typically not conducive to capturing large redhorse species, as they tend to congregate in deeper habitats, and are able to avoid small seine nets. This species has been captured using boat-electrofishing at various locales throughout the Deep River, including the Carbonton Dam reservoir reach (Wayne Starnes, personal communication). Very little life history information is available for the Carolina redhorse, thus it is difficult to speculate how this species will respond to dam removal. Other similar redhorse species are known to be adversely affected by dam construction (R.E. Jenkins, personal communication). The NCWRC and NCSM are studying and monitoring the Carolina redhorse population in the Deep River.

As discussed earlier, electro-fishing was not used during this survey effort, in recognition of the "Collection sensitive waters" designation of the Deep River by the NCWRC. A more comprehensive survey effort conducted at various times throughout the year and using multiple sampling methodologies (boat-electrofishing, backpack electrofishing, seine netting etc.) is needed, particularly in the deeper habitats, to obtain a complete list of all fish species occurring in the Deep River and its tributaries. However, the methods used and the data collected is adequate for establishing fish fauna targeting the Cape Fear shiner. These methods will also allow for the monitoring of changes in community composition over time in response to dam removal.

7.0 ANTICIPATED IMPACTS FROM DAM REMOVAL

Potential beneficial and adverse impacts to the aquatic resources targeted in this study are briefly addressed here.

7.1 Freshwater mussels

Freshwater mussels are expected to re-colonize the restored habitats within the reservoir pool following removal of the Carbonton dam. However, re-colonization of freshwater mussels to restored habitats may take several years due to their life history characteristics: relatively immobile, slow growing and dependent on fish movement for dispersal. Sietman et al. (2001) reported that mussel population recovery took up to 80 years in the Illinois River following extirpation around the turn of the 20th century and recovery was dependent on the distance to source mussel populations as well as host fish and water quality parameters. Abundant mussel and fish populations were documented

upstream and downstream of the existing dam, thus recruitment of many species into the restored habitats can come from both directions.

The survey results demonstrate that presence of the targeted "rare" mussel species was related to habitat complexity within a site. Restoration of the natural flow regime within the former impoundment will likely result in greater habitat complexity in this reach, which will in turn provide more available habitat for many of the targeted mussel species, including the NC state endangered brook floater, Savannah liliput and yellow lampmussel.

Mortality of mussels occurring within the impounded portion of the Deep River are expected to occur following dam removal as waters recede and mussels are stranded and are subject to desiccation and predation. Sethi et al. (2004) documented this following dam removal in Koshkonong Creek in Wisconsin and was also observed on the Little River in North Carolina following water draw down and partial dam removal (personal observations). The mussel species occurring within the impounded portion of the Deep River are widespread, common habitat generalists, or lentic-adapted species that would not naturally occur in as large of numbers without the impoundment. The loss of these individuals may be considered an acceptable impact, when considering the likely beneficial impact of restoring lotic mussel species in this reach.

Localized adverse impacts to mussel populations may also occur downstream of Carbonton dam. Sethi et al. (2004) documented significant mortality to mussels downstream of the dam on Koshkonong Creek following removal. The initial pulse of sediment that resulted from this dam removal, as well as continual deposition of fine sediment caused by head cutting and unstable banks within the formerly impounded section, were attributed to the loss of downstream mussel populations. Localized adverse impacts to mussel populations occurring downstream of Carbonton dam are likely to result from dam removal. The survey results indicate that the many of the mussel species found during the survey effort are widely distributed in the Deep River. Thus, long-term adverse impacts to mussel communities are less likely to occur as sufficient source mussel populations occur in close proximity to the impacted areas.

7.2 Aquatic Snails and Freshwater Clams

Like freshwater mussels, aquatic snails occurring within the impoundment (pointed campeloma, hydrobidae snails) may be subject to desiccation and predation following dam removal. However, these organisms are more mobile than freshwater mussels and may be able to retreat to deeper pools as the water levels recede.

The gravel elimia, a lotic riffle adapted species was found exclusively in riffle habitats dominated by rocky substrates (Sites 1, 3, 4, 5, and 14). Although this species may be adversely affected by downstream sedimentation to riffle habitats caused by dam removal, overall the removal of the Carbonton dam will likely result in an increase of available habitat for this species within the Deep River, as some areas revert to riffle conditions.

Population levels of the ubiquitous Asian clam will likely not be affected either way by dam removal, as it was found in high numbers in un-impounded as well as impounded habitats.

7.3 Fish Populations, Primarily Cape Fear shiner

One of the desired goals of dam removal is to restore existing lentic habitats to their natural lotic state and thus restore the appropriate, pre-impoundment aquatic faunal community. Studies have shown that highly mobile organisms such as fish and organisms with short life cycles (benthic macro-invertebrates) are able to quickly recolonize restored lotic habitats following dam removal in mid sized streams in southern Wisconsin (Kanehl et al. 1997, Stanley et al. 2002). In both of these instances, the return of the desired species, smallmouth bass (*Micropterus dolomieu*) and lotic benthic macro-invertebrate assemblages, respectively, occurred in short periods of time following the respective dam removals. Kanehl et al. (1997) demonstrated an increase in the desired smallmouth bass populations within the former impounded reach, as well as in habitats upstream of the former impoundment. These population increases were the result of recruitment rather than by permanent migration of fish from other areas. Additionally, populations of the undesired common carp (*Cyprinus carpio*) declined dramatically following dam removal.

The pre-dam removal surveys, as well as other survey data within the Deep River system, indicate that similar populations of lotic- adapted fish species occur within the un-impounded river reaches both upstream and downstream of Carbonton dam. Therefore ample source populations exist both upstream and downstream to facilitate recruitment into the restored reaches following dam removal. The removal of the dam is expected to increase the available habitat for the targeted Cape Fear shiner, and connect the two populations isolated by the dam. This increase in available habitat and the connection of populations should result in an increase in population numbers and viability (more genetic interchange, greater range, etc.) over time.

Although it is logical to assume recovery of lotic fish species into the restored reach, which is viewed as a long-term beneficial impact, various short-term adverse impacts to the fish community in the Deep River may also occur from dam removal. This is of particular concern when considering the impacts to the federally endangered Cape Fear shiner. In addition to impacts of conversion of lotic habitats to lentic habitats, sedimentation and water quality degradation have also been identified as factors adversely impacting the Cape Fear shiner (USFWS 1988, Howard 2003). The accumulation of sediments behind dams is well documented, and the removal of dams results in a release of sediment to downstream habitats. The fish fauna below the dam, including the Cape Fear shiner could be adversely impacted by the pulse of sediment released during water draw down and dam removal. Reductions in dissolved oxygen (DO) may also occur downstream during removal as oxygen depleting organic sediments are released. Additionally, concentrations of toxic substances which may have

accumulated in the sediments behind the dam may be released downstream impacting aquatic organisms.

These potential impacts to the Cape Fear shiner were considered by the USFWS prior to dam removal. With measures that were incorporated into the removal project that avoid/minimize the potential for these impacts to occur, it was concluded that significant adverse impacts were unlikely to occur.

As with the impounded portions of the Deep River, beneficial impacts to the fish communities in the impounded portions of McLendons Creek and Big Governors Creek are also likely to result following dam removal. As discussed previously, the suite of fish species captured in the un-impounded portion of Big Governors Creek varies significantly from those that were found in the Deep River and McLendons Creek. It is not clear whether the fish community of the lower portion of Big Governors Creek will be more influenced by the Deep River fauna, or the fauna currently present in the stream above the reservoir pool. Although there is less habitat complexity in the un-impounded portions of McLendons Creek than the Deep River, the fish faunas are fairly similar. Colonization of the restored habitats in the lower portions of McLendons Creek will likely occur from both upstream as well as from the Deep River.

8.0 RECOMMENDATIONS/FURTHER STUDY

This project is expected to result in significant benefits to the aquatic fauna in the Deep River and its tributaries. Qualitative monitoring of the sites sampled during the pre-removal surveys should occur after removal to document general changes in faunal communities and demonstrate success. **Fish communities at the sampling sites should be monitored during the first year following removal. The results of the first-year monitoring should be factored into the decision for future monitoring. Due to their life histories, changes in mussel fauna associated with dam removal will likely not be evident for at least four years post removal. Thus, it is recommended that the freshwater mussel fauna be monitored at the pre-removal survey sites four years following removal. Aquatic snails and freshwater clams will also be sampled during this monitoring, as similar methodologies are used. The results of the 4-year monitoring will determine if future monitoring is warranted.**

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APPENDIX D: NCDWQ HABITAT ASSESSMENT FIELD DATA SHEET

Habitat Assessment Field Data Sheet
Mountain/ Piedmont Streams

Biological Assessment Unit, DWQ **TOTAL SCORE_____**

Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream_____Location/road: _____(Road Name_____)County_____

Date_____**CC#**_____Basin_____Subbasin_____

Observer(s)_____ Type of Study: ☐ Fish ☐Benthos ☐ Basinwide ☐Special Study (Describe) _____

Latitude _____Longitude _____Ecoregion: ☐ MT ☐ P ☐ Slate Belt ☐ Triassic Basin

Water Quality: Temperature_____^{0}C DO _____mg/l Conductivity (corr.) _____µS/cm pH _____

Physical Characterization: Visible land use refers to immediate area that you can see from sampling location - include what you estimate driving thru the watershed in watershed land use.

Visible Land Use: _____%Forest _____%Residential _____%Active Pasture _____% Active Crops
_____%Fallow Fields _____% Commercial _____%Industrial _____%Other - Describe:_____

Watershed land use : ☐Forest ☐Agriculture ☐Urban ☐ Animal operations upstream

Width: (meters) Stream_____ Channel (at top of bank)_____ **Stream Depth**: (m) Avg_____Max ____
☐ Width variable ☐ Large river >25m wide
Bank Height (from deepest part of riffle to top of bank-first flat surface you stand on): (m)_____

Bank Angle: _____° or ☐ NA (Vertical is 90°, horizontal is 0°. Angles > 90° indicate slope is towards mid-channel, < 90° indicate slope is away from channel. NA if bank is too low for bank angle to matter.)
☐ Channelized Ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐ Recent overbank deposits ☐Bar development ☐Buried structures ☐Exposed bedrock
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth ☐Green tinge ☐ Sewage smell
Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
Flow conditions : ☐High ☐Normal ☐Low
Turbidity: ☐Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes)
Good potential for Wetlands Restoration Project?? ☐ YES ☐NO Details_____
Channel Flow Status
Useful especially under abnormal or low flow conditions.

A. Water reaches base of both lower banks, minimal channel substrate exposed	☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed.....	☐
C. Water fills 25-75% of available channel, many logs/snags exposed.....	☐
D. Root mats out of water.....	☐
E. Very little water in channel, mostly present as standing pools.....	☐

Weather Conditions:_____**Photos:** ☐N ☐Y ☐ Digital ☐35mm

Remarks:_____
_____

I. Channel Modification

	Score
A. channel natural, frequent bends	5
B. channel natural, infrequent bends (channelization could be old)	4
C. some channelization present	3
D. more extensive channelization, >40% of stream disrupted	2
E. no bends, completely channelized or rip rapped or gabioned, etc	0

☐ Evidence of dredging ☐Evidence of desnagging=no large woody debris in stream ☐Banks of uniform shape/height

Remarks_____ Subtotal____

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >70% of the reach is rocks, 1 type is present, circle the score of 17. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as **R**are, **C**ommon, or **A**bundant.

____Rocks ____Macrophytes ____Sticks and leafpacks ____Snags and logs ____Undercut banks or root mats

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>70% Score	40-70% Score	20-40% Score	<20% Score
4 or 5 types present	20	16	12	8
3 types present	19	15	11	7
2 types present	18	14	10	6
1 type present	17	13	9	5
No types present	0			

☐ No woody vegetation in riparian zone Remarks_____ Subtotal_____

III. Bottom Substrate (silt, sand, detritus, gravel, cobble, boulder) Look at entire reach for substrate scoring, but only look at riffle for embeddedness, and use rocks from all parts of riffle-look for "mud line" or difficulty extracting rocks.

	Score
A. substrate with good mix of gravel, cobble and boulders	
1. embeddedness <20% (very little sand, usually only behind large boulders)	15
2. embeddedness 20-40%	12
3. embeddedness 40-80%	8
4. embeddedness >80%	3
B. substrate gravel and cobble	
1. embeddedness <20%	14
2. embeddedness 20-40%	11
3. embeddedness 40-80%	6
4. embeddedness >80%	2
C. substrate mostly gravel	
1. embeddedness <50%	8
2. embeddedness >50%	4
D. substrate homogeneous	
1. substrate nearly all bedrock	3
2. substrate nearly all sand	3
3. substrate nearly all detritus	2
4. substrate nearly all silt/ clay	1

Remarks_____Subtotal_____

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow. Pools may take the form of "pocket water", small pools behind boulders or obstructions, in large high gradient streams, or side eddies.

A. Pools present	Score
1. Pools Frequent (>30% of 200m area surveyed)	
a. variety of pool sizes	10
b. pools about the same size (indicates pools filling in)	8
2. Pools Infrequent (<30% of the 200m area surveyed)	
a. variety of pool sizes	6
b. pools about the same size	4
B. Pools absent	0

Subtotal_____

☐ Pool bottom boulder-cobble=hard ☐ Bottom sandy-sink as you walk ☐ Silt bottom ☐ Some pools over wader depth

Remarks_____

Page Total_____

V. Riffle Habitats

Definition: Riffle is area of reaeration-can be debris dam, or narrow channel area.

	Riffles **Frequent** Score	Riffles **Infrequent** Score
A. well defined riffle and run, riffle as wide as stream and extends 2X width of stream....	16	12
B. riffle as wide as stream but riffle length is not 2X stream width	14	7
C. riffle not as wide as stream and riffle length is not 2X stream width	10	3
D. riffles absent.....	0	

Channel Slope: ☐Typical for area ☐Steep=fast flow ☐Low=like a coastal stream Subtotal_____

VI. Bank Stability and Vegetation

FACE UPSTREAM	Left Bank Score	Rt. Bank Score
A. Banks stable		
1. little evidence of erosion or bank failure(except outside of bends), little potential for erosion..	7	7
B. Erosion areas present		
1. diverse **trees**, shrubs, grass; plants healthy with good root systems.....	6	6
2. few trees or small trees and **shrubs**; vegetation appears generally healthy.....	5	5
3. sparse **mixed** vegetation; plant types and conditions suggest poorer soil binding.....	3	3
4. mostly **grasses**, few if any trees and shrubs, high erosion and failure potential at high flow..	2	2
5. little or no bank vegetation, mass erosion and bank failure evident.....	0	0
		Total_____

Remarks_____

VII. Light Penetration Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead. Note shading from mountains, but not use to score this metric.

	Score
A. Stream with **good** canopy with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent.....	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal.....	7
D. Stream with **minimal** canopy - full sun in all but a few areas.....	2
E. **No canopy** and no shading.....	0

Remarks_____Subtotal____

VIII. Riparian Vegetative Zone Width

Definition: Riparian zone for this form is area of natural vegetation adjacent to stream (can go beyond floodplain). Definition: A break in the riparian zone is any place on the stream banks which allows sediment or pollutants to directly enter the stream, such as paths down to stream, storm drains, uprooted trees, otter slides, etc.

FACE UPSTREAM Dominant vegetation: ☐ Trees ☐ Shrubs ☐ Grasses ☐ Weeds/old field ☐Exotics (kudzu, etc)	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. width > 18 meters.....	5	5
2. width 12-18 meters.....	4	4
3. width 6-12 meters.....	3	3
4. width < 6 meters.....	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. width > 18 meters.....	4	4
b. width 12-18 meters.....	3	3
c. width 6-12 meters.....	2	2
d. width < 6 meters.....	1	1
2. breaks common		
a. width > 18 meters.....	3	3
b. width 12-18 meters.....	2	2
c. width 6-12 meters.....	1	1
d. width < 6 meters.....	0	0
		Total_____

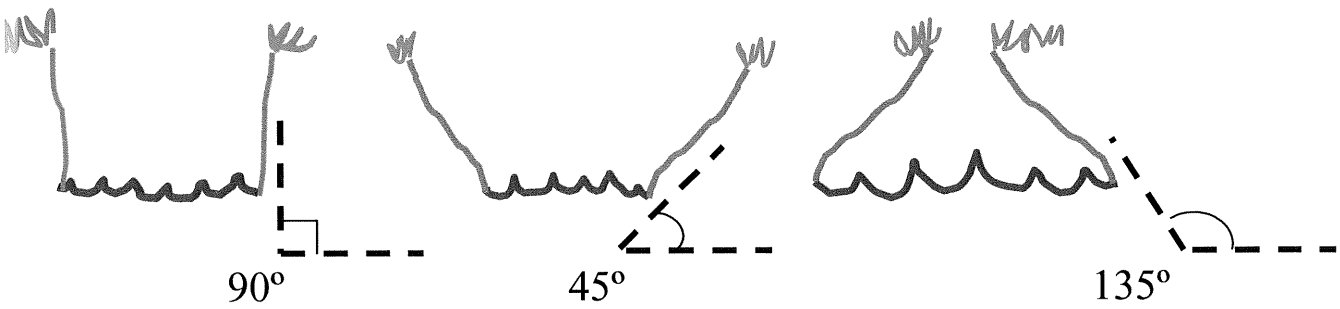
Remarks_____

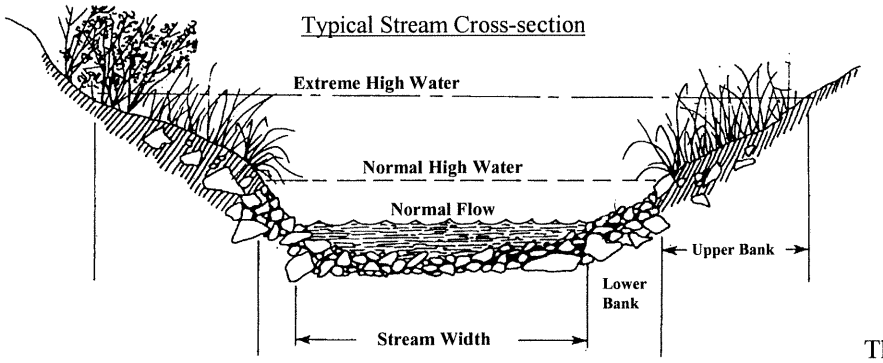
Page Total_____

☐ Disclaimer-form filled out, but score doesn't match subjective opinion-atypical stream. **TOTAL SCORE**_____

Supplement for Habitat Assessment Field Data Sheet

Diagram to determine bank angle:





This side is 45° bank angle.

Site Sketch:

Other comments:_____

_____

_____

_____

_____

APPENDIX E: RE-ESTABLISHED RIFFLE PICTURES

Re-established Riffle 1

Re-established Riffle 2

Re-established Riffle 3

Re-established Riffle 4

Re-established Riffle 5

Re-established Riffle 6

Re-established Riffle 7

Re-established Riffle 8

Re-established Riffle 9

Re-established Riffle 10

Re-established Riffle 11

Re-established Riffle 12

Re-established Riffle 13

Re-established Riffle 14

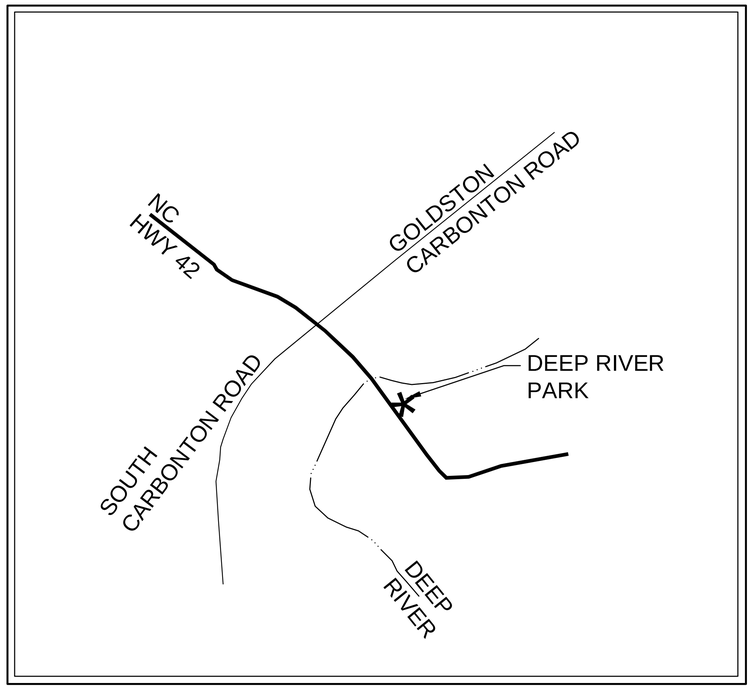
Re-established Riffle 15

APPENDIX F: DEEP RIVER PARK PLANS

DEEP RIVER PARK

DEEP RIVER
LEE & CHATHAM COUNTY
CARBONTON NORTH CAROLINA

MAY, 2006



PROJECT SITE VICINITY MAP:

0 1/2" 1"
SCALE: 1"=1'

LIST OF DRAWINGS:

L1	SITE PLAN - LAYOUT
G1	SITE PLAN - GRADING
SE1	SITE PLAN - SEDIMENT & EROSION CONTROL
SD1-SD2	SITE DETAILS

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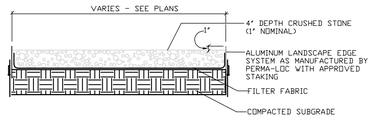
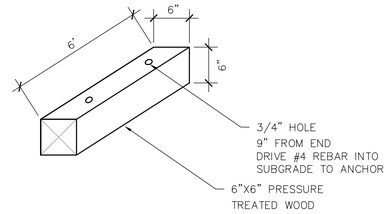
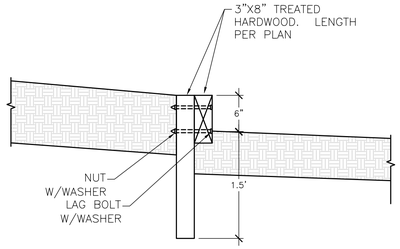


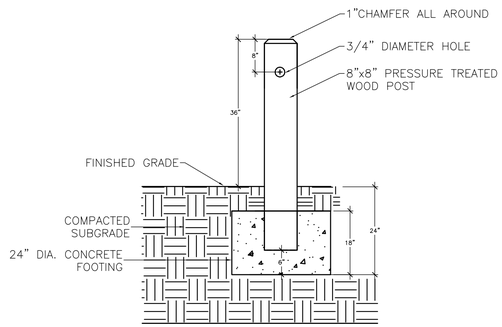
GRAVEL PARKING LOT AND ROADWAY
N.T.S.



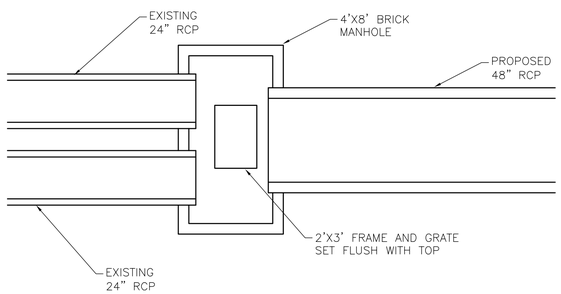
6' WOOD WHEELSTOP

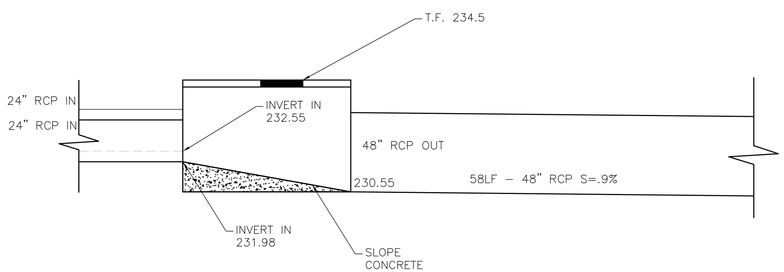


WOOD STEP
N.T.S.

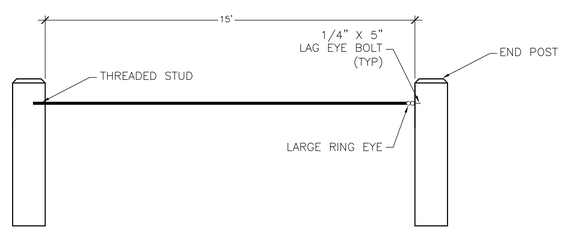


WOOD BOLLARD W/WIRE STRAND
N.T.S.





BRICK MANHOLE BASE W/FLAT SLAB TOP
N.T.S.



WOOD BOLLARD W/WIRE STRAND GATE
N.T.S.

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REVISIONS

SITE DETAILS

DEEP RIVER PARK
LEE & CHATHAM COUNTY

NC HWY 42
CARBONTON, NORTH CAROLINA

PBS	PBS	KWK
DESIGNED	DRAWN	CHECKED

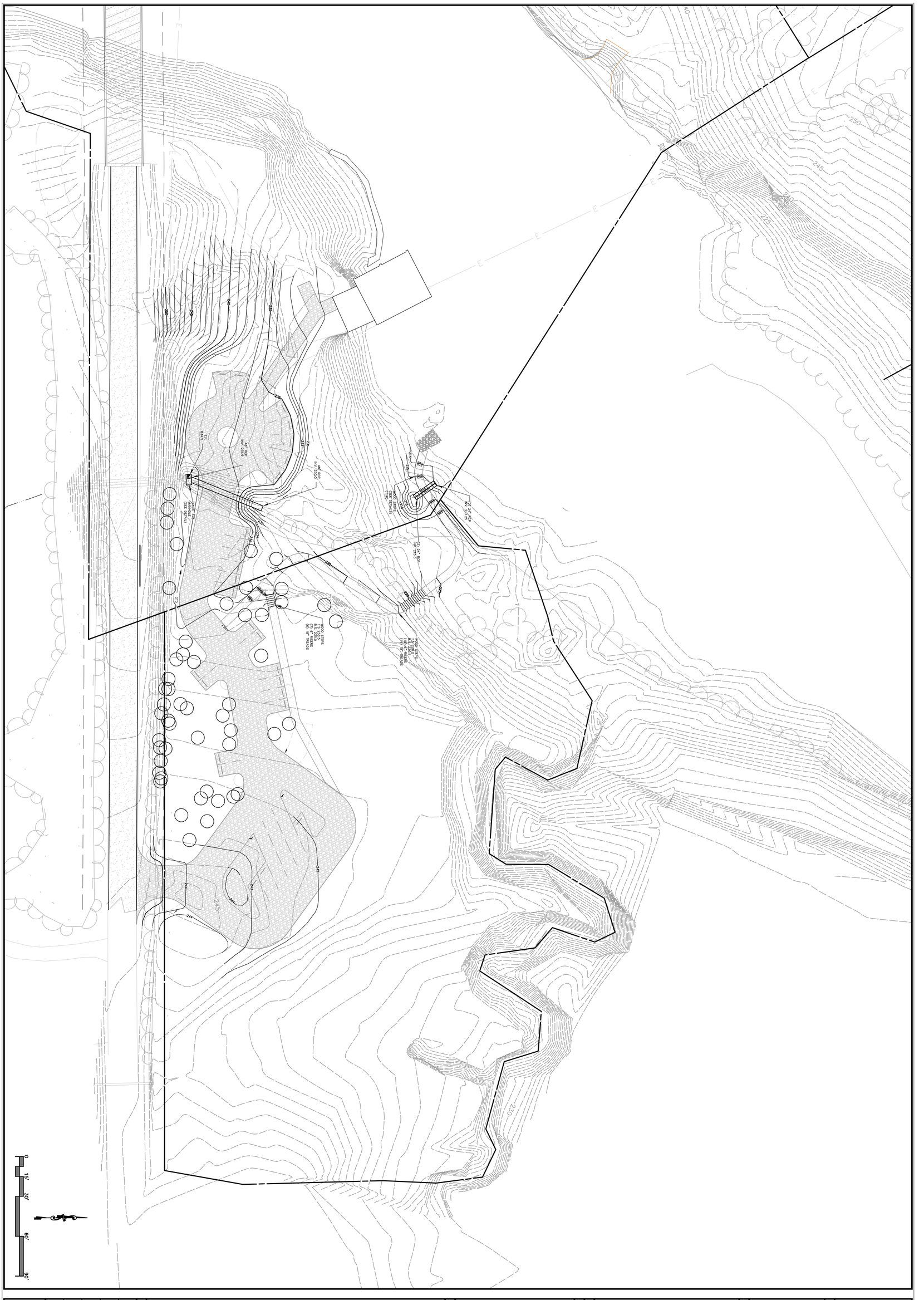
SCALE

DATE
MAY 25, 2006

PROJECT NO.
2691-01-05

2961-02lowell\dwg\parktitleanddetails

SD2
SHEET NO.



SHEET NO.
G1

DWG NAME
parkgrading.dwg

PROJECT NO.
2691-02

DATE
MAY 25 2006

SCALE
1"=30'

DESIGNED PBS
DRAWN JD
CHECKED KWK

GRADING PLAN

DEEP RIVER PARK
LEE & CHATHAM COUNTY

NC HWY 42
CARBONTON, NORTH CAROLINA

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LAYOUT PLAN

DEEP RIVER PARK
LEE & CHATHAM COUNTY

NC HWY 42
CARBONTON, NORTH CAROLINA

DESIGNED	DRAWN	CHECKED
PBS	PBS	KWK

SCALE 1"=30'

DATE MAY 25, 2006

PROJECT NO. 2691-01

DWG NAME PARKLAYOUT.DWG

SHEET NO. L1

SHEET NO.
SE1

DWG. NAME: PARKSE&E.DWG

PROJECT NO. 2691-01

DATE: MAY 25, 2006

SCALE: 1"=30'

DESIGNED: PBS
DRAWN: PBS
CHECKED: KWK

SEDIMENT AND EROSION CONTROL PLAN

DEEP RIVER PARK
LEE & CHATHAM COUNTY

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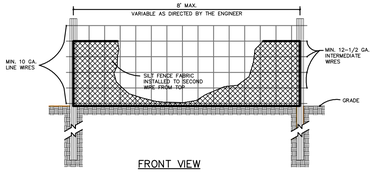
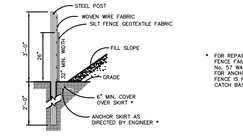


FRONT VIEW



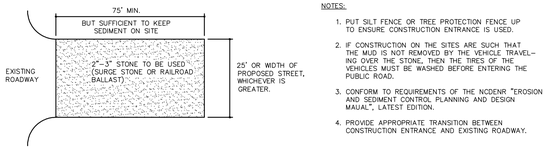
NOTE:
-USE SILT FENCE ONLY WHEN DRAINAGE AREA DOES NOT EXCEED 1/4 ACRE AND NEVER IN AREAS OF CONCENTRATED FLOW
-END OF SILT FENCE NEEDS TO BE TURNED UPHILL.

* FOR REPAIR OF SILT FENCE FAILURES, USE NO. 57 WASHED STONE. FOR ANCHOR WHEN SILT FENCE IS PROTECTING CATCH BASIN.

SIDE VIEW

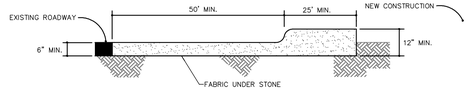
REVISIONS	
DATE	DESCRIPTION

STANDARD TEMPORARY SILT FENCE | 1



PLAN

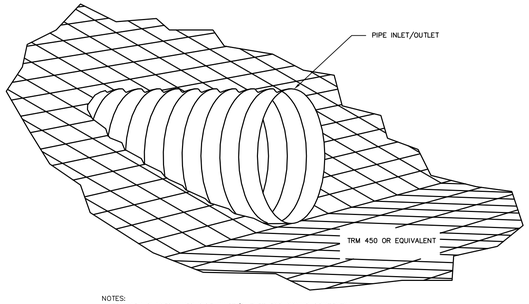
NOTES:
1. PUT SILT FENCE OR TREE PROTECTION FENCE UP TO ENSURE CONSTRUCTION ENTRANCE IS USED.
2. IF CONSTRUCTION ON THE SITES ARE SUCH THAT THE MUD IS NOT REMOVED BY THE VEHICLE TRAVELING OVER THE STONE, THEN THE TIRES OF THE VEHICLES MUST BE WASHED BEFORE ENTERING THE PUBLIC ROAD.
3. CONFORM TO REQUIREMENTS OF THE NCDENR "EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MAUAL", LATEST EDITION.
4. PROVIDE APPROPRIATE TRANSITION BETWEEN CONSTRUCTION ENTRANCE AND EXISTING ROADWAY.



CROSS SECTION

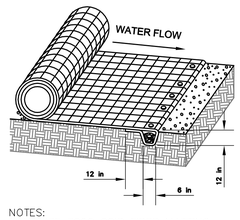
REVISIONS	
DATE	DESCRIPTION

CONSTRUCTION ENTRANCE | 7



NOTES:
1. TRM 450 PLACED OVER PIPE INLET/OUTLET FOR SCOUR PROTECTION

PIPE INLET / OUTLET PROTECTION
N.T.S.

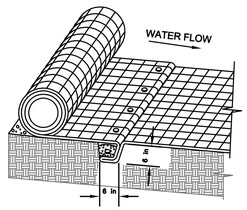


NOTES:
1. UTILIZE 700G COIR FIBER MATTING.

2. SECURE AT 1 ft INTERVALS (OR AS RECOMMENDED BY MANUFACTURER BASED ON SLOPE), BACKFILL AND COMPACT SOIL

3. TO BE USED AT TOP OF ALL MATTING AREAS.

INITIAL MATTING ANCHOR TRENCH



NOTES:
1. UTILIZE 700G COIR FIBER MATTING.

2. SECURE AT 1 ft INTERVALS (OR AS RECOMMENDED BY MANUFACTURER BASED ON SLOPE), BACKFILL AND COMPACT SOIL

3. ANCHOR, STAPLE AND OVERLAP IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.

4. TO BE USED ON ALL MATTING AREAS AT INTERVALS AS RECOMMENDED BY THE MANUFACTURER.

INTERMITTANT MATTING CHECK SLOT

CONSTRUCTION SEQUENCE / SEDIMENT & EROSION CONTROL NOTES

EROSION AND SEDIMENT CONTROL SHALL PROCEED IN THE FOLLOWING MANNER:

1. PRIOR TO COMMENCEMENT OF WORK, A PRECONSTRUCTION MEETING SHALL BE HELD WITH THE ENGINEER AND REPRESENTATIVES OF THE CONTRACTOR, UTILITIES AND OWNER. AT THIS MEETING, THE SEDIMENT AND EROSION CONTROL PLAN WILL BE DISCUSSED.
2. CONTRACTOR TO STAKE OUT LIMIT OF DISTURBANCE AND VEGETATION TO BE RETAINED. NO DISTURBANCE IS TO TAKE PLACE BEYOND THE LIMITS STAKED. CONTRACTOR SHALL TAKE SPECIAL PRECAUTIONS TO PROTECT TREES AND AND EXISTING IMPROVEMENTS TO REMAIN.
3. CONTRACTOR TO COORDINATE WORK SCHEDULE WITH IMPACTED PROPERTY OWNERS TO MAINTAIN SAFE VEHICLE AND PEDESTRIAN ACCESS AND PARKING. CONTRACTOR TO MINIMIZE DISRUPTION TO THE GREATEST EXTENT PRACTICABLE.
4. CONTRACTOR TO INSTALL SEDIMENT AND EROSION CONTROLS PRIOR TO CLEARING AND GRUBBING. INSTALL CONSTRUCTION ENTRANCE PADS AS DEPICTED ON THE PLANS.
5. THROUGH FLOW OF WATERCOURSE SHALL BE MAINTAINED DURING CONSTRUCTION SO AS NOT TO SUSPEND SEDIMENT FROM EARTHWORK ACTIVITIES.
6. INITIATE EARTHWORK OPERATIONS AFTER ALL SEDIMENT AND EROSION CONTROLS ARE IN PLACE.
7. AREAS OF ACTIVITY AND EXPOSED AREAS ARE TO BE MINIMIZED. STABILIZE ALL SLOPES IMMEDIATELY AFTER THEIR ESTABLISHMENT.
8. ESTABLISH ALL SLOPES TO GRADE IN AREAS OF DISTURBANCE AS SOON AS POSSIBLE. TEMPORARY SEED AND MULCH IN ACCORDANCE WITH THE LANDSCAPE SPECIFICATIONS.
9. THE SEDIMENT AND EROSION CONTROL PLAN MAY BE MODIFIED BY THE SITE ENGINEER AS NECESSITATED BY CHANGING SITE CONDITIONS. ADDITIONAL CONTROL DEVICES BESIDES WHAT IS SHOWN IN PLANS WILL BE ADDED BY THE ENGINEER IF NEEDED.
10. ALL SEDIMENT CONTROL MEASURES SHALL BE INSPECTED AT LEAST ONCE EVERY SEVEN CALENDAR DAYS AND AFTER STORMS GREATER THAN 0.5 INCHES OF PRECIPITATION DURING ANY 24-HOUR PERIOD. DAMAGED OR INEFFECTIVE DEVICES SHALL BE REPAIRED OR REPLACED, AS NECESSARY. ALL SEDIMENT CONTROL FEATURES SHALL BE MAINTAINED UNTIL FINAL STABILIZATION HAS BEEN OBTAINED.
11. INSPECTION OF THE SITE FOR EROSION SHALL CONTINUE FOR A PERIOD OF THREE MONTHS AFTER COMPLETION WHEN RAINFALLS OF ONE INCH OR MORE OCCUR.
12. ALL EROSION CONTROL DEVICES SHALL BE PROPERLY MAINTAINED DURING ALL PHASES OF CONSTRUCTION UNTIL THE COMPLETION OF ALL CONSTRUCTION ACTIVITIES AND ALL DISTURBED AREAS HAVE BEEN STABILIZED. ALL TEMPORARY CONTROL DEVICES SHALL BE REMOVED WHEN CONSTRUCTION IS COMPLETE AND THE SITE IS STABILIZED.
13. THE CONTRACTOR MUST TAKE NECESSARY ACTION TO MINIMIZE THE TRACKING OF MUD ONTO THE PAVED ROADWAY FROM CONSTRUCTION AREAS. THE CONTRACTOR SHALL REMOVE MUD/SOIL FROM PAVEMENT DAILY, AS MAY BE REQUIRED.
14. THE SITE SHOULD BE KEPT CLEAN OF LOOSE DEBRIS AND BUILDING MATERIALS SUCH THAT NONE OF THE ABOVE ENTER STORMWATER FACILITIES, ROADWAYS, WATERCOURSES, OR WETLANDS.
15. A COPY OF ALL PLANS AND REVISIONS, AND THE SEDIMENT AND EROSION CONTROL PLAN, SHALL BE MAINTAINED ON-SITE AT ALL TIMES DURING CONSTRUCTION.
16. A COPY OF ALL INSPECTION LOGS SHALL BE RETAINED FOR THE DURATION OF THE PROJECT.
17. ALL SEDIMENT AND EROSION CONTROL MEASURES SHALL BE REMOVED ONLY UPON STABILIZATION OF ALL UPGRADIENT AREAS.

SEDIMENT & EROSION CONTROL SPECIFICATIONS

GENERAL:

THESE GUIDELINES SHALL APPLY TO ALL WORK CONSISTING OF ANY AND ALL TEMPORARY AND/OR PERMANENT MEASURES TO CONTROL WATER POLLUTION AND SOIL EROSION, AS MAY BE REQUIRED, DURING THE CONSTRUCTION OF THE PROJECT.

IN GENERAL, ALL CONSTRUCTION ACTIVITIES SHALL PROCEED IN SUCH A MANNER SO AS NOT TO POLLUTE ANY WETLANDS, WATERCOURSE, WATERBODY, CONDUIT CARRYING WATER, ETC. THE CONTRACTOR SHALL LIMIT, INSOFAR AS POSSIBLE, THE SURFACE AREA OF EARTH MATERIALS EXPOSED BY CONSTRUCTION METHODS AND IMMEDIATELY PROVIDE PERMANENT AND TEMPORARY POLLUTION CONTROL MEASURES TO PREVENT CONTAMINATION OF ADJACENT WETLANDS, WATERCOURSES, WATERBODIES AND TO PREVENT, INSOFAR AS POSSIBLE, EROSION ON THE SITE.

LAND GRADING GENERAL:

1. THE RESHAPING OF THE GROUND SURFACE BY EXCAVATION AND FILLING OR A COMBINATION OF BOTH, TO OBTAIN PLANNED GRADES, SHALL PROCEED IN ACCORDANCE WITH THE FOLLOWING CRITERIA:
   a. THE CUT FACE OF EARTH EXCAVATION SHALL NOT BE STEEPER THAN TWO HORIZONTAL TO ONE VERTICAL (2:1).
   b. THE PERMANENT EXPOSED FACES OF FILLS SHALL NOT BE STEEPER THAN TWO HORIZONTAL TO ONE VERTICAL (2:1).
   c. THE CUT FACE OF ROCK EXCAVATION SHALL NOT BE STEEPER THAN ONE HORIZONTAL TO FOUR VERTICAL (1:4).
   d. PROVISION SHOULD BE MADE TO CONDUCT SURFACE WATER SAFELY TO STORM DRAINS TO PREVENT SURFACE RUNOFF FROM DAMAGING CUT FACES AND FILL SLOPES.

TOPSOILING GENERAL:

1. TOPSOIL SHALL BE SPREAD OVER ALL EXPOSED AREAS IN ORDER TO PROVIDE A SOIL MEDIUM HAVING FAVORABLE CHARACTERISTICS FOR THE ESTABLISHMENT, GROWTH AND MAINTENANCE OF VEGETATION.
2. UPON ATTAINING FINAL SUBGRADES, SCARIFY SURFACE TO PROVIDE A GOOD BOND WITH TOPSOIL.
3. REMOVE ALL LARGE STONES, TREE LIMBS, ROOTS AND CONSTRUCTION DEBRIS.
4. APPLY LIME ACCORDING TO SOIL TEST OR AT THE RATE OF TWO (2) TONS PER ACRE.

MATERIAL:

1. TOPSOIL SHOULD HAVE PHYSICAL, CHEMICAL AND BIOLOGICAL CHARACTERISTICS FAVORABLE TO THE GROWTH OF PLANTS.
2. TOPSOIL SHOULD HAVE A SANDY OR LOAMY TEXTURE.
3. TOPSOIL SHOULD BE RELATIVELY FREE OF SUBSOIL MATERIAL AND MUST BE FREE OF STONES (OVER 1" IN DIAMETER), LUMPS OF SOIL, ROOTS, TREE LIMBS AND TRASH OR CONSTRUCTION DEBRIS. IT SHOULD BE FREE OF ROOTS OR RHIZOMES SUCH AS THISTLE, NUTGRASS AND QUACKGRASS.
4. AN ORGANIC MATTER CONTENT OF SIX PERCENT (6%) IS REQUIRED. AVOID LIGHT COLORED SUBSOIL MATERIAL.
5. SOLUBLE SALT CONTENT OF OVER 500 PARTS PER MILLION (PPM) IS LESS SUITABLE. AVOID TIDAL MARSH SOILS BECAUSE OF HIGH SALT CONTENT AND SULFUR ACIDITY.
6. THE pH SHOULD BE MORE THAN 6.0. IF LESS, ADD LIME TO INCREASE pH TO AN ACCEPTABLE LEVEL.

APPLICATION:

1. AVOID SPREADING WHEN TOPSOIL IS WET OR FROZEN.
2. SPREAD TOPSOIL UNIFORMLY TO A DEPTH OF AT LEAST SIX INCHES (6") OR TO THE DEPTH SHOWN ON THE LANDSCAPING PLANS.

TEMPORARY VEGETATIVE COVER

1. TEMPORARY VEGETATIVE COVER SHALL BE ESTABLISHED ON ALL UNPROTECTED AREAS THAT PRODUCE SEDIMENT, AREAS WHERE FINAL GRADING HAS BEEN COMPLETED AND AREAS WHERE THE ESTIMATED PERIOD OF BARE SOIL EXPOSURE IS LESS THAN 12 MONTHS. TEMPORARY SEED AND MULCH ALL DISTURBED AREAS ACCORDING TO NCDOT STANDARD SPECIFICATIONS.

SITE PREPARATION:

1. INSTALL REQUIRED SURFACE WATER CONTROL MEASURES.
2. REMOVE LOOSE ROCK, STONE AND CONSTRUCTION DEBRIS FROM AREA.
3. APPLY LIME ACCORDING TO SOIL TEST OR AT A RATE OF ONE 45 LBS OF GROUND DOLOMITIC LIMESTONE PER SF.
4. APPLY FERTILIZER ACCORDING TO SOIL TEST OR AT THE RATE OF 1000 LBS. OF 10-10-10 PER ACRE (23 LBS. PER 1,000 SQ. FT.) AND SECOND APPLICATION OF 200 LBS. OF 10-10-10 PER ACRE(5 LBS. PER 1,000 SQ. FT.) WHEN GRASS IS FOUR INCHES (4") TO SIX INCHES (6") HIGH. APPLY ONLY WHEN GRASS IS DRY.
5. UNLESS HYDROSEEDED, WORK IN LIME AND FERTILIZER TO A DEPTH OF FOUR (4") INCHES USING A DISK OR ANY SUITABLE EQUIPMENT.
6. TILLAGE SHOULD ACHIEVE A REASONABLY UNIFORM, LOOSE SEEDBED. WORK ON CONTOUR IF SITE IS SLOPING.

ESTABLISHMENT:

1. SELECT APPROPRIATE SPECIES FOR THE SITUATION. NOTE RATES AND SEEDING DATES (SEE VEGETATIVE COVER SELECTION & MULCHING SPECIFICATION).
2. APPLY SEED UNIFORMLY ACCORDING TO THE RATE INDICATED BY BROADCASTING, DRILLING OR HYDRAULIC APPLICATION.
3. UNLESS HYDROSEEDED, COVER RYE GRAIN WITH NOT MORE THAN 1/4 INCH OF SOIL USING SUITABLE EQUIPMENT.
4. MULCH IMMEDIATELY AFTER SEEDING IF REQUIRED (SEE VEGETATIVE COVER SELECTION & MULCHING SPECIFICATION BELOW). APPLY STRAW OR HAY MULCH AND ANCHOR TO SLOPES GREATER THAN 3% OR WHERE CONCENTRATED FLOW WILL OCCUR.

VEGETATIVE COVER

GENERAL:

1. PERMANENT VEGETATIVE COVER SHALL BE ESTABLISHED AS VARIOUS SECTIONS OF THE PROJECT ARE COMPLETED IN ORDER TO STABILIZE THE SOIL, REDUCE DOWNSTREAM DAMAGE FROM SEDIMENT AND RUNOFF, AND TO ENHANCE THE AESTHETIC NATURE OF THE SITE. IT WILL BE APPLIED TO ALL CONSTRUCTION AREAS SUBJECT TO EROSION WHERE FINAL GRADING HAS BEEN COMPLETED AND A PERMANENT COVER IS NEEDED.

SITE PREPARATION:

1. INSTALL REQUIRED SURFACE WATER CONTROL MEASURES.
2. REMOVE LOOSE ROCK, STONE AND CONSTRUCTION DEBRIS FROM AREA.
3. PERFORM ALL PLANTING OPERATIONS PARALLEL TO THE CONTOURS OF THE SLOPE.
4. APPLY TOPSOIL AS INDICATED ELSEWHERE HEREIN.
5. APPLY FERTILIZER ACCORDING TO SOIL TEST OR:
   - OF 10-10-10 FERTILIZER PER ACRE (23 LBS. PER 1,000 SQ. FT.); THEN SIX TO EIGHT WEEKS LATER, APPLY ON THE SURFACE AN ADDITIONAL 300 LBS. OF 10-10-10 FERTILIZER PER ACRE. AFTER SEPTEMBER 1, TEMPORARY VEGETATIVE COVER SHALL BE APPLIED.

VEGETATIVE COVER SELECTION & MULCHING TEMPORARY VEGETATIVE COVER:

JANUARY 1 – APRIL 15
RYE GRAIN
120 LBS/AC

APRIL 15 – AUGUST 15
GERMAN MILLET
40 LBS/AC

AUGUST 15 – DECEMBER 30
RYE GRAIN
120 LBS/AC

SOIL AMENDMENTS FOR TEMOPORARY VEGETATION

AGRICULTURAL LIMESTONE 2000LBS/AC
10-10-10 FERTILIZED 1000LBS/AC
MULCH/STRAW 4000 LBS/AC

PERMANENT VEGETATIVE COVER:

PERMANENT GRASS: "RIPARIAN BUFFER SEED MIX" AT 20LBS/ACRE FROM MELLOW MARSH FARM, SILER CITY, NORTH CAROLIINA OR APPROVED EQUAL.

TEMPORARY MULCHING:
STRAY OR HAY 70-90 LBS./1,000 SQ.FT.
(TEMPORARY VEGETATIVE AREAS)

WOOD FIBER IN HYDROMULCH SLURRY 25-50 LBS./1,000 SQ. FT.

ESTABLISHMENT:

1. SMOOTH AND FIRM SEEDBED WITH CULTIPACKER OR OTHER SIMILAR EQUIPMENT PRIOR TO SEEDING (EXCEPT WHEN HYDROSEEDING).
2. SELECT ADAPTED SEED MIXTURE FOR THE SPECIFIC SITUATION. NOTE RATES AND THE SEEDING DATES (SEE VEGETATIVE COVER SELECTION & MULCHING SPECIFICATION BELOW).
3. APPLY SEED UNIFORMLY ACCORDING TO RATE INDICATED, BY BROADCASTING, DRILLING OR HYDRAULIC APPLICATION.
4. COVER GRASS AND LEGUME SEED WITH NOT MORE THAN 1/4 INCH OF SOIL WITH SUITABLE EQUIPMENT (EXCEPT WHEN HYDROSEEDING).
5. MULCH IMMEDIATELY AFTER SEEDING, IF REQUIRED, ACCORDING TO TEMPORARY MULCHING SPECIFICATIONS. (SEE VEGETATIVE COVER SELECTION & MULCHING SPECIFICATION BELOW).
6. USE PROPER INOCULANT ON ALL LEGUME SEEDINGS, USE FOUR TIMES NORMAL RATES WHEN HYDROSEEDING.
7. USE SOD WHERE THERE IS A HEAVY CONCENTRATION OF WATER AND IN CRITICAL AREAS WHERE IT IS IMPORTANT TO GET A QUICK VEGETATIVE COVER TO PREVENT EROSION.

MAINTENANCE:

1. TEST FOR SOIL ACIDITY EVERY THREE YEARS AND LIME AS REQUIRED.
2. ON SITES WHERE GRASSES PREDOMINATE, BROADCAST ANNUALLY 500 POUNDS OF 10-10-10 FERTILIZER PER ACRE (12 LBS. PER 1,000 SQ. FT.) OR AS NEEDED ACCORDING TO ANNUAL SOIL TESTS.
3. ON SITES WHERE LEGUMES PREDOMINATE, BROADCAST EVERY THREE YEARS OR AS INDICATED BY SOIL TEST 300 POUNDS OF 0-20-20 OR EQUIVALENT PER ACRE (8 LBS PER 1,000 SQ. FT.).

REVISIONS

Engineering, Surveying, Architecture and Environmental Science
MILONE & MACBROOM®
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SEDIMENT & EROSION CONTROL DETAILS

DEEP RIVER PARK
LEE AND CHATHAM COUNTY

NC HWY 42
CARBONTON, NORTH CAROLINA

PBS	PBS	KWK
DESIGNED	DRAWN	CHECKED

SCALE

DATE MAY 25, 2006

PROJECT NO. 2691-01-05

2961-02lowell\dwg\parktitleanddetails

SD1

SHEET NO.

APPENDIX G: EROSION EVALUATION REPORTS

EcoScience

EcoScience Corporation

1101 Haynes Street, Suite 101
Raleigh, North Carolina 919-828-3433

MEMORANDUM

TO: George Howard,
Restoration Systems, LLC (RS)

FROM: Matt Cusack, EcoScience Corporation

DATE: July 21, 2006

RE: Former Carbonton Dam Erosion Evaluation Number 1 **06-277.01**

The purpose of this memorandum it to provide you with the results of the first erosion assessment of the former impoundment of the Carbonton Dam performed in accordance with your Section 401 permit obligations. The former impoundment included 126,673 linear feet of affected stream reaches that extended throughout portions of Lee, Chatham, and Moore Counties, North Carolina.

This evaluation was performed to document any evidence of erosion within the former impoundment including but not limited to bank failure, loss of stream bank trees, severe head-cuts, and the loss or gain of large depositional features.

HISTORY

The North Carolina Division of Water Quality (NCDWQ) Section 401 permit condition #9 associated with the removal of the Carbonton Dam Deep River Restoration Site requires that a "survey [of] the present lake bed and its flooded tributaries [shall occur] at least every two weeks (bi-weekly) or within three days of a rain more than or equal to one inch at Moncure, NC." In order to satisfy permit condition #9, Restoration Systems, LLC (RS) authorized EcoScience Corporation (ESC) to conduct weather related erosion evaluations within the former Carbonton Impoundment (ESC Proposal P06-003 January 13, 2006).

As described in detail within this memorandum, RS and ESC collected historical weather information that suggested that the permit condition requested by NCDWQ presents several logistical difficulties. First, no USGS river gauge is present near Carbonton, NC. No publicly available or trustworthy real-time weather data are available in or around Carbonton, NC. The nearest weather station to Carbonton is located in Sanford, NC. Second, ESC believes that using rainfall from one weather station from within the 215-square mile watershed is not properly indicative of increased river stage conditions within the former impoundment. Thus, ESC has investigated and developed a new method for determining when a field evaluation should be performed.

In preparation for these evaluations, ESC has collected two years of nearly continuous daily precipitation and river stage data. If the permit condition #9 remains as stated, then more than 20 field evaluations would have been required during the period for which ESC collected the correlated rain/river stage data. It is important to note that many of the one inch rain events do not have a corresponding rise in river stage. Since the perceived purpose of the NCDWQ permit condition is to evaluate the former impoundment after increased river stage to monitor for erosion, then a one inch rainfall event is not the best indicator for the initiation of a site visit. Isolated thunderstorms can produce large amounts of precipitation in a localized area, without contributing significant rain to the

overall watershed. To monitor multiple weather stations in real-time throughout the watershed to identify a regional precipitation event is time consuming and not practicable. ESC has observed on Figure 1 that the greater than or equal to one-inch rain events that generate a corresponding rise in river stage appear to result in a river stage increase to at least 1500 cubic feet per second (cfs). Thus, ESC proposes to use the correlation between large, regional rain events that cause more than a 1500 cfs reading at the Ramseur gaging station to be the "initiation threshold" for a field evaluation. ESC estimates that this initiation threshold will occur after a river stage rise equal to ten percent of bankfull.

METHODS

Following an approximate 2.5-inch rainfall event that occurred in the upstream watershed, a peak in river stage of over 2400 cubic feet per second (cfs) was recorded at the USGS Ramseur river gage on April 27, 2006 (Figure 1). Once the 1500 cfs initiation threshold requiring an erosion evaluation was exceeded, ESC monitored the river stage until the river stage fell below the safe evaluation threshold of 1000 cfs, which occurred on April 28, 2006. ESC personnel performed the erosion evaluations on May 1 and 2, 2006. The activities on May 1 included observation points along the main stem of the Deep River and at accessible points along tributaries that comprised the former site impoundment,. The activities on May 2 included a survey assessment of the substrate bar located between NC42 and the former dam location within the Deep River. The duties carried out on May 1 were required to be completed within within a 72 hour period of April 28. ESC expects to continue using these methods for future evaluations of greater than 1500 cfs river stage event.s

RIVER TRANSIT EROSION EVALUATION

A two-person team performed a twelve-mile canoe transit of the Deep River. The point of ingress was the Glendon Carthage Road bridge and the point of egress was the North Carolina Wildlife Resource Commission boat ramp (Figure 2). The team stopped at the mouth of all credited tributaries as described in the Mitigation Plan (Restoration Systems 2006) as well as at points along the river where notable conditions occurred. At each observation point, GPS data was collected for the location, photography and/or videography was taken, and notes where recorded to describe the condition.

River Observation Point 1

River Observation Point 1 is located on the Deep River just below the Glendon Carthage bridge crossing (Figure 2). The observation point occurs up stream of the limits of the credited stream channel but is included because of the significant volume of bank material that has eroded into the channel. The bank failure begins approximately 20 feet up from waters edge and has eroded approximately 3 feet downward (Photo 1).

River Observation Point 2

River Observation Point 2 is located near Monitoring Station 12 at the confluence of the Deep River and an unnamed tributary (Figure 2). The observation point occurs upstream of the limits of the credited stream channel, but is included due to the impact of the storm event on a sand bar located in the outside bend of the Deep River. Stormflow eroded significant portions of the sand bar and up-rooted herbaceous and woody vegetation leaving behind depression pools and bare soil (Photo 2).

River Observation Point 3

River Observation Point 3 is located near Monitoring Station 11 at the confluence of the Deep River and an unnamed tributary (Figure 2). Minor bank erosion has occurred within the unnamed tributary and a minor head-cut has developed at the confluence with the Deep River. Streamflow has eroded down through the deposited silt sediments of the former impoundment and developed a more incised channel. The removal of the silt material has uncovered a coarser substrate below (Photo 3).

River Observation Point 4

River Observation Point 4 is located just downstream of the Norfolk-Southern rail bridge on the Deep River (Figure 2) and is important because of the severe erosion and loss of bank material that was observed. River flow is concentrated in the middle bridge span due to rock and debris constrictions on either side of the river. The concentrated flow discharges towards the outside bank of the river, resulting in significant erosion in high flow events. Following the storm event, the bank at this location was nearly vertical with some areas of exposed bedrock (Photo 4). This erosion feature has not changed since a review of the impoundment in December 2005, which suggests that the feature has eroded to bed rock and may have stabilized.

River Observation Point 5

River Observation Point 5 is located on the Deep River at the confluence with Lick Creek (Figure 2). Bank erosion was not an issue at the confluence and there was no evidence of the formation of a head-cut. Scouring of the silt material within Lick Creek has uncovered a courser substrate below (Photo 5).

River Observation Point 6

River Observation Point 6 is located on the Deep River at the confluence with McClendon's Creek (Figure 2). No erosion or bank failures could be seen from the confluence and the majority of the banks remained well vegetated following the rise in storm flow (Photo 6).

River Observation Point 7

River Observation Point 7 is located on the Deep River at the confluence with Big Governors Creek (Figure 2). No erosion or bank failures could be seen from the confluence and the majority of the banks remained well vegetated following the rise in storm flow. A few areas at waters edge showed signs of scour but the majority of the bank material appeared stable and still intact (Photo 7).

River Observation Point 8

River Observation Point 8 is located near Monitoring Station 5 at the confluence of the Deep River and an unnamed tributary (Figure 2). A significant head-cut was observed at this confluence and is depicted in Picture 9. The channel of the unnamed tributary is approximately 6 feet above the level of the Deep River and the head-cut is slowly carving into the tributary to reduce the difference. The tributary has very steep banks but no erosion or bank failures were observed. A layer of sediment remains in the channel (Photos 8-9).

River Observation Point 9

River Observation Point 9 is located on the Deep River at the confluence with an unnamed tributary

on the Knight Cattle Corporation property (Figure 2). A large head-cut is present at the confluence and severe erosion of the banks was observed. Vegetation is lacking along the banks of the unnamed tributary and sloughing of bank material is a problem here. Banks are steep and incised. Sediment material within the unnamed tributary covers any coarse material below and the addition of eroded bank material adds to the silty layer (see Knight Video).

River Observation Point 10

River Observation Point 10 is located on the Deep River at the confluence with an unnamed tributary (Figure 2). A steep head-cut was observed at this confluence with significant bank failures. The height difference between the unnamed tributary and the Deep River is approximately four feet. Vegetation along the tributary banks is well established but at the knick point of the head-cut, no vegetation has been able to establish. Erosion and sediment transfer will continue until the tributary matches the height of the Deep River (Photos 10-12).

River Observation Point 11

River Observation Point 11 is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 27. Moderate erosion was experienced here as a result of the high storm flow and loss of bank material was observed. A head-cut has formed at the confluence and sediment transport through the tributary has deepened the existing channel (Photo 13).

River Observation Point 12

River Observation Point 12 is located on the Deep River at the confluence with an unnamed tributary (Figure 2). A large head-cut has formed at the confluence and bank failure on the right bank of the tributary has resulted in steep, incised banks. Lack of vegetation on the banks of the confluence has advanced the transport and erosion of bank material (Photo 14).

River Observation Point 13

River Observation Point 13 is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 2. The banks of the tributary at the confluence are very steep and two head-cuts have formed. The larger head-cut has extended approximately 20 feet upstream from the confluence and a second, smaller head-cut has formed at the confluence. Significant erosion has occurred here and sediment transport has deepened the existing channel (Photo 15).

River Observation Point 14

River Observation Point 14 is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 23. The banks at the confluence are very steep and highly eroded, with little to no vegetation. A large head-cut has extended approximately 15 feet into the tributary, moving sediment out to the Deep River (Photo 16).

River Observation Point 15

River Observation Point 16 is located on the Deep River at the confluence with Line Creek (Figure 2). The south facing bank of the confluence was well vegetated but had a large separation of bank material towards the Deep River. The opposite bank lacked vegetation and had minor erosion.

Banks within Line Creek are deeply incised and sediment material washed from the channel has accumulated at the confluence (Photo 17).

LAND TRANSIT EROSION EVALUATION

A two-person team reviewed as many credited tributaries during the daylight hours as possible at public road crossings and at properties for which Restoration Systems has secured access. Either a 500 foot reach or 20 bankfull widths of each credited tributary were evaluated at each stop, which ever was greater. Some long-term monitoring stations were visited that were not on credited reaches to compare conditions to previous visits in order to further describe the extent of the flooding event. At each observation point, GPS data was collected for the location, photography was taken, and notes where recorded to describe the condition.

Land Observation Point 1

Land Observation Point 1 was taken at the crossing of Carbonton Road and Line Creek, a credited tributary to the Deep River (Figure 2). Signs of increased flow were apparent however no significant erosion conditions were observed. Sediment deposition was observed within the adjacent floodplain on leaves and vegetation near the ground surface (Photo 18 and Photo 19). Beaver activity and debris upstream of the road crossing resulted in a water table height increase that slowly returned to baseflow elevation without significant flow velocity (Photo 20).

Land Observation Point 2

Land Observation Point 2 was taken at Monitoring Station 45 near the crossing of Cool Springs Road and McClendons Creek (Figure 2). This section of McClendons Creek is a non-credited section but was visited to compare the stream condition that was observed the previous week during monitoring station sampling. Stormflow appears to have been at or near bankfull however there were no signs of significant bank failure observed. A moderate layer of fine sediment was observed on streamside vegetation signifying some erosion/sedimentation in the upstream watershed (Photo 21). Stream channel structure (rock, coarse woody debris, bank trees, etc.) and composition resembled the condition observed during monitoring station sampling the previous week.

Land Observation Point 3

Land Observation Point 3 was taken at Monitoring Station 47 near the crossing of Glendon Carthage Road and McClendon's Creek, a credited tributary to the Deep River (Figure 2). As expected, signs of more significant stormflow were apparent at Land Observation Point 3 in comparison to Land Observation Point 2 located further upstream on McClendon's Creek. Stormflow appears to have been at or over bankfull however there were no signs of significant bank failure observed. A moderate layer of fine sediment was observed on streamside and floodplain vegetation signifying erosion/sedimentation in the upstream watershed (Photo 22).

Land Observation Point 4

Land Observation Point 4 was taken at Monitoring Station 40 near the crossing of Steel Bridge Road and Little Governer's Creek, a credited tributary to the Deep River (Figure 2). This section of Little Governer's Creek received significant stormflow with overbank flooding apparent in multiple locations. Sedimentation on leaves and debris within the floodplain was observed over 60 feet from the stream (Photo 23). Some sections of the bank that were exposed following the dewatering of the impoundment have begun to slough downslope toward the current lotic water level (Figure 4 and

Photo 24-26). However, with the exception of the occasional migration of these bank sections, no significant bank failure was observed. These areas will be monitored closely to ensure that they do not undercut the higher bank that was associated with the former impoundment area. Several small ephemeral-intermittent tributaries were observed to have slight developing head-cuts (Photo 27). These areas have been marked and will be monitored following additional increases in stream flow.

Land Observation Point 5

Land Observation Point 5 was taken at the crossing of an unnamed road located on the Knight Cattle Corporation property and an unnamed credited tributary to the Deep River located upstream of Monitoring Station 29 (Figure 2). Stormflow appears to have reached approximately half bankfull stage and there were no signs of significant bank failure observed. A thin layer of fine sediment was observed on streamside vegetation signifying some erosion/sedimentation in the upstream watershed (Photo 28). At the confluence of the UT and the Deep River, a significant head-cut was observed. For additional details, see River Observation Point 9 of this document.

SUMMARY

Conditions within the former impoundment of the Deep River and it's tributaries during the first erosion evaluation (May 1, 2006) ranged from areas with localized severe erosion, to areas with little to no erosion observed. The majority of all confluences within the former impoundment of the Deep River were observed to be unstable as a result of a head-cut. The formation of head-cuts is expected as the former impounded Deep River makes a transition from a lentic to lotic flow regime, and appropriate sediment transport occurs. Loss of bank material due to storm flow scouring was observed throughout many tributaries as herbaceous vegetation attempts to re-establish. Banks within the Deep River were observed to be fairly stable with the exception of treefalls at or near waters edge. Well established herbaceous vegetation was observed along both banks of the Deep River below the elevation of the former dam crest pool. Heavily shaded areas have the least amount of herbaceous vegetation and those areas are experiencing the worst erosion. Woody debris exposed following de-watering of the former impoundment has collected in numerous logjams. A single, large, potentially problematic logjam formed behind the NC 42 bridge crossing , and RS and NCDOT were notified of this logjam on May 1, 2006. ESC understands that NCDOT cleaned the log jam from the NC 42 bridge within two days.

SUBSTRATE ISLAND SURVEY

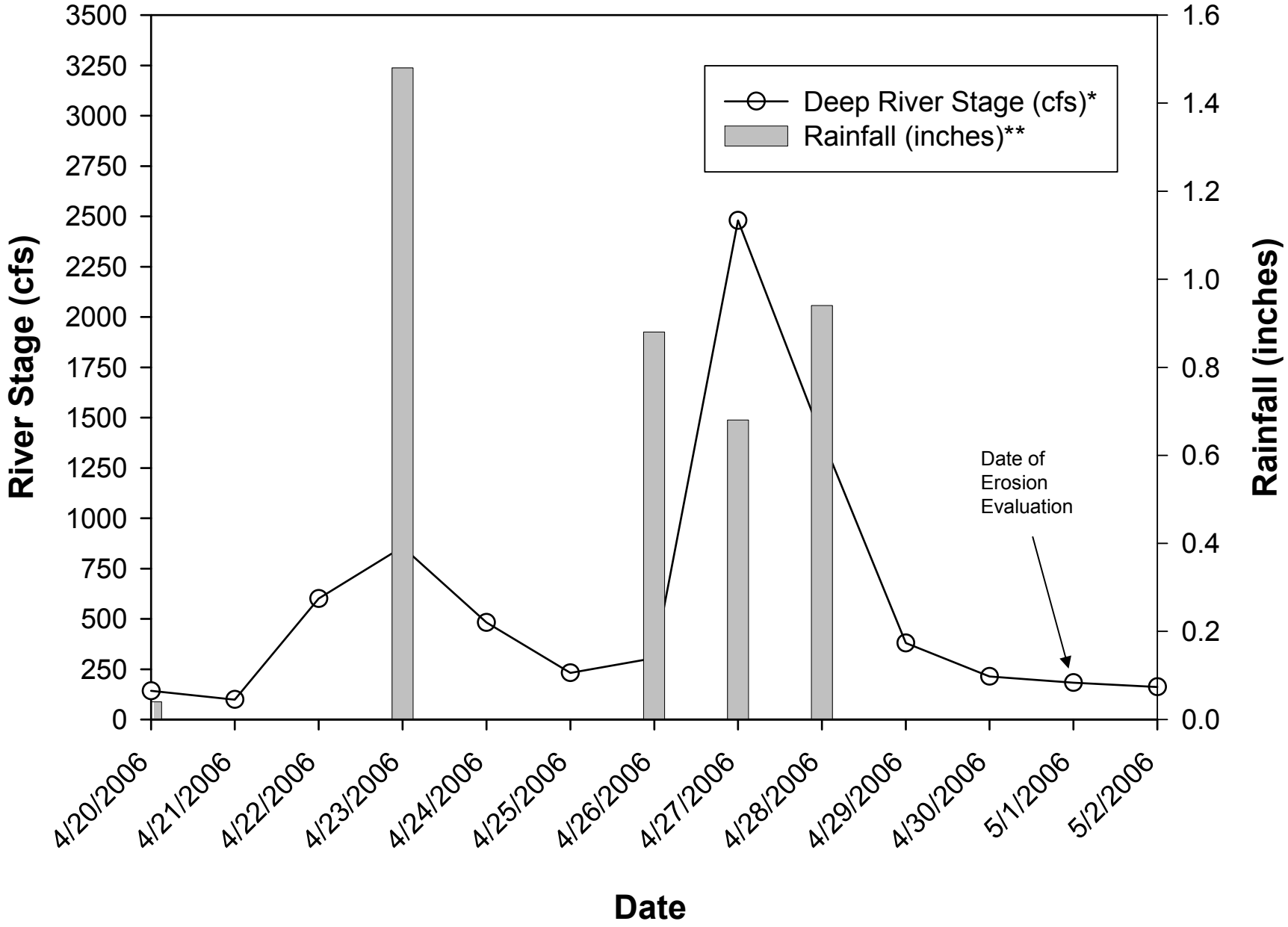
In addition to the erosion evaluation, multiple cross-sections of the substrate island between the NC 42 bridge and the former dam footprint of the Carbonton Dam were completed. Three (3) permanent cross-sections were established to monitor the character or size of the substrate island following substantial river stage events. One (1) permanent cross-section was established just upstream of the former dam to monitor the river profile following high river stage events and to track movement of the substrate island material (Figure 4). Cross-sectional surveys were completed using Total Station survey equipment.

RIFFLE ESTABLISHMENT

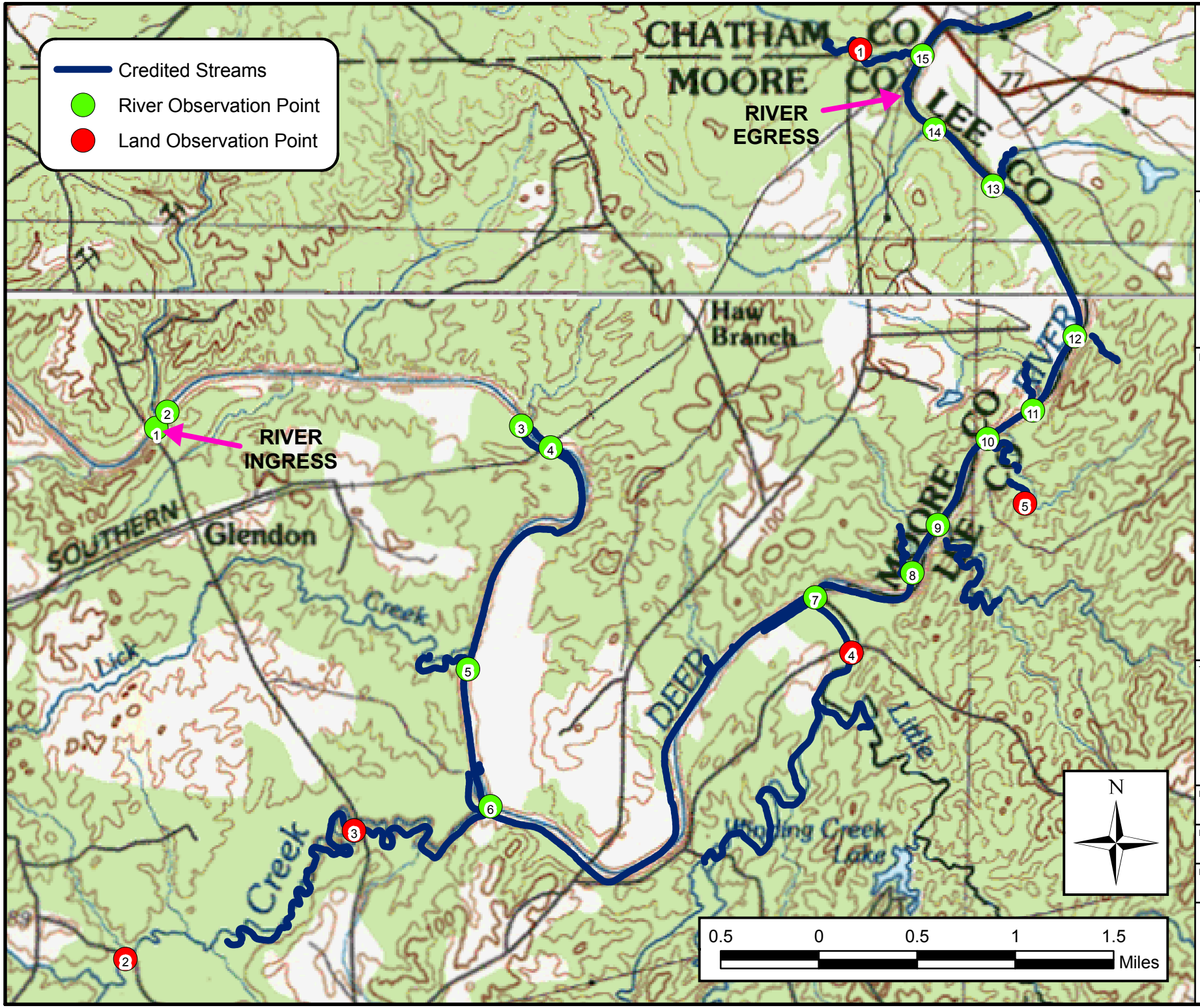
Following the dewatering of the Carbonton Dam impoundment, several riffles have developed within the Deep River. These riffles have been observed and documented during field outings. (Figure 5). Photos 1-6 in Deep River Riffle Establishment Photos section of this document show the location and character of the newly formed riffles.

DEEP RIVER EROSION EVALUATION FIGURES

Figure 1. River Stage vs. Rainfall Conditions Leading up to the 5-1-2006 Erosion Evaluation Survey



* River Stage Data collected from USGS Station #02100500 located on the Deep River at Ramseur, NC.
** Rainfall Data collected from NC Climate Retrieval and Observations Network of the Southeast Database Station #317924 located at Siler City, NC.



EcoScience Corporation
Raleigh, North Carolina

CLIENT:

NRS Restoration Systems, LLC
Natural Resources Restoration & Conservation

PROJECT:

Deep River-Carbonton Dam Restoration Site

Chatham, Lee and Moore Counties, North Carolina

TITLE:

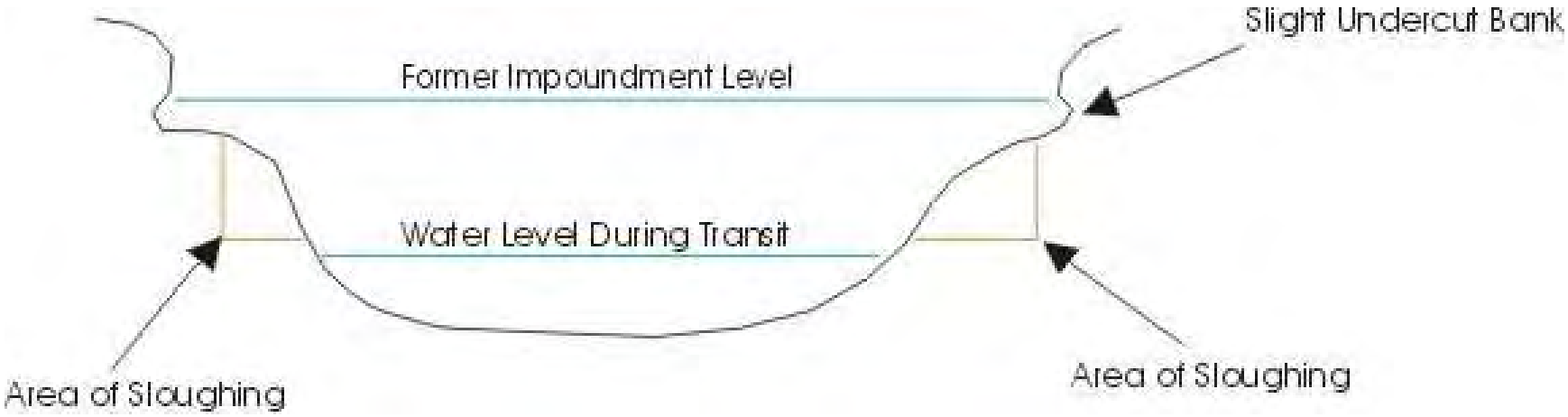
Erosion Evaluation Observation Points 5-1-2006

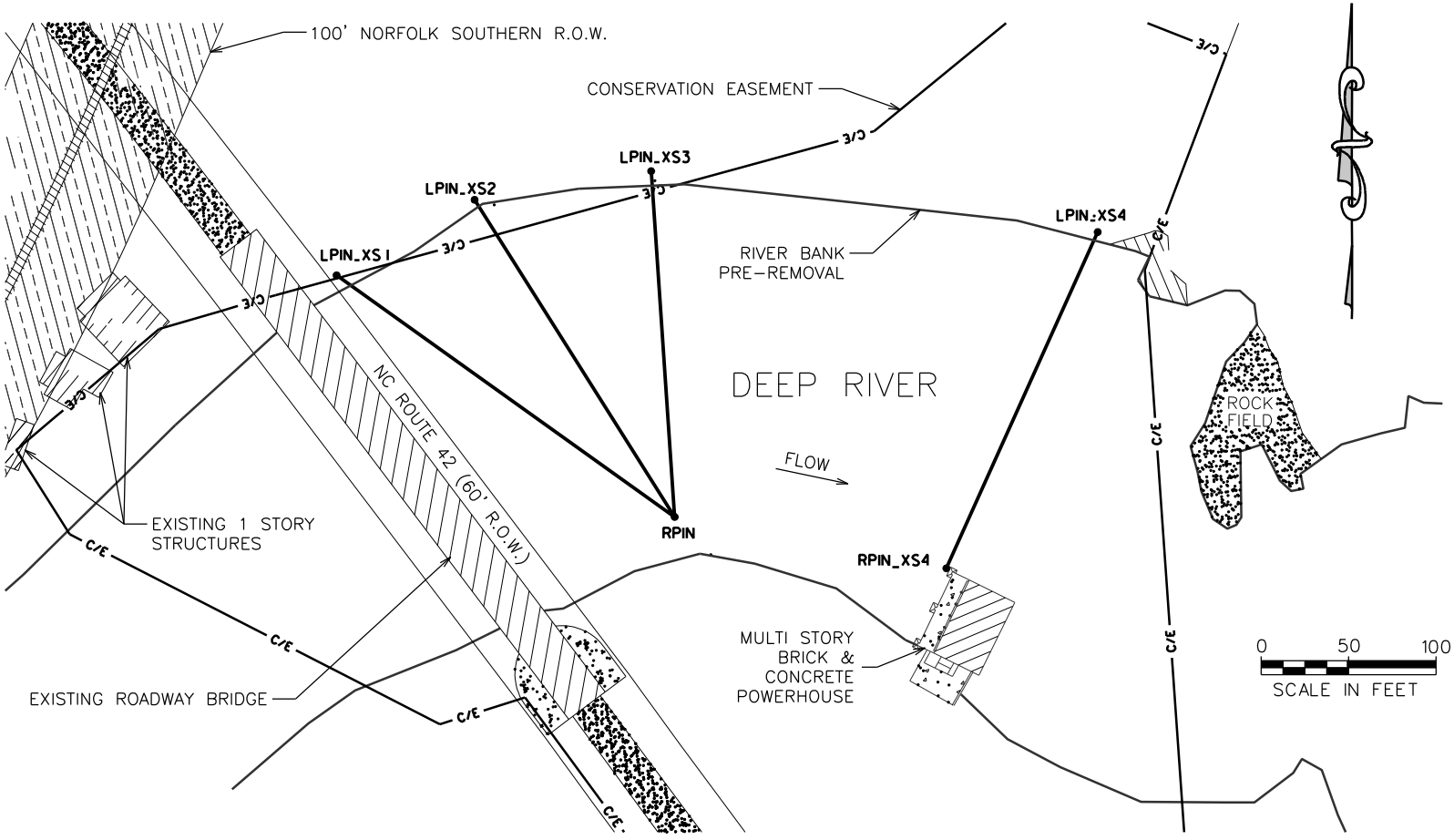
Dwn By:	Ckd By:
DGJ	MCG
Date:	Scale:
JUL 2006	AS SHOWN

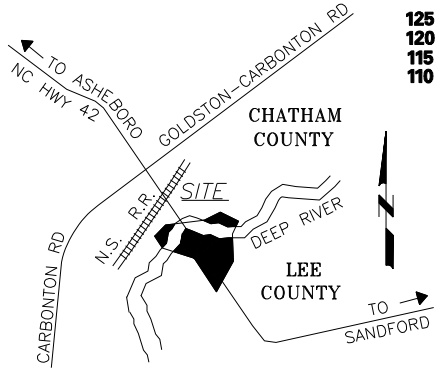
ESC Project No.
06-277.00

FIGURE
2

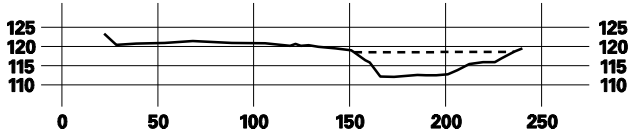
Figure 3. Stream Bank Slough at Little Governers Creek 5-1-2006 Erosion Evaluation Survey







VICINITY MAP (NTS)



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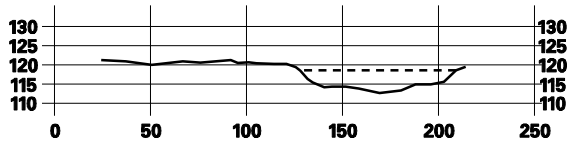

X-SECT 2

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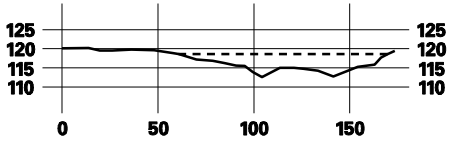

X-SECT 3

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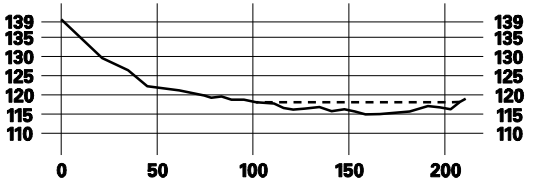


X-SECT 4

SCALE: (H=1:100 / V=1:50)

EcoScience Corporation
Raleigh, North Carolina

REVISIONS

Client:
RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

Project:

DEEP RIVER CARBONTON DAM RESTORATION SITE

LEE COUNTY & CHATHAM COUNTY, NORTH CAROLINA

Title:

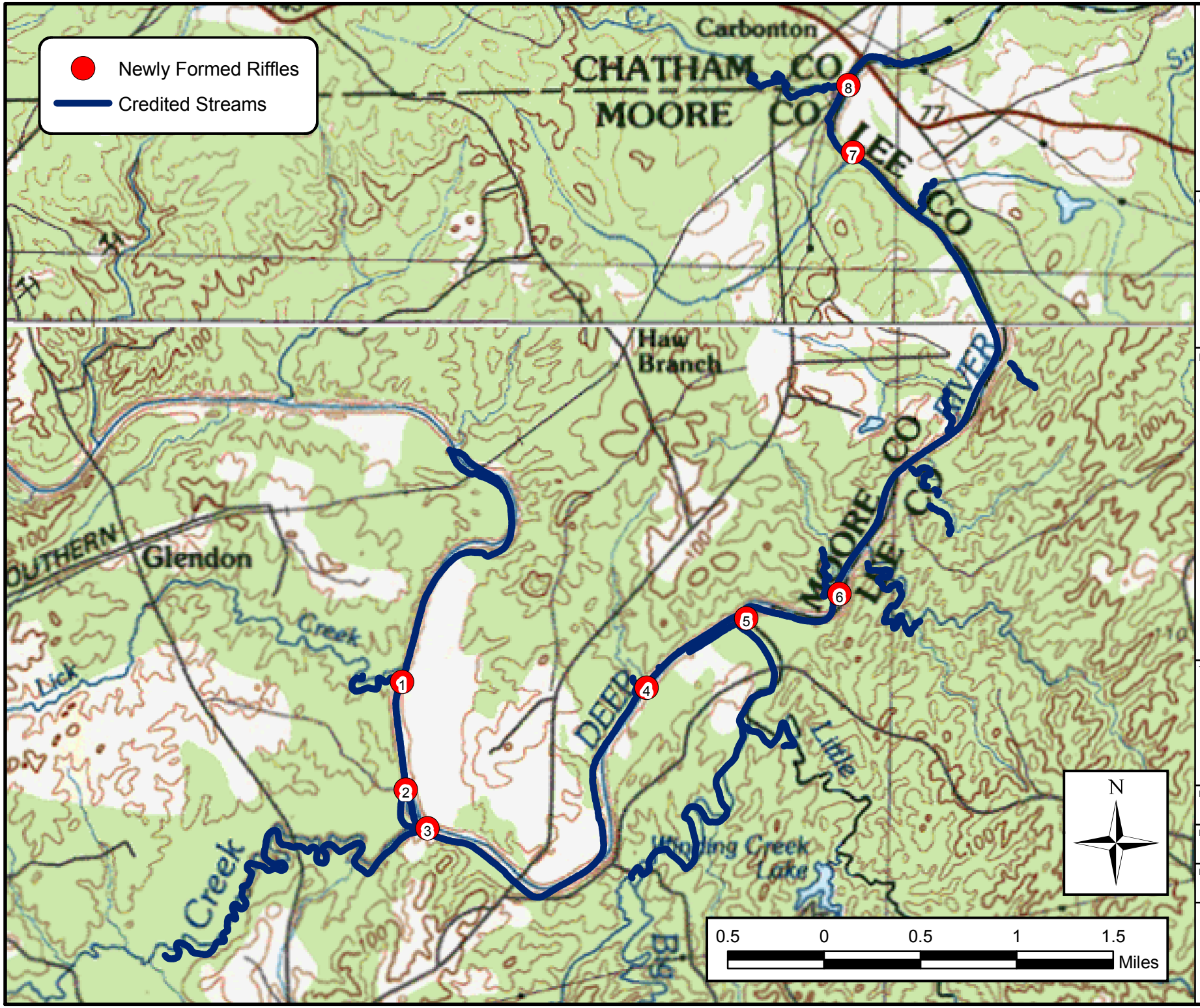
SUBSTRATE ISLAND MONITORING

Dwn By:	Date:
JDG	MAY 2006
Ckd By:	Scale:
DGJ	1"= 100'

ESC Project No.: 06-277

FIGURE

4



EcoScience Corporation
Raleigh, North Carolina

CLIENT:
RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

PROJECT:

Deep River-Carbonton Dam Restoration Site

Chatham, Lee and Moore Counties, North Carolina

TITLE:

Newly Formed Riffles May 2006

Dwn By:	Ckd By:
DGJ	MCG
Date:	Scale:
MAY 2006	AS SHOWN

ESC Project No.
06-277.00

FIGURE
5

DEEP RIVER EROSION EVALUATION PHOTOS

Photo 1. River Observation Point 1

Location: Deep River downstream of Glendon Carthage Road crossing

Description: Erosion of bank material into the Deep River

Photo 2. River Observation Point 2

Location: Deep River near Monitoring Station 12

Description: Scouring along the banks due to overland storm flow

Photo 3. River Observation Point 3

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 11

Description: Minor bank erosion and headcutting

Photo 4. River Observation Point 4

Location: Deep River downstream of the Norfolk-Southern rail bridge

Description: Bank failure and erosion into the Deep River.

Photo 5. River Observation Point 5

Location: Confluence of the Deep River and Lick Creek

Description: Coarsening of stream substrate through sediment transport

Photo 6. River Observation Point 6

Location: Confluence of the Deep River and McClendon's Creek

Description: Stable banks without signs of erosion

Photo 7. River Observation Point 7

Location: Confluence of the Deep River and Big Governors Creek.

Description: Stable banks with only minor erosion

Photo 8. River Observation Point 8

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 5

Description: Large headcut with incised banks

Photo 9. River Observation Point 8

Location: Upstream view of an unnamed tributary near Monitoring Station 5

Description: Well vegetated banks upstream leading to increased erosion at the confluence

Photo 10. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary

Description: Sloughing of bank material

Photo 11. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary

Description: Large headcut and eroded banks

Photo 12. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary

Description: Upstream view of the tributary beyond the headcut

Photo 13. River Observation Point 11

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 27

Description: Headcutting and erosion of bank material

Photo 14. River Observation Point 12

Location: Confluence of the Deep River and an unnamed tributary

Description: Headcut and erosion of bank material

Photo 15. River Observation Point 13

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 2

Description: Severe headcutting and erosion of bank material

Photo 16. River Observation Point 14

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 23

Description: Severe headcutting and erosion of bank material

Photo 17. River Observation Point 15

Location: Confluence of the Deep River and Line Creek

Description: Large separation of bank material

Photo 18. Land Observation Point 1

Location: Downstream of the Carbonton Road and Line Creek crossing

Description: Thin layer of deposition at ground surface within the floodplain

Photo 19. Land Observation Point 1

Location: Upstream of the Carbonton Road and Line Creek crossing

Description: Thin layer of deposition on stream bank vegetation

Photo 20. Land Observation Point 1

Location: Upstream of Carbonton Road and Line Creek crossing

Description: Coarse woody debris at culvert intake leading under Carbonton Road

Photo 21. Land Observation Point 2

Location: McClendons Creek left bank at Monitoring Station 45

Description: Moderate layer of fine sediment deposited on stream bank

Photo 22. Land Observation Point 3

Location: McClendons Creek left bank at Monitoring Station 47

Description: Moderate layer of fine sediment deposited on stream bank and vegetation

Photo 23. Land Observation Point 4

Location: Little Governers Creek right bank immediately upstream of Steel Bridge Road crossing (picture taken from the bridge looking down at the bank and floodplain)

Description: Sedimentation on leaves approximately 1.5 feet above bankfull

Photo 24. Land Observation Point 4

Location: Little Governers Creek left bank upstream of Monitoring Station 40

Description: Some exposed sections of the stream bank following the dewatering of the impoundment have begun to slough toward the current lotic water level

Photo 25. Land Observation Point 4

Location: Little Governers Creek left bank upstream of Monitoring Station 40

Description: Some exposed sections of the stream bank following the dewatering of the impoundment have begun to slough toward the current lotic water level

Photo 26. Land Observation Point 4

Location: Little Governers Creek left bank downstream of Steel Bridge Road crossing

Description: Stream bank slough occurring immediately downstream of a riffle in the outside bend of the creek

Photo 27. Land Observation Point 4

Location: Little Governers Creek right bank upstream of Monitoring Station 40

Description: Developing slight headcut on small ephemeral-intermittent tributary

Photo 28. Land Observation Point 5

Location: UT to Deep River at Monitoring Station 29

Description: Approximate level of stormflow and resultant sediment stained vegetation*

*Camera malfunction prohibited documentation of stream on day of transit. Picture above was taken in March 2006 during annual monitoring activities.

DEEP RIVER RIFFLE ESTABLISHMENT PHOTOS

Photo 1. New Riffle 1

Location: Deep River downstream of the confluence with Lick Creek, at Monitoring Station 9.

Photo 2. New Riffle 4

Location: Deep River upstream of the confluence with an unnamed tributary, at Monitoring Station 55.

Photo 3. New Riffle 5

Location: Deep River at the confluence with Big Governors Creek.

Photo 4. New Riffle 6

Location: Deep River at the confluence with an unnamed tributary at Monitoring Station 5.

Photo 5. New Riffle 7

Location: Deep River at the confluence with an unnamed tributary at Monitoring Station 23.

Photo 6. New Riffle 8

Location: Deep River at the confluence with Line Creek.

EcoScience

EcoScience Corporation

1101 Haynes Street, Suite 101
Raleigh, North Carolina 919-828-3433

MEMORANDUM

TO: George Howard,
Restoration Systems, LLC (RS)

FROM: Matt Cusack

DATE: July 25, 2006

RE: Erosion Evaluation No. 2 (6-26-2006) **06-277.02**

The purpose of this memorandum it to provide you with the results of the second erosion assessment of the former impoundment of the Carbonton Dam performed in accordance with your Section 401 permit obligations. The former impoundment included 126,673 linear feet of affected stream reaches that extended throughout portions of Lee, Chatham, and Moore Counties, North Carolina.

This evaluation was performed to document any evidence of erosion within the former impoundment including but not limited to bank failure, loss of stream bank trees, severe head-cuts, and the loss or gain of large depositional features.

History

The North Carolina Division of Water Quality (NCDWQ) Section 401 permit condition #9 associated with the Carbonton Dam – Deep River Restoration Site requires that a "survey [of] the present lake bed and its flooded tributaries [shall occur] at least every two weeks (bi-weekly) or within three days of a rain more than or equal to one inch at Moncure, NC." In order to satisfy permit condition #9, Restoration Systems, LLC authorized EcoScience Corporation (ESC) to conduct weather related erosion evaluations within the former Carbonton Impoundment (ESC Proposal P06-003 January 13,2006).

As described in greater detail within the summary memorandum for erosion transit 1, ESC has observed that the greater than or equal to one-inch rain events that generate a corresponding rise in river stage appear to result in a river stage increase to at least 1500 cubic feet per second (cfs). Thus, ESC proposes to use the correlation between large, regional rain events that cause more than a 1500 cfs reading at the Ramseur gaging station to be the "initiation threshold" for a field evaluation. ESC estimates that this initiation threshold occurs after a river stage rise equal to ten percent of bankfull.

Methods

The remnants of Alberto, the season first tropical storm of 2006, unleashed heavy rain over a large area of central North Carolina on June 13, 2006. The National Weather Service recorded 7.6 inches of rain at its Raleigh office with as much as 8 inches of rain recorded along the storm's path. While the Deep River stage was still elevated a second, large non-tropical rainfall event resulted in an average of 2.1 inches of rainfall within the upper Deep River watershed on June 24, 2006 (Figure 1). Included in the storms path was the upper watershed of the Deep River including

Guilford, Moore, and Randolph counties. The resulting event caused the USGS gauge at Ramseur to register a peak discharge on June 23, 2006 of 7700 cubic feet per second (cfs) **(**Figure 2). The "initiation threshold" from this storm occurred on June 23 and the "evaluation threshold" on June 25. An erosion evaluation was conducted within the formerly impounded reaches of the Deep River on June 26, 2006. The activities on June 26 included observation points along the main stem of the Deep River and at accessible points along tributaries that comprised the former site impoundment. The activities on June 27 included a survey assessment of the substrate bar located between NC42 and the former dam location within the Deep River. The duties carried out on June 26 were required to be completed within a 72 hour period of June 25. ESC expects to continue using these methods for future evaluations of greater than 1500 cfs river stage events.

River Transit Erosion Evaluation

A two-person team performed a twelve-mile canoe transit of the Deep River. The point of ingress was the Glendon Carthage Road bridge and the point of egress was the North Carolina Wildlife Resource Commission boat ramp (Figure 3). The team stopped at the mouth of all credited tributaries as described in the Mitigation Plan (Restoration Systems 2006) as well as at points along the river where notable conditions occurred. At each observation point, GPS data was collected for the location, photography and/or videography was taken, and notes were recorded to describe the condition. Observation points previously evaluated during the first erosion evaluation (May 1, 2006) that showed no signs of change are not documented by this current evaluation. The numeric labels assigned to each observation point are unique to only this evaluation. Observation points from the first erosion evaluation (May 1, 2006) that were revisited during this evaluation have been noted in the text.

River Observation Point 1

River Observation Point 1 is located on the Deep River downstream of the Glendon Carthage Road crossing (Figure 2). At this point on the Deep River, sediment and organic debris was scoured from the river bank and transported downstream following the rise in storm flow (Photo 1). This is a common occurrence in areas where herbaceous vegetation has not adequately established. Observation Point 1 was not formerly impounded, and is an example of ambient erosion that affects reference reaches of the Deep River.

River Observation Point 2

River Observation Point 2 (previously evaluated on May 1, 2006) is located just downstream of the Norfolk-Southern rail bridge on the Deep River (Figure 2). Continued erosion and loss of bank material was observed. The increase in storm flow discharged from beneath the bridge results in an increased sediment transport capacity. Stream banks remain nearly vertical as large boulders continue to accumulate at the toe of the slope (Photo 2).

River Observation Point 3

River Observation Point 3 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with Lick Creek (Figure 2). Bank erosion was not an issue at the confluence and there was no evidence of the formation of a head-cut. A large logjam has formed within the Deep River at the confluence from an accumulation of woody debris that has been trapped behind a recent tree fall (Photo 3).

River Observation Point 4

River Observation Point 4 is located on the Deep River approximately 1000 feet below the confluence with Lick Creek near Monitoring Cross-section 9 (Figure 2). At this location a tree and surrounding bank material has eroded into the Deep River. The increase in storm flow, combined

with scouring beneath the tree and poorly established herbaceous vegetation, has contributed to bank instability (Photo 4).

River Observation Point 5

River Observation Point 5 is located on the Deep River at the confluence with the upstream end of an oxbow near McClendon's Creek. At this location well established herbaceous vegetation was observed to have been scoured due to an increase in storm surge. Most of the vegetation appeared to be intact and holding bank material in place (Photo 5). During the storm event this area was inundated as noted by sediment deposition on vegetation surrounding the oxbow channel.

River Observation Point 6

River Observation Point 6 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with McClendon's Creek (Figure 2). No erosion or bank failures could be seen from the confluence and the majority of the banks remained well vegetated following the rise in storm flow (Photo 6).

River Observation Point 7

River Observation Point 7 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with Big Governors Creek (Figure 2). Minor erosion and bank failures could be seen from the confluence and the majority of the banks remained well vegetated following the rise in storm flow. A few areas at waters edge showed continued scouring but the majority of the bank material appeared stable and still intact. A large accumulation of woody debris has collected at the confluence (Photo 7).

River Observation Point 8

River Observation Point 8 (previously evaluated on May 1, 2006) is located near Monitoring Station 5 at the confluence of the Deep River and an unnamed tributary (Figure 2). The previously observed head-cut has continued to transport sediment from the tributary and the banks show continued signs of erosion. Large amounts of bank material have sloughed into the tributary channel and deposition has accumulated at the confluence with the Deep River. The nearly closed canopy over the tributary has greatly limited the establishment of herbaceous vegetation which would provide additional bank stability (Photo 8).

River Observation Point 9

River Observation Point 9 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with an unnamed tributary on the Knight Cattle Corporation property (Figure 2). A head-cut has continued to migrate up the tributary and bank material continues to erode. Herbaceous vegetation has not established and banks are steep and incised as a result of storm flow scour (Photo 9).

River Observation Point 10

River Observation Point 10 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 27. A head-cut has continues to transport sediment from the tributary and has eroded further upstream. In some areas the banks are steep and incised. A large tree has fallen from the banks at the confluence and has accumulated additional woody debris from the Deep River (Photo 10).

River Observation Point 11

River Observation Point 11 (previously evaluated on May 1, 2006) is located on the Deep River at

the confluence with an unnamed tributary (Figure 2). A large head-cut at the confluence appears to have only slightly migrated upstream, but bank material continues to erode. Lack of vegetation on the banks of the confluence has allowed for continued transport and erosion of bank material (Photo 11).

River Observation Point 12

River Observation Point 12 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 2. The banks of the tributary at the confluence remain very steep, and previously observed head-cuts appear to have only slightly moved up the tributary. Significant erosion of bank material continues and a large tree fall at the confluence has slowed the transport of sediment from the tributary (Photo 12).

River Observation Point 13

River Observation Point 13 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 23. A large head-cut has continued moving sediment out of the tributary and banks remain steep and unvegetated. Only minor signs of bank erosion near the confluence were observed (Photo 13).

River Observation Point 14

River Observation Point 14 (previously evaluated on May 1, 2006) is located on the Deep River at the confluence with Line Creek (Figure 2). Line Creek continues to experience severe bank erosion. Banks within Line Creek are deeply incised and sediment accumulation at the confluence has increased. Large amounts of woody debris are scattered throughout the channel (Photo 14).

Land Transit Erosion Evaluation

A two-person team reviewed as many credited tributaries during daylight hours as possible at public road crossings. Either a 500 foot reach or 20 bankfull widths of each credited tributary were evaluated at each stop, whichever was greater. Some long-term monitoring stations were visited that were not on credited reaches to compare conditions to previous visits in order to further describe the extent of the flooding event. At each observation point, photographs were taken and notes were recorded to describe notable conditions.

Land Observation Point 1

Land Observation Point 1 was taken at the crossing of Carbonton Road and Line Creek, a credited tributary to the Deep River (Figure 2). Signs of increased flow were apparent; however, no significant erosion conditions were observed. Sediment deposition was observed within the adjacent floodplain on leaves and vegetation near the ground surface. The banks of Line Creek appear generally stable and well-vegetated, resulting in little to no erosive action. Beaver activity and debris upstream of the road crossing resulted in a water table height increase that slowly returned to baseflow elevation without significant flow velocity (Photos 15-17).

Land Observation Point 2

Land Observation Point 2 was taken at Monitoring Station 45 near the crossing of Cool Springs Road and McClendons Creek (Figure 2). This section of McClendons Creek is a non-credited section but was visited to compare the stream condition that was observed previously during monitoring station sampling. Stormflow appears to have been above bankfull, though there were no signs of significant bank failure observed. Streamflow appears to have overtopped the road at its crossing of McClendon's Creek at this point, as large amounts of gravel were found to have been

washed a short distance downstream (Photo 18). A moderate layer of fine sediment was observed on streamside vegetation signifying some erosion/sedimentation in the upstream watershed and significant drainage patterns were observed outside the channel of McClendon's Creek. Large and numerous pools of standing water were found within the floodplain of McClendon's Creek at this location, indicating overbanking of the stream with little subsequent drainage (Photos 19-20).

Land Observation Point 3

Land Observation Point 3 was taken at Monitoring Station 47 near the crossing of Glendon Carthage Road and McClendons Creek, a credited tributary to the Deep River (Figure 2). As expected, signs of more significant stormflow were apparent at Land Observation Point 3 in comparison to Land Observation Point 2 located further upstream on McClendons Creek. Stormflow appears to have been at or over bankfull though no significant bank failures were noted. Undercut banks as well as several areas of exposed, unvegetated bank areas, subject to potential erosion were observed (Photos 21-23). A moderate layer of fine sediment was observed on streamside and floodplain vegetation signifying erosion/sedimentation in the upstream watershed.

Land Observation Point 4

Land Observation Point 4 was taken at Monitoring Station 40 near the crossing of Steel Bridge Road and Little Governors Creek, a credited tributary to the Deep River (Figure 2). This section of Little Governors Creek received significant stormflows with overbank flooding apparent in multiple locations. A large tree has fallen as the bank beneath it has been undercut substantially (Photo 24). Many stretches of streambank along this reach of Deep Governors Creek show signs of severe undercutting (Photo 25) and in several areas, portions of the banks have sloughed off. Just downstream from the Steel Bridge Road bridge, a large tributary is deeply incised with evidence of large, recent alluvial deposits near its confluence with Deep Governors Creek (Photo 26).

Summary

The rain event which triggered this erosion evaluation caused the USGS gauge at Ramseur to register a peak discharge on June 23, 2006 of 7700 cubic feet per second (cfs). This peak discharge is more than three times the peak discharge (2400 cfs) of the storm event which initiated the first erosion evaluation on May 1, 2006. Despite the dramatically higher rainfall totals and peak discharge associated with this storm, the Deep River and its tributaries were observed to experience similar levels of sediment erosion as those observed during the first evaluation. Head-cuts observed during the first evaluation continue to transport sediment from the tributaries into the Deep River. Scouring and erosion of tributary banks was only problematic in areas where herbaceous vegetation has not established. Banks of the Deep River are stable and generally well vegetated, with a few areas of undercutting observed. Woody debris was still evident throughout the former impoundment, but bridge spans did not accumulate as much material as noted during the first evaluation.

SUBSTRATE ISLAND SURVEY

In addition to the erosion evaluation, multiple cross-sections of the substrate island between the NC 42 bridge and the former dam footprint of the Carbonton Dam were completed on June 27, 2006. Three (3) permanent cross-sections previously established over the substrate island, and one (1) permanent cross-section previously established just upstream of the former dam, were completed. Figure 4 maps the location of the substrate island cross-sections and Figure 4A compares the cross-sectional surveys of May 2, 2006 and June 27, 2006. Erosion of the substrate island is primarily evident within cross-section 1 with scouring along the outside of the bend on the left bank.

Cross-sections 2 and 3 show only minor signs of sediment transport from within the channel and no signs of change at the river banks. Cross-section 4 shows that the Deep River is stable at the location of the former dam.

DEEP RIVER EROSION EVALUATION FIGURES

YADKIN
FORSYTH
GUILFORD
DAVIE
DAVIDSON
RANDOLPH
CHATHAM
ROWAN
CABARRUS
STANLY
MONTGOMERY
MOORE
LEE
HARNETT

LEGEND

Deep River watershed upstream of Carbonton Dam

Rainfall Estimate (inches)

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- >4

N

Notes:
Source of Doppler Rain Estimate is from
http://www.srh.noaa.gov/rfcshare/precip_analysis.php

5 0 5 Miles

EcoScience Corporation
Raleigh, North Carolina

CLIENT:

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

PROJECT:

CARBONTON DAM EROSION EVALUATION

Lee, Chatham, and Moore Counties
North Carolina

TITLE:

Total Rainfall Estimate for 6-24-2006 Rain Event

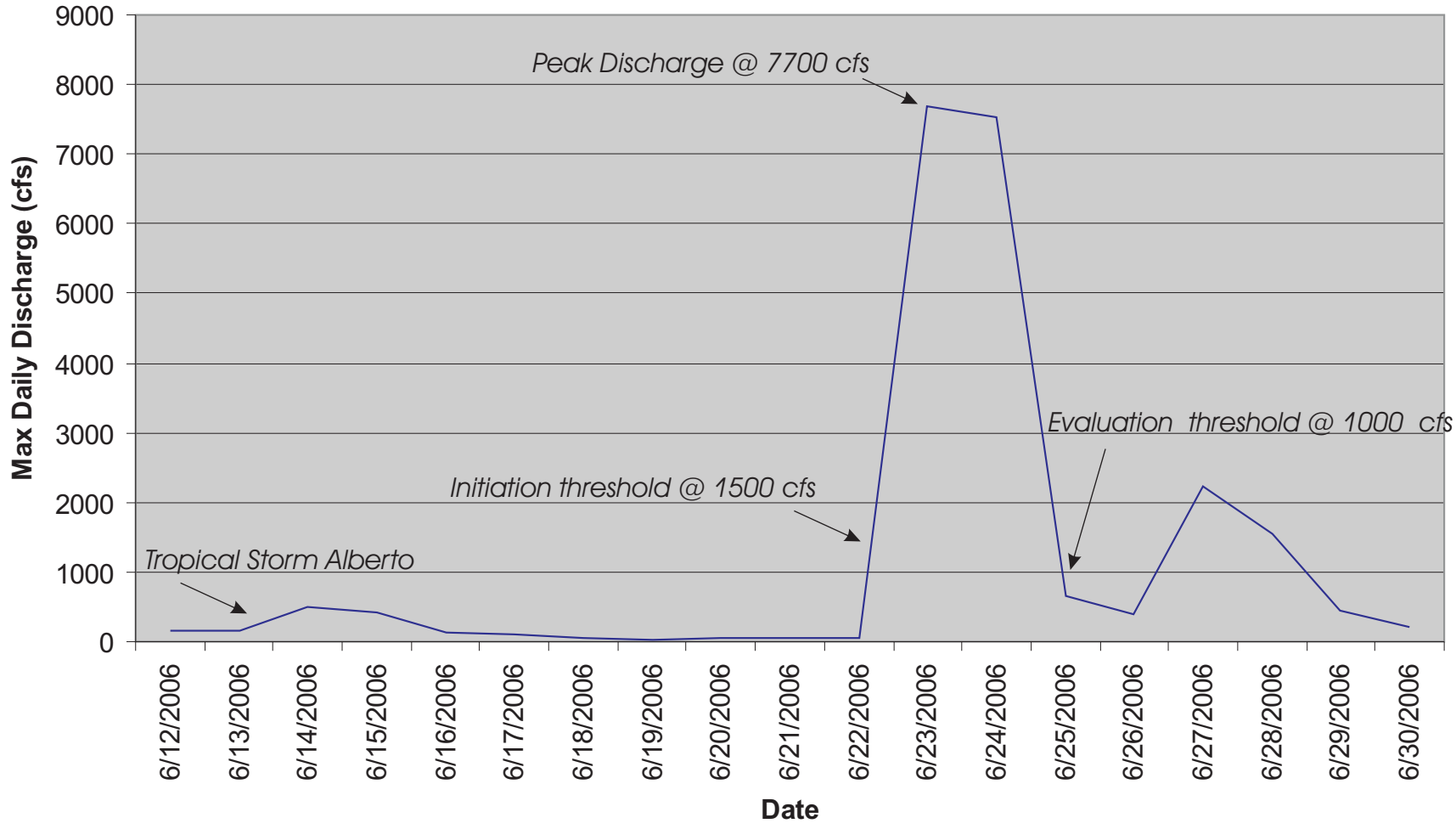
Dwn By:	Ckd By:
MTC	MCG
Date:	Scale:
JUL 2005	AS SHOWN

ESC Project No.: 06-277.02

FIGURE

1

FIGURE 1. USGS 02100500 Deep River at Ramseur, NC

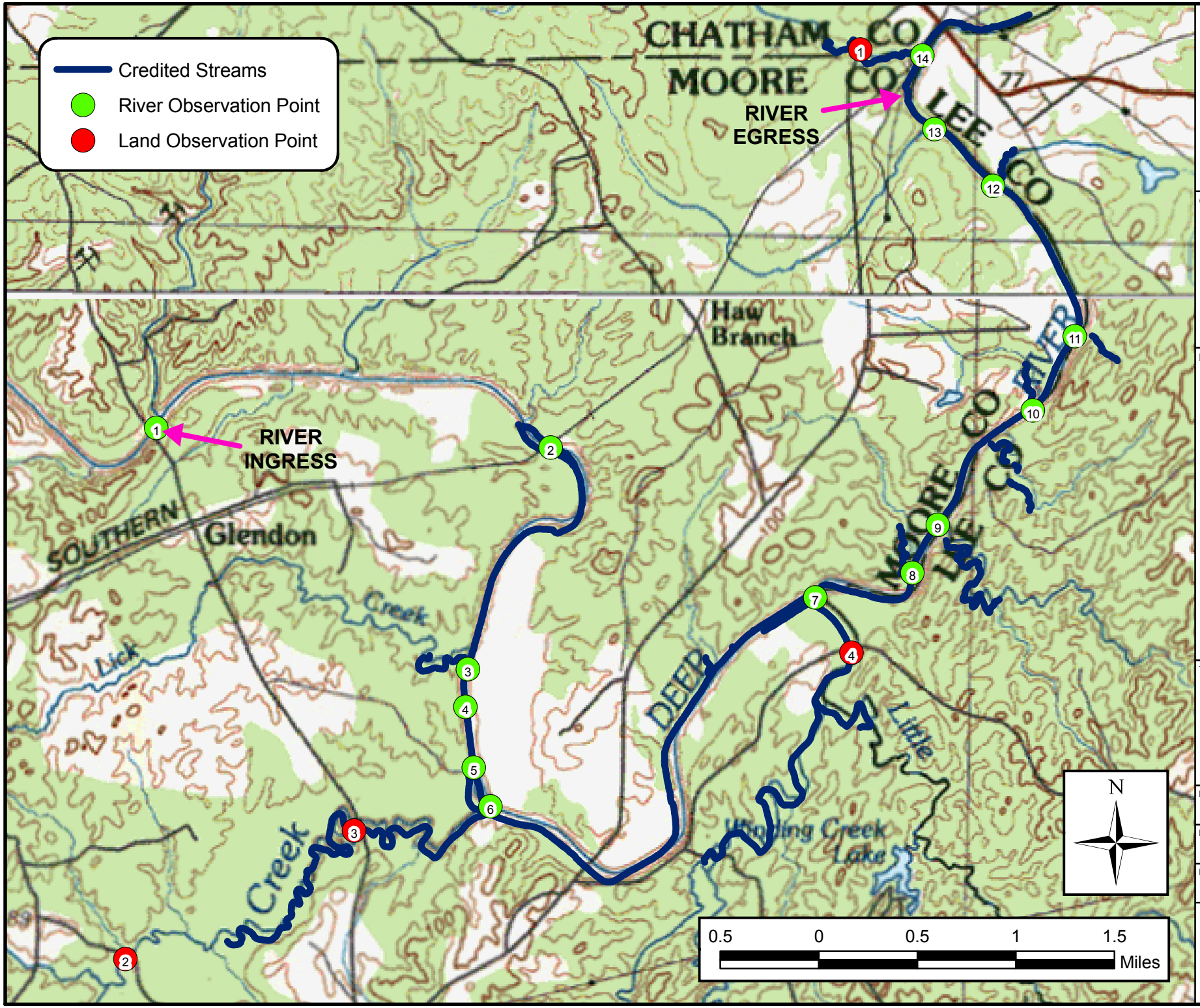


EcoScience Corporation
Raleigh, North Carolina

EVENT DISCHARGE AT GAUGE NEAR RAMSEUR, NC
CARBONTON DAM RESTORATION SITE
Erosion Evaluation (6-26-2006)

Dwn. by:	MCG
Ckd by:	MCG
Date:	JULY 2006
Project:	06-277

FIGURE 2



EcoScience Corporation
Raleigh, North Carolina

CLIENT:

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

PROJECT:

Deep River-Carbonton Dam Restoration Site

Chatham, Lee and Moore Counties, North Carolina

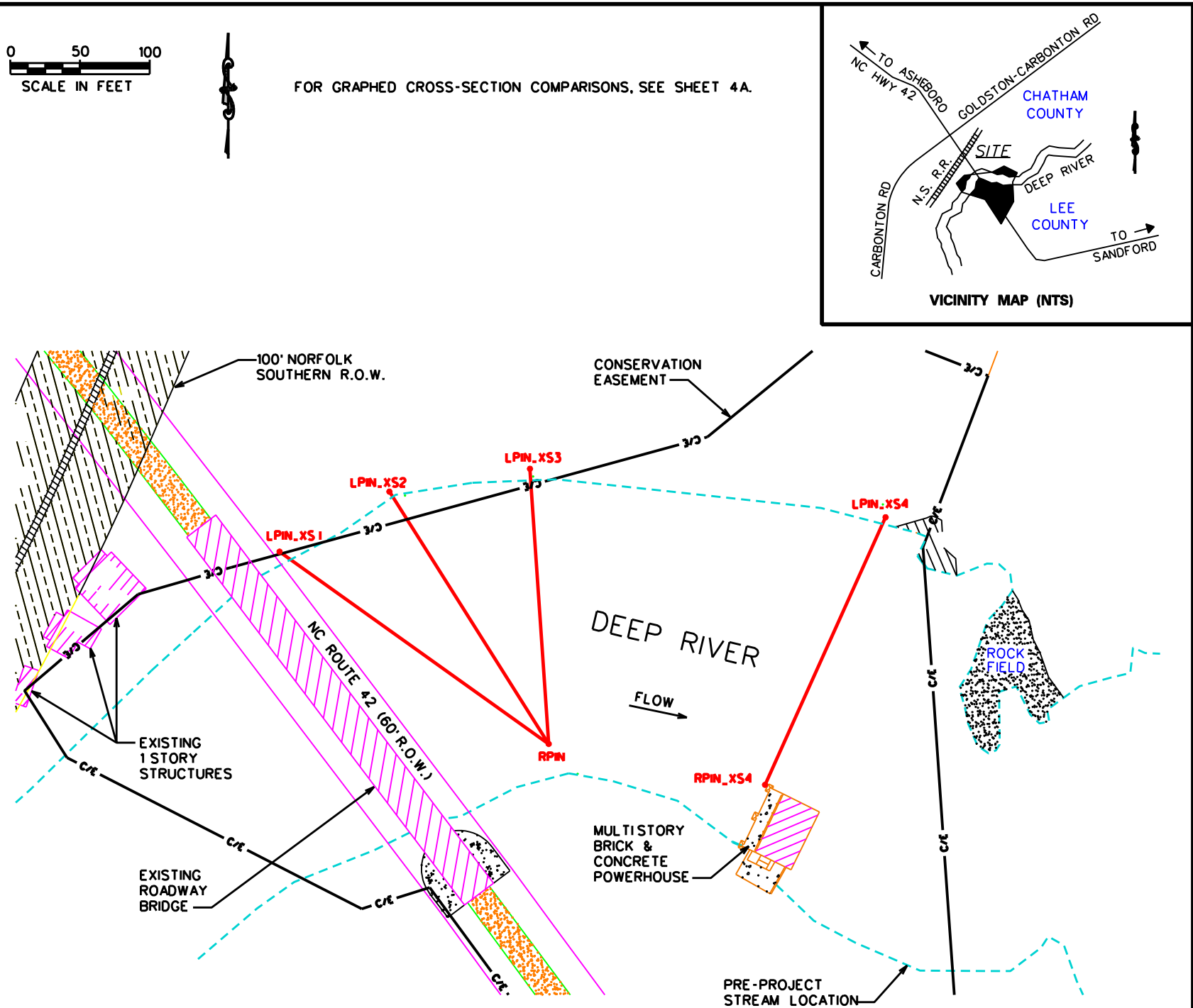
TITLE:

Erosion Evaluation Observation Points 6-26-2006

Dwn By:	Ckd By:
DGJ	MCG
Date:	Scale:
JUL 2006	AS SHOWN

ESC Project No.
06-277.00

FIGURE
3



EcoScience Corporation
Raleigh, North Carolina

REVISIONS	

Client: RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

Project:

DEEP RIVER CARBONTON DAM RESTORATION SITE

LEE COUNTY & CHATHAM COUNTY, NORTH CAROLINA

Title:

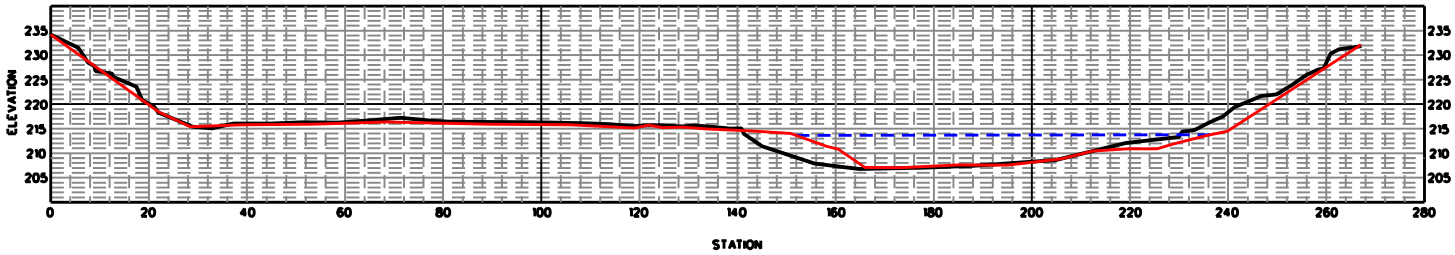
SUBSTRATE ISLAND MONITORING PLAN VIEW 6-27-06

Dwn By:	Date:
JDG	JUL 2006
Ckd By:	Scale:
DGJ	1" = 100'

ESC Project No.: 06-277

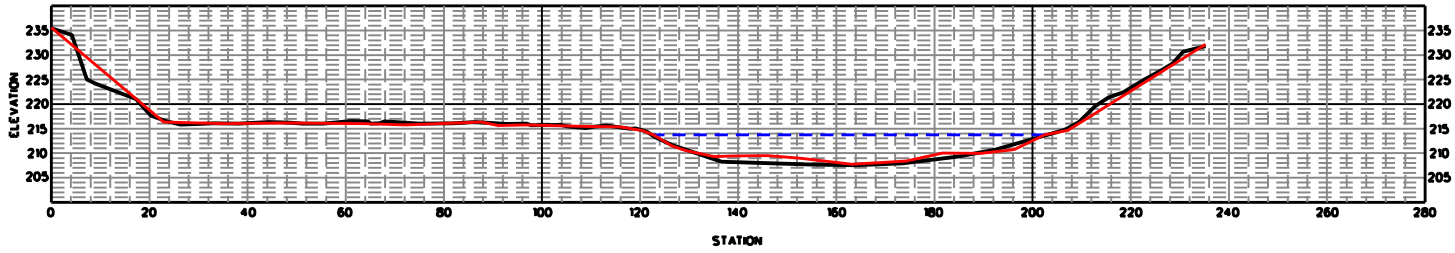
FIGURE

4



X–SECT 1

SCALE: H=1:40 / V=1:40



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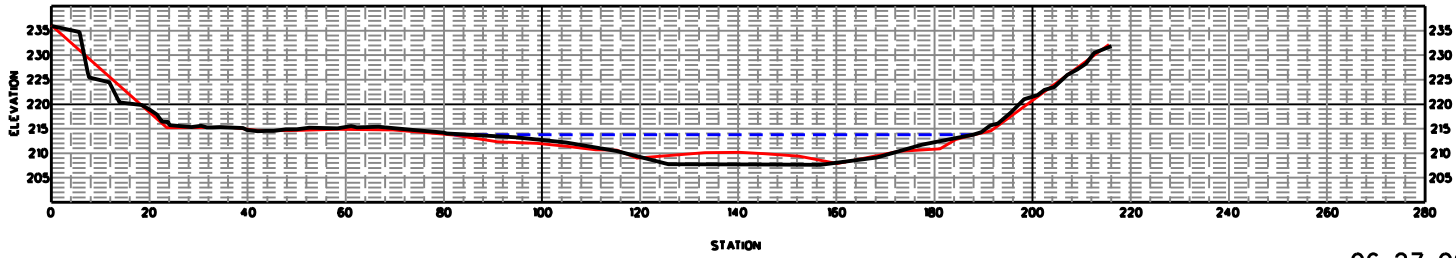
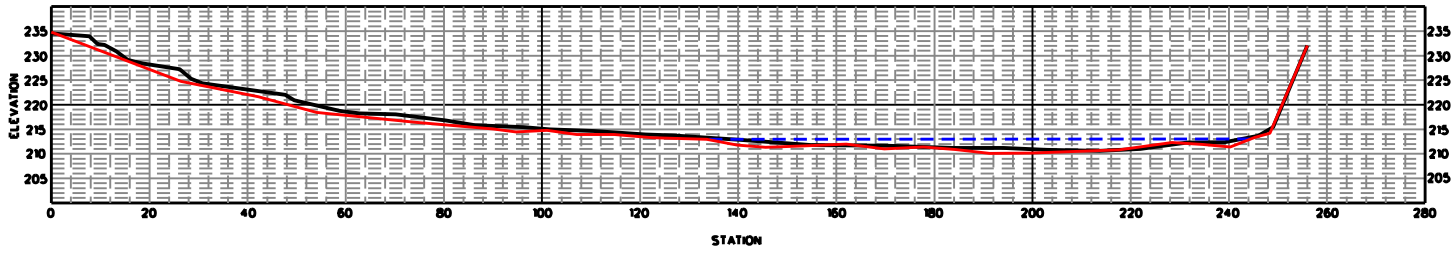


X–SECT 3

06-27-06 X-SECTS
05-02-06 X-SECTS
05-02-06 POOL ELEVATION



X–SECT 4

EcoScience Corporation
Raleigh, North Carolina

REVISIONS

Client:
RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

Project:
DEEP RIVER CARBONTON DAM RESTORATION SITE

LEE COUNTY & CHATHAM COUNTY, NORTH CAROLINA

Title:
SUBSTRATE ISLAND MONITORING CROSS-SECTIONS 6–27–06

Dwn By:	Date:
JDG	JUL 2006
Ckd By:	Scale:
DGJ	AS SHOWN

ESC Project No.: 06-277

FIGURE
4A

DEEP RIVER EROSION EVALUATION PHOTOS

Photo 1. River Observation Point 1

Location: Deep River downstream of Glendon Carthage Road crossing

Description: Erosion of bank material into the Deep River

May1, 2006: Erosion Evaluation 1

Photo 2. River Observation Point 2

Location: Deep River downstream of the Norfolk-Southern rail bridge
Description: Bank failure and continued erosion into the Deep River.

May1, 2006: Erosion Evaluation 1

Photo 3. River Observation Point 3

Location: Confluence of the Deep River and Lick Creek
Description: Tree fall and log jam formation at the confluence

Photo 4. River Observation Point 4

Location: Deep River downstream of Monitoring Cross-section 9.

Description: Bank failure and erosion into the Deep River.

Photo 5. River Observation Point 5

Location: Confluence of the upstream end of an oxbow channel and the Deep River

Description: Overland flow and sediment transport resulting from storm surge.

May1, 2006: Erosion Evaluation 1

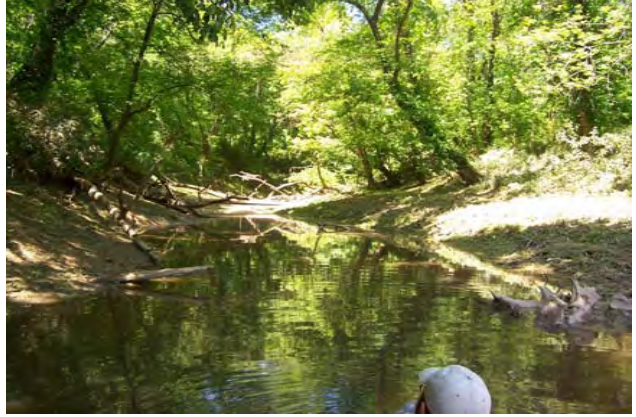


Photo 6. River Observation Point 6

Location: Confluence of the Deep River and McClendon's Creek
Description: Stable banks without signs of erosion

May1, 2006: Erosion Evaluation 1

Photo 7. River Observation Point 7

Location: Confluence of the Deep River and Big Govenor's Creek.
Description: Stable banks with only minor erosion. Woody debris deposition.

May1, 2006: Erosion Evaluation 1

Photo 8. River Observation Point 8

Location: Confluence of the Deep River and an unnamed tributary
Description: Continued sloughing of bank material.

Photo 9. River Observation Point 9

Location: Confluence of the Deep River and an unnamed tributary

Description: Continued headcutting and erosion of bank material

May1, 2006:
Erosion
Evaluation 1

Photo 10. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 27
Description: Continued headcutting and erosion of bank material

May1, 2006:
Erosion
Evaluation 1

Photo 11. River Observation Point 11

Location: Confluence of the Deep River and an unnamed tributary
Description: Continued headcutting and erosion of bank material

May1, 2006: Erosion Evaluation 1

Photo 12. River Observation Point 12

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 2
Description: Continued headcutting behind a log jam created by tree fall

May1, 2006: Erosion Evaluation 1

Photo 13. River Observation Point 13

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 23
Description: Continued headcutting and erosion of bank material

May1, 2006:
Erosion
Evaluation 1

Photo 14. River Observation Point 14

Location: Confluence of the Deep River and Line Creek
Description: Continued erosion of bank material and woody debris

Photo 15. Land Observation Point 1

Location: Line Creek

Description: Stable banks and well established herbaceous vegetation

Photo 16. Land Observation Point 1

Location: Line Creek

Description: High water level remaining from storm surge

Photo 17. Land Observation Point 1

Location: Line Creek

Description: Sediment deposition

Photo 18. Land Observation Point 2

Location: McClendon's Creek near Monitoring Station 45

Description: Gravel deposition on stream banks

Photo 19. Land Observation Point 2

Location: McClendon's Creek near Monitoring Station 45

Description: Stable banks and well established herbaceous vegetation

Photo 20. Land Observation Point 2

Location: McClendon's Creek near Monitoring Station 45

Description: Pool of standing water within floodplain

Photo 21. Land Observation Point 3

Location: McClendon's Creek near Monitoring Station 47

Description: Bank erosion

Photo 22. Land Observation Point 3

Location: McClendon's Creek near Monitoring Station 47

Description: Bank erosion

Photo 23. Land Observation Point 3

Location: McClendon's Creek near Monitoring Station 47

Description: Undercut bank

Photo 24. Land Observation Point 4

Location: Governor's Creek near Monitoring Station 40

Description: Undercut tree fallen into the channel

Photo 25. Land Observation Point 4

Location: Governor's Creek near Monitoring Station 40

Description: Stream bank undercutting

Photo 26. Land Observation Point 4

Location: Governor's Creek near Monitoring Station 40

Description: Undercut banks with sediment deposition

APPENDIX H: MONITORING PICTURES AND VIDEOS (DATA CD)