CARBONTON DAM – DEEP RIVER WATERSHED
RESTORATION SITE
2007 Annual Monitoring Report (Year 2)

Ecosystem Enhancement PROGRAM

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2007 Annual Monitoring Report (Year 2)

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

Prepared for: NCDENR - ECOSYSTEM ENHANCEMENT PROGRAM
1652 Mail Service Center
Raleigh, North Carolina 27699-1619

Prepared by: ECOSCIENCE CORPORATION
1101 Haynes Street, Suite 101
Raleigh, North Carolina 27604

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PREPARED BY:

RESTORATION SYSTEMS, LLC
PROJECT MANAGER: GEORGE HOWARD
1101 Haynes Street Suite 211
Raleigh, North Carolina 27604

ECOSCIENCE CORPORATION
PROJECT MANAGER: MATT CUSACK
1101 Haynes Street, Suite 101
Raleigh, NC 27604

AND

THE CATENA GROUP
PROJECT MANAGER: TIM SAVIDGE
410-B Millstone Drive
HILLSBOROUGH, NC 27278

EXECUTIVE SUMMARY

Introduction

Dam removal projects performed pursuant to the guidance released by the North Carolina Dam Removal Task Force (DRTF) are required to quantitatively demonstrate chemical and biological improvements to the watershed in order to achieve compensatory mitigation credit (DRTF 2001). The following monitoring report documents the latest efforts of Restoration Systems, LLC, on behalf of the N.C. Ecosystem Enhancement Program (NCEEP), to document changes in the study area of the Carbonton Dam removal project (Cape Fear Hydrologic Unit 03030003). The suite of ecological evaluations performed and described herein establishes new standards for mitigation monitoring. This standard is in keeping with the goal set forth by state and federal agencies to provide functional ecological gains to North Carolina watersheds through the efforts of the NCEEP and its contract partners.

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 restored unhindered flow to 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 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 absent or greatly diminished within areas of the Deep River impounded by the former dam. These affected 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.

Second year monitoring activities began in March 2007, 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, and Year 1 monitoring values collected in April-June 2006.

Monitoring Plan

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

1) re-colonization of rare and protected 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).

Second Year Monitoring Results

Water Quality

AMS data indicate that dissolved oxygen concentrations within the former Site Impoundment continue to persist above (3.41 mg/L higher) the established threshold required to meet the success criteria. Additionally, water temperature and fecal coliform levels have remained below the state standard during Year 2 monitoring.

The Year 2 mean biotic index (used as a proxy for water quality) for formerly impounded stations is slightly more than (0.3) one standard deviation of the reference mean. Year 1 data show that following dam removal, the success criterion was met by 0.21. Some variability may be present between years, but a significant decrease in the mean biotic index of formerly impounded stations in Year 2 (1.13 lower) indicates the presence of a benthic community with a low tolerance for poor water quality.

Monitoring results following dam removal on the Deep River show an overall improved water quality and achievement of established success criteria.

Aquatic Community

The results of the Year 2 monitoring fish survey demonstrate continued transition to lotic conditions within the former reservoir pool in the Deep River and a major tributary, McLendon's Creek. Riffle, run, and pool habitats continue to develop and numerous riffle-adapted species were found in relatively high densities at various locations throughout the surveyed reach. A total of 34 fish species were collected in Year 2 surveys, compared to only 24 species collected prior to dam removal. Compared to Year 1 surveys, species diversity and abundance were higher at all but one fish monitoring site.

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

The NCDWQ Habitat Assessment Field Data Sheet was completed at each station in order to evaluate the quality of in stream habitat and to provide a comparable score that describes the available habitat. Compared to baseline conditions, the mean total score of the formerly impounded stations quantitatively increased in Year 2 monitoring from 42.39 to 58.59, indicating improved aquatic habitat.

Rare and Protected Aquatic Species

Rare and Protected Aquatic Species success criteria within the former Site Impoundment is based on the documented presence of any rare species throughout the monitoring period. Fish surveys targeted the recolonization of the federally endangered Cape Fear shiner (*Notropsis mekistocholas*) in habitats previously impounded by the dam. A total of 41 specimens of the endangered Cape Fear shiner were collected during the Year 2 fish surveys. These individuals were identified throughout the former Site Impoundment at eight of the sampling sites, while an additional six sites continue to develop favorable habitat for future colonization. Additionally, at least ten of the sampling sites contain emerging fish communities that emulate reference conditions found beyond the former impoundment.

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. Cursory surveillance for freshwater mussels indicates that mussel recruitment is already beginning in some of the newly established riffle habitats. Among the notable mussel species observed in the former Site Impoundment is the state-listed yellow lampmussel (*Lampsilis cariosa*).

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 provided funding to the University of North Carolina at Chapel Hill to support original research by Adam Riggsbee, PhD, and Jason Julian, PhD. Dr. Riggsbee has three papers in press and one in revision from his dam removal research while Dr. Julian has one paper in review pertaining to the restored reach of the Deep River.

Furthermore, a new public park has been established at the site of the former dam that consists of vehicle parking, picnicking sites, bank fishing, and improved access to the river for kayakers and canoeists. RS is in the process of transferring the new park to the Deep River Park Association.

Summary

After the second year of monitoring, the removal of Carbonton Dam has resulted in the continued restoration of lotic conditions with functional improvements recorded in water quality, fish abundance, and sediment transport. Mitigation success has been demonstrated for the following criteria: Re-introduction of rare and endangered aquatic species, water quality improvement with respect to dissolved oxygen concentrations and benthic biotic indices, scientific research, and public recreation. Continued monitoring is necessary to confirm success for the convergence of benthic EPT taxa to reference data, and the recolonization of mollusks in the newly restored lotic community.

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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 (35.5200N, -79.3485W). 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 and removal 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.

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

Primary Success Criteria	Channel Restored (feet)	Mitigation Ratio	SMU
1) Water Quality 2) Improved Aquatic Community 3) Rare and Protected Aquatic Species	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) Human recreation 2) Scientific value	-----	Up to 20 percent bonus	Up to 25,335
Total Potential SMUs			114,356
Total Committed 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
Installation of Trees and Shrubs	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
Year 2 Stream Monitoring	September 2007	July 2007	November 2007

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 impounded 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: Carbonton 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
Ecological Monitors EcoScience Corporation The Catena Group (TCG)	 1101 Haynes Street Suite 101 Raleigh, NC 27604 (919) 828-3433 410-B Millstone Drive Hillsborough, NC 27278 (919) 732-1300
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
Reference Site ID	Deep River
Dominant Soil Types	N/A (stream restoration project only)
USGS HUC for Project and Reference	03030003
NCDWQ Sub-basin for Project and Reference	03-06-10
NCDWQ classification for Project and Reference	WS-IV HQW, WS-V HQW
Any portion of any project segment 303d listed?	No (NCDWQ 2006)
Reasons for 303d listing or stressor	
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	MS4 NPDES
Percent of project easement fenced	N/A

2.0 PROJECT MONITORING AND RESULTS

The monitoring results described herein will document the Year 2 (2007) monitoring activities performed to determine the project's 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 Year 1 (2006) monitoring for a total of fifty-two (52). Pre-removal baseline data (2005), Year 1 monitoring data, and Year 2 monitoring data will be compared to evaluate improvements in water quality, the aquatic community, rare and protected species, and human values within the former Site Impoundment.

2.1 WATER QUALITY

2.1.1 Biotic Indices

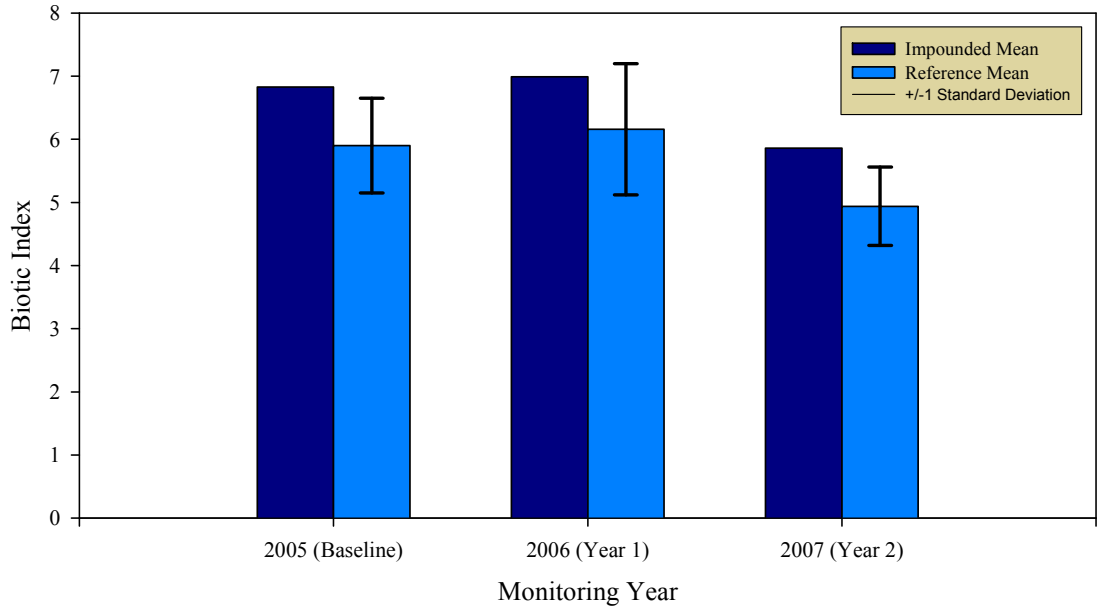
After identification of collected macroinvertebrates, the North Carolina Tolerance Values or Hilsenhoff Tolerance Values were assigned to each of the collected species. These Tolerance Values range from 0 for organisms intolerant of organic wastes to 10 for organisms very tolerant of organic wastes. The biotic indices of each station sampled for benthic macroinvertebrates were tallied, and then summary data were generated for comparison between formerly impounded and 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. Table 5 presents the summary data for benthic biotic indices of both formerly impounded and reference stations.

Table 5. Benthic Biotic Indices of Formerly Impounded and Reference Stations

	2005 (Baseline)		2006 (Year 1)		2007 (Year 2)	
	FORMERLY IMPOUNDED STATIONS	**REFERENCE STATIONS**	**FORMERLY IMPOUNDED STATIONS**	**REFERENCE STATIONS**	**FORMERLY IMPOUNDED STATIONS**	**REFERENCE STATIONS**
	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index	Biotic Index
High	7.97	6.91	8.58	7.62	8.52	5.71
Low	5.67	4.78	5.76	4.29	4.28	3.92
Mean	**6.83**	5.90	**6.99**	6.16	**5.86**	4.94
Median	6.79	5.99	6.72	6.02	5.30	5.02
Standard Deviation	0.83	0.75	0.95	1.04	1.52	0.62
Standard Deviation of Reference mean **(Success Criterion)**	**6.65**		**7.20**		**5.56**	

The mean biotic index from the formerly impounded stations (μ=5.86) is slightly more than one standard deviation of the reference station (μ=5.56). Although the formerly impounded dataset was 0.3 too high to meet the success criterion for Year 2, the Year 1 data show that the success criterion was met by 0.21. Therefore, some variability between years may be present. It is important to note that the mean biotic index from the formerly impounded stations (μ=5.86) is significantly lower than the mean from Year 1 monitoring (μ=6.99). This change indicates the progression of a benthic community less tolerant of poor water quality. The following Graph 1 depicts the change in biotic indices from 2005 to present from both the formerly impounded and reference stations.

Graph 1. Mean Biotic Index of Formerly Impounded Stations vs. Reference Stations with Standard Deviation
Note: A lower index value is indicative of less tolerant species (= higher water quality)



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 the former 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. Due to time delay between collection date and public availability, the most recent AMS data available from NCDWQ is through December 6, 2006 at NC42, and through December 28, 2006 at Ramseur. 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 be used to evaluate physical water chemistry and associated 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 (daily average no less than 5.0 mg/L). Table 6 provides the minimum, maximum, and mean instantaneous values for dissolved oxygen recorded within the former Site Impoundment, as well as the number of samples that fell below the state standard during baseline, Year 1, and Year 2 monitoring.

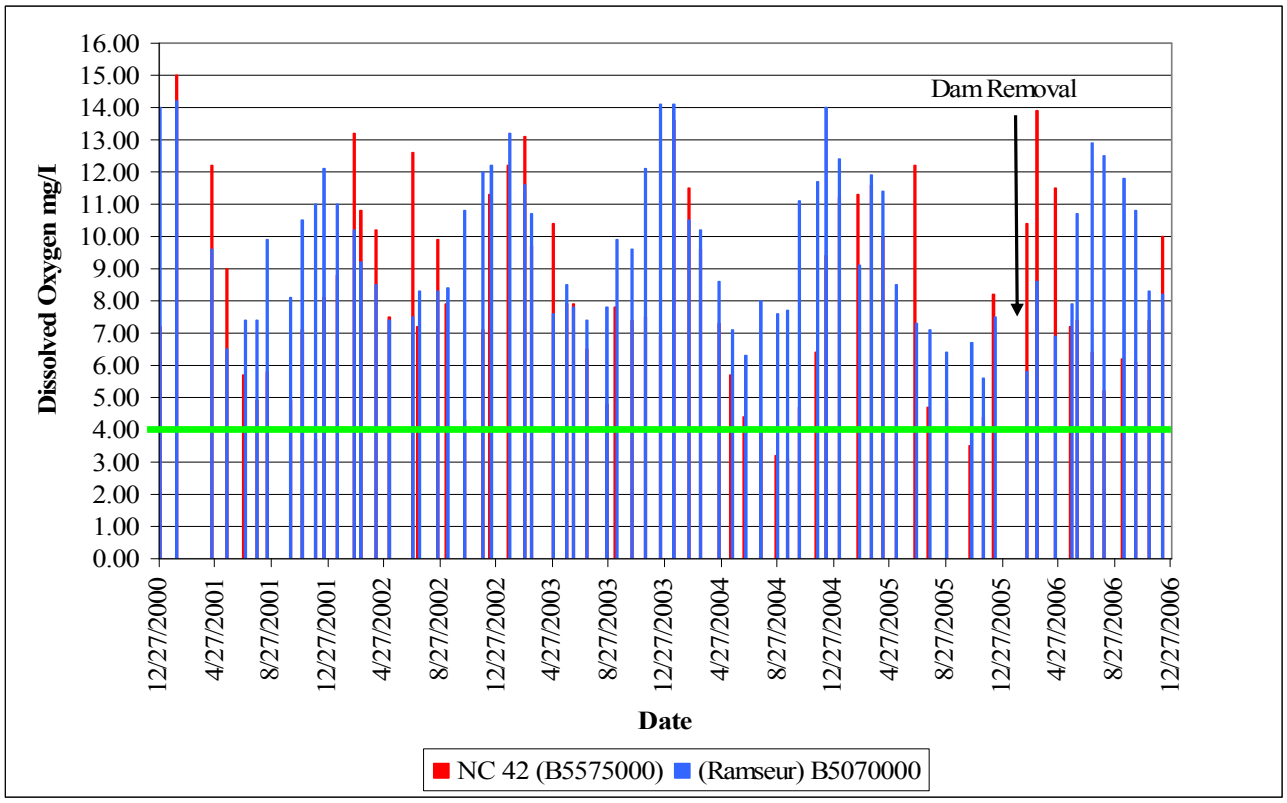
Table 6. Dissolved Oxygen Summary Data

	Baseline	Year 1	Year 2
Minimum Value (mg/L)	1.10	7.20	5.20
Maximum Value (mg/L)	15.00	13.90	10.60
Mean Value (mg/L)	8.07	10.87	7.41
Number of Samples Below State Standard	6	0	0

Graph 2 depicts the AMS dissolved oxygen concentrations measured at a 0.1 meter depth within the Site Impoundment (B5575000), and at the reference location (B5070000), from December 2000 through December 2006. Since the removal of Carbonton Dam, instantaneous dissolved oxygen concentrations within the former Site Impoundment have remained at or above 4.0 mg/L.

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 success as the river returns to lotic conditions. It is also expected that dissolved oxygen levels within the former impoundment will stay above the state standard as free-flowing conditions persist.

Graph 2. Recorded Dissolved Oxygen Concentrations in the Deep River (Green line indicates state standard of 4.0mg/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 during baseline, Year 1, and Year 2 monitoring, as well as the number of samples the recorded value exceeded the state standard.

Table 7. Water Temperature Summary Data

	Baseline	Year 1	Year 2
Minimum Value (deg F)	65.48	41.18	45.32
Maximum Value (deg F)	87.62	64.58	85.82
Mean Value (deg F)	63.26	52.76	67.57
Number of Samples Exceeding State Standard	0	0	0

Water temperature within the former Site Impoundment has remained below the state standard of 90 degrees Fahrenheit since dam removal on February 3, 2006.

2.1.2.3 Fecal Coliform

In order to achieve success, fecal coliform concentrations within the former Site Impoundment cannot exceed an average daily count 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 during

baseline, Year 1, and Year 2 monitoring, as well as the number of samples the recorded value exceeded the state standard.

Table 8. Fecal Coliform Summary Data

	Baseline	Year 1	Year 2
Minimum Value (count/100 ml)	3	22	26.0
Maximum Value (count/100ml	6300	47	160.0
Mean Value (count/100ml)	369.7	35.7	62.6
Number of Samples Exceeding State Standard	31	0	0

Fecal coliform within the former Site Impoundment has remained below the state standard of 200/100 ml since dam removal on February 3, 2006

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

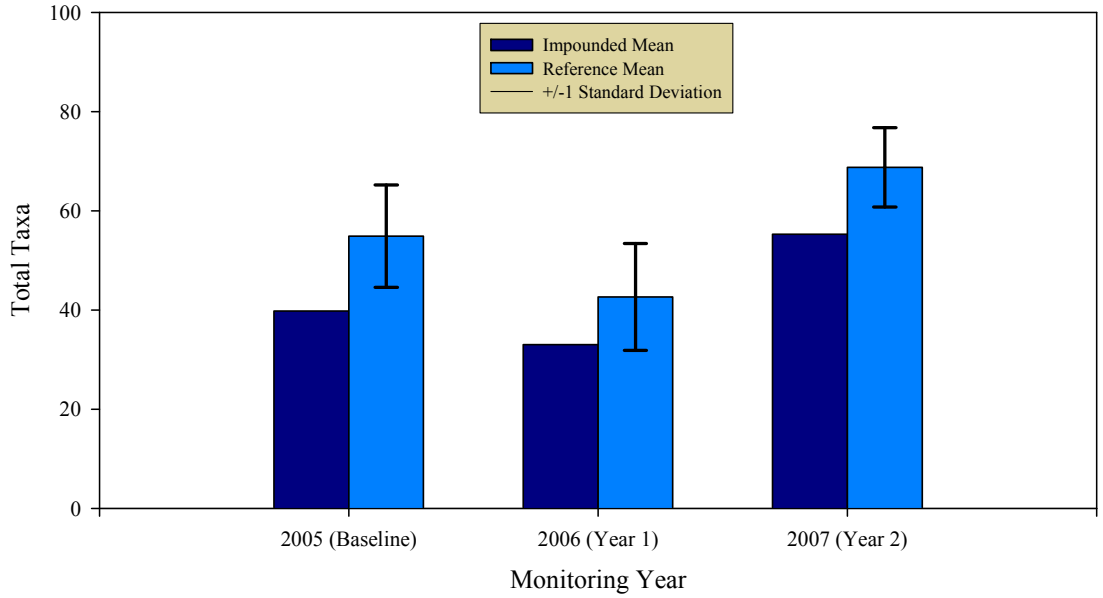
Benthic macroinvertebrates were sampled within the former Site Impoundment, as well as in the reference reaches both within the Deep River and its major tributaries. Stations were visited prior to dam removal (2005) and subsequently sampled in 2006 and 2007 at the same locations. The comparative metrics 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 macroinvertebrate data, located 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 NCDWQ-certified benthic identification laboratory.

Table 9 provides the baseline, Year 1, and Year 2 summary data for the benthic macroinvertebrate collections. The summary data shows that mean values for all metrics improved at impounded stations in Year 2 monitoring. Graph 3 and Graph 4 depict the change in mean total taxa and mean EPT richness from 2005 to present from both the formerly impounded and reference stations. The graphs show that mean total taxa and mean EPT richness increased in the current monitoring year. Moderate drought conditions within the Deep River watershed during benthic sampling (March 28 – May 1) contributed to low flow conditions and may have altered benthic community composition and abundance. Continued sampling is recommended to ensure that data sets are more reflective of normal ambient conditions without the influence of extraordinary factors such as 100-year droughts.

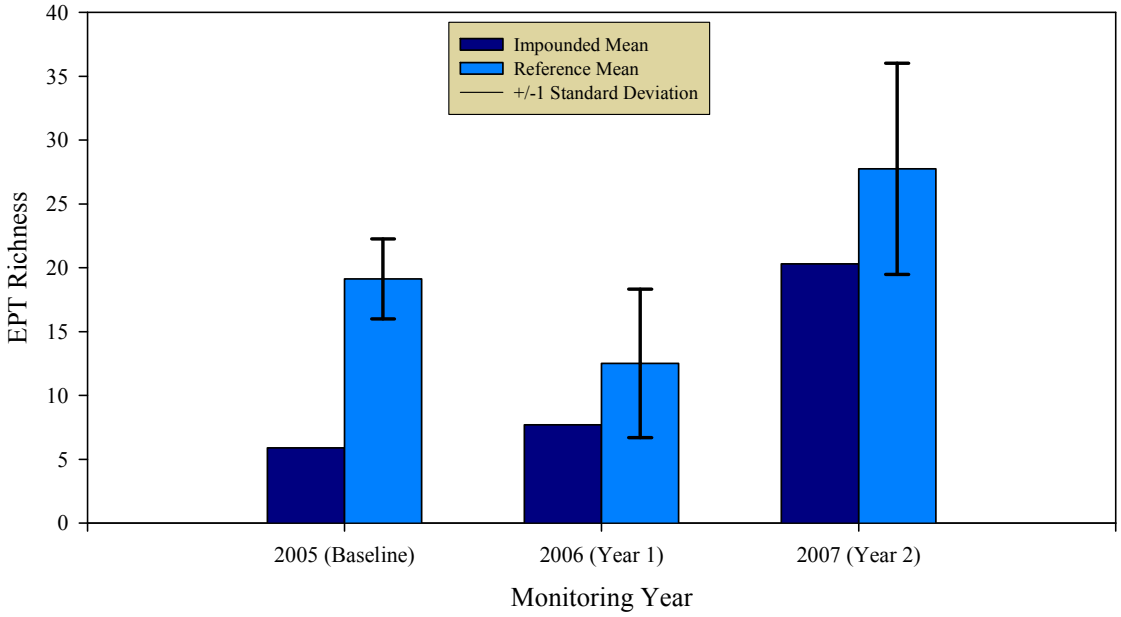
Table 9. Benthic macroinvertebrate summary data

Baseline (2005)	Formerly 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
Mean	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
Year 1 (2006)	**Formerly 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
Mean	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
Year 2 (2007)	**Formerly Impounded Stations**				**Reference Stations**			
	Total Organisms	Total Taxa	EPT Richness	Biotic Index	Total Organisms	Total Taxa	EPT Richness	Biotic Index
High	1168.00	83.00	36.00	8.52	1242.00	83.00	38.00	5.71
Low	117.00	31.00	1.00	4.28	506.00	59.00	14.00	3.92
Mean	466.40	55.30	20.30	5.86	849.63	68.75	27.75	4.94
Median	475.00	60.00	24.50	5.30	861.50	66.50	31.00	5.02
Standard Deviation	318.14	18.76	13.00	1.52	250.69	8.01	8.28	0.62

Graph 3. Mean Total Taxa of Impounded Stations vs. Reference Stations with Standard Deviation



Graph 4. Mean EPT Richness of Impounded Stations vs. Reference Stations with Standard Deviation



2.2.2 Fishes

Fish surveys were conducted at all but one (Site 10- too deep to adequately survey) of the 15 permanent fish monitoring sites established on the Deep River, McLendon's Creek, and Big Governor's Creek. One additional site (Site 1.5) was sampled due to the development of exceptional riffle/run habitat. A combination of seine netting, hand-held dip netting, visual observations, and hook and line methods were used to inventory fish species. In McLendon's Creek and Big Governor's Creek, electro-shocking was employed in conjunction with dip netting and seine netting due to the amount of heavy woody debris that precluded the effectiveness of seine netting. Electro-fishing was not used at sites on the Deep River in recognition of the "Collection Sensitive Waters" designation of the Deep River by the North Carolina Wildlife Resource Commission (WRC).

A total of 34 fish species were collected at the fifteen fish monitoring sites. Survey collections demonstrate that riffle adapted species continue to colonize in newly restored habitats that were previously impounded. Additionally, at least ten of the sampling sites contain emerging fish communities that emulate reference conditions found beyond the former impoundment. Overall, a greater number of fish species were documented throughout the former impoundment during Year 2 monitoring relative to baseline and Year 1 surveys. 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 pre and

post dam removal stations. 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. Cursory surveillance for freshwater mussels at the time of fish surveys indicates that mussel recruitment is already beginning in some of the newly established riffle habitats, and is expected to be widespread by Year 4 sampling.

2.2.4 Habitat Assessment

Habitat assessment data were collected at all 52 monitoring stations to evaluate the potential for changing aquatic habitats to support changes 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 from baseline and Year 2 monitoring. The categories channel modification, light penetration, and riparian vegetative zone width typically did not change in the span of a single monitoring year. Other categories including instream habitat, bottom substrate, and bank stability showed improvement within formerly impounded stations. Compared to baseline data, the mean total score of the formerly impounded stations quantitatively increased in Year 2 monitoring from 42.39 to 58.59. The mean total score for reference stations remained relatively unchanged with an increase of only 1.22. Success evaluation is defined as a perceived progression of the former Site Impoundment habitat values toward those of the lotic reference stations. During Year 2 monitoring, the mean total score for stations in the former Site Impoundment increased 6.7 percent compared to Year 1, and shifted to within only 2.19 points of matching the mean total score of the reference stations.

Table 10. Comparison of Habitat Assessment Data from Baseline and Year 2 for Impounded and Reference Stations

	BASELINE (2005)									YEAR-2 MONITORING (2007)									
		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
FORMERLY IMPOUNDED STATIONS	1	4	7	1	0	0	9	0	7	**28**	1	4	10	12	8	14	11	0	7	**66**
	2	4	11	1	0	0	12	0	10	**38**	2	4	18	1	10	0	12	0	10	**55**
	3	5	12	3	0	0	14	2	9	**45**	3	5	14	8	0	0	11	2	9	**49**
	4	4	14	1	0	0	14	2	10	**45**	4	4	15	14	10	0	14	2	10	**69**
	5	4	12	1	0	0	14	2	10	**43**	5	4	19	11	10	14	14	2	10	**84**
	6	4	10	1	0	0	12	0	10	**37**	6	4	15	12	0	0	12	0	10	**53**
	7	4	10	1	0	0	12	0	9	**36**	7	4	16	11	8	0	14	0	9	**62**
	8	4	12	8	0	0	14	2	7	**47**	8	4	16	15	10	14	13	2	7	**81**
	9	4	10	1	0	0	14	2	8	**39**	9	4	15	3	10	0	14	2	8	**56**
	10	5	16	12	0	0	14	2	10	**59**	10	5	16	15	10	14	11	2	10	**83**
	11	4	14	12	0	0	11	2	10	**53**	11	4	16	2	6	10	13	2	10	**63**
	20	4	7	1	0	0	6	0	10	**28**	20	4	11	1	8	0	14	0	10	**48**
	21	5	6	1	0	0	4	0	2	**18**	21	5	14	1	8	0	9	7	6	**50**
	22	5	5	1	0	0	4	0	8	**23**	22	5	10	1	0	0	14	0	8	**38**
	23	5	9	1	0	0	5	2	8	**30**	23	5	6	1	10	14	14	2	8	**60**
	24	4	11	1	0	0	10	7	4	**37**	24	4	17	1	0	0	14	7	4	**47**
	27	5	9	1	0	0	12	10	10	**47**	27	5	16	12	10	14	12	10	10	**89**
	29	5	5	1	0	0	12	10	10	**43**	29	5	9	1	0	0	12	10	10	**47**
	30	5	13	1	0	0	14	10	10	**53**	30	5	11	1	0	0	10	10	10	**47**
	31	5	10	1	0	0	12	10	10	**48**	31	5	10	1	0	0	10	10	10	**46**
	32	4	5	1	0	0	10	8	10	**38**	32	4	10	1	0	0	12	8	10	**45**
	34	4	11	1	0	0	14	10	10	**50**	34	4	0	0	0	0	12	10	10	**36**
	36	4	6	1	0	0	4	8	8	**31**	36	4	9	1	0	0	12	8	8	**42**
	38	5	19	1	0	0	5	10	10	**50**	38	5	15	1	0	0	12	10	10	**53**
	40	2	16	1	0	0	14	8	10	**51**	40	2	10	1	0	0	12	8	10	**43**
	41	5	6	1	0	0	12	8	10	**42**	41	5	10	1	8	0	12	8	10	**54**
	42	5	11	1	0	0	12	10	10	**49**	42	5	14	1	8	0	12	10	10	**60**
	43	5	6	1	0	0	10	10	10	**42**	43	5	14	1	8	0	12	10	10	**60**
	47	5	11	6	0	0	14	10	10	**56**	47	5	14	11	6	14	12	10	10	**82**
	48	5	11	1	0	0	12	7	10	**46**	48	5	14	1	10	10	12	7	10	**69**
	49	5	11	1	0	0	12	7	10	**46**	49	5	9	11	8	0	12	7	10	**62**
	50	4	15	3	0	0	12	7	10	**51**	50	4	10	3	3	0	12	10	10	**52**
	51	5	12	1	0	0	12	10	10	**50**	51	5	9	1	8	0	12	10	10	**55**
	55	Station not established in 2005								**N/A**	55	5	20	8	10	14	14	7	8	**86**
	MEAN	**4.45**	**10.39**	**2.15**	**0.00**	**0.00**	**10.97**	**5.33**	**9.09**	**42.39**	**MEAN**	**4.47**	**12.71**	**4.88**	**5.50**	**3.88**	**12.29**	**5.68**	**9.18**	**58.59**
REFERENCE STATIONS	12	4	20	12	6	7	14	2	10	**75**	12	4	16	12	6	14	12	2	10	**76**
	14	2	14	3	4	10	4	2	0	**39**	14	4	19	12	6	16	10	2	0	**69**
	15	4	11	8	8	0	10	7	10	**58**	15	4	15	11	10	0	13	7	10	**70**
	16	4	11	12	8	0	12	2	10	**59**	16	4	10	11	10	0	14	2	10	**61**
	17	4	11	2	4	3	12	2	10	**48**	17	4	5	4	0	0	12	2	10	**37**
	18	4	11	8	6	3	10	7	6	**55**	18	4	11	14	8	10	12	7	6	**72**
	19	4	16	11	6	0	12	2	10	**61**	19	4	14	12	10	0	14	2	10	**66**
	25	5	8	1	8	0	12	10	10	**54**	25	5	18	1	0	0	14	10	10	**58**
	26	5	10	1	8	0	14	10	10	**58**	26	5	0	1	0	0	6	10	10	**32**
	33	5	6	8	8	16	13	10	10	**76**	33	5	0	4	0	0	14	10	10	**43**
	35	4	5	1	4	0	10	8	10	**42**	35	4	13	1	8	0	5	8	10	**49**
	37	5	16	1	3	7	14	10	9	**65**	37	5	14	1	0	7	14	10	9	**60**
	39	5	11	3	6	0	12	7	9	**53**	39	5	11	1	0	10	12	7	9	**55**
	44	4	16	2	8	3	13	7	10	**63**	44	4	16	4	10	10	12	7	10	**73**
	45	4	15	6	6	0	12	8	10	**61**	45	4	19	12	8	7	12	8	10	**80**
	52	4	20	15	6	7	14	0	10	**76**	52	4	15	12	10	16	13	0	10	**80**
	53	4	20	11	4	14	12	2	9	**76**	53	4	19	12	6	14	10	2	10	**77**
	54	5	6	1	8	0	13	10	10	**53**	54	5	0	1	0	0	10	10	10	**36**
	MEAN	**4.22**	**12.61**	**5.89**	**6.17**	**3.89**	**11.83**	**5.89**	**9.06**	**59.56**	**MEAN**	**4.33**	**11.94**	**7.00**	**5.11**	**5.78**	**11.61**	**5.89**	**9.11**	**60.78**

2.2.4.1 Sediment Class Size Distribution

Sediment grain size distribution was analyzed at 38 monitoring stations in 2007 (24 formerly impounded, 14 reference). These locations were selected from the Deep River and it's tributaries at stations where water depths allowed for 100-count pebble counts to be performed consistent with the Wolman method (Wolman 1954). Weighted sieve analyses were not performed in Year 2 monitoring due to sampling limitations of the ponar dredge. Increased stream velocities have rendered the ponar dredge difficult to use, and unreliable for consistent results. Lower water levels throughout the former Site Impoundment have allowed for pebble counts in areas where the ponar dredge was previously used. Only data collected from the Wolman pebble count method at the 38 monitoring stations selected in Year 2 monitoring was considered for purposes of data comparison.

As expected D16, D50, and D84 values from stations within the former Site Impoundment continued coarsening during Year 2 monitoring. The medium grain size (D50) for impounded stations sampled in 2007 is 5.85 mm 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. Table 11 provides baseline, Year 1, and Year 2 sediment grain size distributions attained by pebble count method for both reference and impounded stations.

Sediment grain size classes are defined as follows (per Wolman 1954):

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

EcoScience Corporation staff performs a pebble count on the Deep River

Table 11. Sediment Class Size Distribution

	Station	Baseline (2005)			Year 1 (2006)			Year 2 (2007)		
		d16	d50	d84	d16	d50	d84	d16	d50	d84
IMPOUNDED	3	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	>256 mm	<2 mm	64-128 mm	>256 mm
	4	<2 mm	<2 mm	<2 mm	2-8 mm	8-16 mm	16-32 mm	<2 mm	2-8 mm	16-32 mm
	6	16-32 mm	16-32 mm	16-32 mm	2-8 mm	2-8 mm	2-8 mm	<2 mm	8-16 mm	>256 mm
	8	<2 mm	<2 mm	<2 mm	<2 mm	8-16 mm	16-32 mm	<2 mm	32-64 mm	16-32 mm
	10	2-8 mm	8-16 mm	16-32 mm	<2 mm	2-8 mm	32-64 mm	16-32 mm	32-64 mm	>256 mm
	22	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	<2 mm
	24	<2 mm	<2 mm	<2 mm	<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	<2 mm	2-8 mm	8-16 mm
	29	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	<2 mm
	31	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	<2 mm
	34	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	<2 mm
	38	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm
	41	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	2-8 mm
	43	<2 mm	<2 mm	<2 mm	<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	<2 mm	2-8 mm	16-32 mm
	49	<2 mm	<2 mm	<2 mm	2-8 mm	2-8 mm	2-8 mm	<2 mm	8-16 mm	16-32 mm
	50	<2 mm	<2 mm	16-32 mm	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	8-16 mm
	51	<2 mm	<2 mm	<2 mm	<2 mm	<2 mm	2-8 mm	<2 mm	<2 mm	<2 mm
	55	Cross-section not established in 2005			2-8 mm	8-16 mm	16-32 mm	2-8 mm	16-32 mm	32-64 mm
REFERENCE	12	8-16 mm	16-32 mm	>256 mm	2-8 mm	8-16 mm	64-128 mm	2-8 mm	16-32 mm	128-256 mm
	14	<2 mm	64-128 mm	>256 mm	<2 mm	2-8 mm	128-256 mm	<2 mm	8-16 mm	32-64 mm
	16	<2 mm	2-8 mm	32-64 mm	2-8 mm	16-32 mm	32-64 mm	<2 mm	16-32 mm	64-128 mm
	18	<2 mm	32-64 mm	32-64 mm	8-16 mm	32-64 mm	64-128 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	<2 mm	16-32 mm	64-128 mm
	25	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	<2 mm
	33	<2 mm	2-8 mm	16-32 mm	<2 mm	2-8 mm	8-16 mm	<2 mm	2-8 mm	8-16 mm
	35	<2 mm	<2 mm	<2 mm	<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	<2 mm	<2 mm	<2 mm
	44	<2 mm	8-16 mm	16-32 mm	<2 mm	<2 mm	8-16 mm	<2 mm	2-8 mm	16-32 mm
	45	<2 mm	8-16 mm	64-128 mm	<2 mm	<2 mm	16-32 mm	<2 mm	2-8 mm	32-64 mm
	52	8-16 mm	32-64 mm	64-128 mm	2-8 mm	8-16 mm	128-256 mm	2-8 mm	16-32 mm	64-128 mm
	54	<2 mm	<2 mm	<2 mm	<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 2007. Thirty-four (34) permanent cross-sections were revisited throughout the former Site Impoundment and on tributaries where functional restoration is expected to occur. Eighteen (18) 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, Year 1, and Year 2 cross-sectional surveys are displayed on Figures 4A-4D (Appendix A). Table 12 provides 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 compared to conditions assessed during Year 1 monitoring. Only minor scouring and transportation of bank material was detected at formerly impounded stations, with an associated increase in bankfull areas. High flow, bankfull events that occurred during Year 2 monitoring (November 27, 2006, and December 28, 2006) have further demonstrated that the Deep River is generally stable, and that erosion is localized. 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 in 2006. Hence, the discrepancies in cross-sectional dimensions and bankfull channel geometry between the baseline and Year 1 monitoring data at these locations.

EcoScience Corporation staff performs a cross-section survey of the Deep River

EcoScience Corporation staff performs a cross-section survey of Line Creek

Table 12. Cross-section Bankfull Channel Geometry

		2005 (Baseline)					2006 (Year-1)					2007 (Year-2)				
	Station	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth	Abkf (ft)	Wbkf (ft)	Dmax (ft)	Dbkf (ft)	width: depth
Formerly Impounded Stations	1	4707.0	235.2	27.2	20.0	11.8	4702.7	235.0	27.7	20.0	11.8	4884.9	235.2	28.5	20.8	11.3
	2	3837.0	196.3	28.0	19.6	10.0	3771.9	196.0	27.0	19.2	10.2	3883.0	201.7	27.1	19.3	10.5
	3	2849.0	166.2	23.9	17.1	9.7	2897.2	158.8	24.3	18.2	8.7	2964.5	159.2	24.7	18.6	8.6
	4	4229.1	185.2	29.9	22.8	8.1	3632.1	193.7	24.4	18.8	10.3	3457.1	191.9	23.4	18.0	10.6
	5	2783.1	174.6	23.7	15.9	11.0	2792.5	165.8	23.2	16.8	9.9	2860.5	169.0	23.7	16.9	10.0
	6	3362.5	188.2	22.8	17.9	10.5	3450.9	187.7	22.8	18.4	10.2	3487.0	189.2	23.4	18.4	10.3
	7	2443.2	149.8	19.0	16.3	9.2	2869.7	173.8	20.4	16.5	10.5	2897.3	193.8	20.4	15.0	13.0
	8	3098.8	181.6	24.1	17.1	10.6	3341.5	185.2	28.6	18.0	10.3	3434.9	184.9	25.4	18.6	10.0
	9	2064.0	172.5	15.0	12.0	14.4	2108.0	173.5	15.0	12.2	14.2	2094.4	176.6	14.9	11.9	14.9
	10	2221.5	199.0	18.0	11.2	17.8	2423.6	195.9	18.6	12.4	15.8	2353.2	199.9	18.9	11.8	17.0
	11	3591.3	199.5	24.3	18.0	11.1	3720.9	199.3	24.6	18.7	10.7	3706.3	198.9	24.8	18.6	10.7
	20	72.2	42.9	3.6	1.7	25.2	86.2	44.1	4.4	2.0	22.1	108.9	45.5	4.2	2.4	19.0
	21	149.6	57.9	3.6	2.6	22.3	187.8	77.9	4.4	2.4	32.5	199.1	64.8	4.8	3.1	21.1
	22	148.9	49.1	4.8	3.0	16.4	184.1	56.8	5.8	3.2	17.8	195.5	52.1	5.9	3.8	13.9
	23	76.6	30.2	4.7	2.5	12.1	104.8	34.5	5.7	3.0	11.5	116.7	38.8	6.7	3.0	12.9
	24	65.6	39.6	2.9	1.7	23.3	54.4	37.1	2.4	1.5	24.7	41.4	31.2	2.1	1.3	23.5
	27	62.3	24.9	3.9	2.5	10.0	73.4	28.6	4.5	2.6	11.0	81.8	28.78	5.7	2.8	10.1
	29	43.2	13.5	4.8	2.5	5.4	64.2	16.6	6.2	10.4	1.6	66.3	16.46	6.4	4.0	4.1
	30	153.2	22.1	8.8	6.9	3.2	115.5	29.5	6.5	3.9	7.6	113.5	30.68	6.5	3.7	8.3
	31	141.2	29.3	6.5	4.8	6.1	147.3	28.9	6.9	5.1	5.7	160.6	29.75	7.9	5.4	5.5
	32	72.1	15.5	7.5	4.6	3.4	75.7	15.9	8.0	4.8	3.3	78.5	15.87	8.6	4.9	3.2
	34	37.1	18.7	4.1	2.0	9.4	39.8	18.7	4.2	2.1	8.9	35.0	18.14	3.8	1.9	9.4
	36	111.3	21.5	9.2	5.2	4.1	111.6	21.1	9.3	5.3	4.0	110.6	21.56	9.7	5.1	4.2
	38	269.7	43.2	8.6	6.2	7.0	256.3	40.7	8.0	32.0	1.3	254.1	40.91	7.9	6.2	6.6
	40	329.2	53.3	8.2	6.2	8.6	431.2	53.3	10.6	8.1	6.6	461.1	54.78	11.4	8.4	6.5
	41	429.9	50.3	11.4	8.6	5.9	521.8	48.2	13.4	10.8	4.5	419.4	51.4	10.9	8.2	6.3
	42	139.4	30.9	6.0	4.5	6.9	156.9	32.1	7.0	4.9	6.6	167.7	30.2	7.4	5.6	5.4
	43	155.9	29.4	6.7	5.3	5.6	176.8	31.1	7.4	5.7	5.5	187.0	32.67	8.0	5.7	5.7
	47	318.5	60.5	7.8	5.3	11.4	312.7	56.3	8.0	5.6	10.1	320.7	60.6	8.1	5.3	11.4
	48	695.0	72.9	13.8	9.5	7.7	630.8	69.5	13.4	9.1	7.6	674.5	70.4	12.8	9.6	7.3
	49	550.4	59.7	13.7	9.2	6.5	380.5	59.1	10.1	6.5	9.1	406.8	54.5	12.0	7.5	7.3
	50	378.9	59.8	7.7	6.3	9.5	388.6	59.2	8.7	6.6	9.0	381.5	58.1	8.1	6.6	8.9
	51	209.5	39.9	10.8	5.3	7.5	203.9	35.6	10.7	5.7	6.2	211.2	38.0	10.8	5.6	6.8
	55	N/A	N/A	N/A	N/A	N/A	3357.6	228.4	18.0	14.7	15.5	3428.4	236.0	18.7	14.5	16.3
Reference Stations	12	3054.7	212.8	17.4	14.4	14.8	3029.3	213.0	17.5	14.2	15.0	3065.6	213.3	17.6	14.4	14.8
	14	6111.5	393.8	22.6	15.5	25.4	5924.9	402.6	21.6	14.7	27.4	6458.5	454.5	21.2	14.2	32.0
	15	3241.5	187.2	23.7	17.3	10.8	3583.2	200.0	24.9	17.9	11.2	3668.1	202.6	25.7	18.1	11.2
	16	2370.1	176.7	16.3	13.4	13.2	2382.1	173.3	16.6	13.7	12.7	2526.5	187.2	17.3	13.5	13.9
	17	2864.3	193.5	24.7	20.0	9.7	3466.6	201.9	22.7	17.2	11.7	3561.8	202.4	24.0	17.6	11.5
	18	1722.0	181.5	12.3	9.5	19.1	1697.3	174.5	12.2	9.7	18.0	1756.4	174.6	12.7	10.1	17.4
	19	2647.0	167.9	21.1	15.8	10.6	2581.6	167.6	20.6	15.4	10.9	2662.1	166.9	21.1	15.9	10.5
	25	22.7	19.9	2.3	1.1	18.1	24.4	20.7	2.3	10.6	2.0	24.6	20.7	2.3	1.2	17.4
	26	5.9	13.1	0.9	0.5	26.2	5.9	12.7	0.8	0.5	25.4	11.1	17.59	1.9	0.6	27.8
	33	9.6	7.0	2.2	1.4	5.0	15.4	9.8	3.0	1.6	6.1	25.9	20.13	3.7	1.3	15.6
	35	93.2	28.1	6.3	3.3	8.5	102.8	26.9	6.3	3.8	7.1	101.3	28.99	7.8	3.5	8.3
	37	6.2	11.3	1.0	0.6	18.8	6.0	9.5	1.1	0.6	15.8	7.3	11.04	1.4	0.7	16.7
	39	287.6	42.0	9.3	6.9	6.1	272.5	40.4	8.7	6.8	5.9	283.7	41.23	9.1	6.9	6.0
	44	310.3	49.7	8.1	6.2	8.0	332.3	51.9	8.4	6.4	8.1	360.5	52.3	8.7	6.9	7.6
	45	289.3	59.8	8.9	4.8	12.5	293.7	56.0	9.0	5.2	10.8	306.9	57.4	8.7	5.3	10.7
	52	2909.8	228.1	16.0	12.8	17.8	2798.1	220.9	15.6	12.7	17.4	2825.7	220.9	15.6	12.8	17.3
	53	2146.7	165.6	20.4	13.0	12.7	1882.9	160.7	19.3	11.7	13.7	2134.4	165.0	19.8	12.9	12.8
	54	17.7	10.7	2.7	1.7	6.3	14.6	9.4	2.4	1.6	5.9	17.4	10.9	2.7	1.6	6.8

*New cross-section pins established in 2006.

2.2.4.3 Flow Velocity

Flow velocity was not measured during Year 2 (2007) monitoring because a substantial increase in river flow was demonstrated in Year 1 (2006) monitoring. The mean maximum flow velocity within the Site Impoundment recorded at the water's surface during Year 1 monitoring increased from 0.03 m/sec to 0.76 m/sec, while flow velocity recorded at the stream bottom also increased substantially from 0.03 m/sec to 0.62 m/sec. Thus, surface and stream bottom flow velocities in the former Impoundment exhibited an increase greater than one order of magnitude. Following the initial increase in velocity from the removal of Carbonton Dam, stream flow will now fluctuate greatly as determined by drought and precipitation events, and can no longer be attributed to restoration efforts.

2.2.4.4 Photography and Videography

Photography and videography were conducted during Year 2 monitoring data collection to assess qualitative changes in channel cross-sections and in-stream habitat. Monitoring pictures and videos for all stations have been included on a digital video disc (DVD) in Appendix E.

2.3 RARE AND 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 protected aquatic species criterion. The federally endangered Cape Fear shiner was found during Year 2 fish surveys by TCG at eight sampling sites throughout the Deep River. A total of 41 individuals of the endangered Cape Fear shiner were collected during the Year 2 surveys. Furthermore, favorable habitat areas for the Cape Fear shiner have developed at many other locations, and the recruitment of new populations is expected to continue over time.

2.4 RESERVE CRITERIA

2.4.1 Public Recreation

The establishment of a recreational park in the vicinity of the former Carbonton Dam was completed during Year 2 monitoring. The newly completed Carbonton Park consists of vehicle parking, picnicing sites, bank fishing, and improved access to the river for kayakers and canoeists. RS is in the process of transferring the new park to the Deep River Park Association.

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.

Boat launch adjacent to historic powerhouse, Deep River Park

Stairs and pathway leading to boating access, Deep River Park

Picnic area and parking, Deep River Park

2.4.2 Scientific Research

The former Site Impoundment was subject to original research by Adam Riggsbee, PhD and a University of Chapel Hill (UNC-CH) Jason Julian, PhD. RS has provided UNC-CH with funding for any research project the university deems necessary. Julian's completed dissertation involved 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 investigated the role of sediment suspensions (resulting from dam removal) on nutrient and organic matter availability within the downstream water column (Riggsbee 2006). Dr. Riggsbee has three papers in press and one in revision from his dam removal research (Riggsbee et.al. 2007), while Dr. Julian has one paper in review (Julian et.al. 2007) pertaining to the restored reach of the Deep River. Dr. Riggsbee has also given numerous oral presentations at professional conferences regarding his research.

The amount of credit to be derived from the 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.

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 gaging 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 November 27, 2006 and December 28, 2006. During these evaluations, minor erosion throughout the former impoundment was observed. Stable channel geometry (detailed in monitoring cross-sectional data) was observed despite elevated storm flow conditions. Detailed reports submitted for each of these evaluations are included in Appendix F.

2.6 SUMMARY

Table 13 shows the primary and reserve mitigation success criteria and parameters for this project. The final column evaluates the success in fulfilling project criteria.

Table 13. Mitigation Success Criteria Summary

	Criterion	Parameter	Anticipated Change/Result	2008 Success
Primary success criteria:	Re-colonization of rare and protected aquatic species	Presence/absence of rare/protected individuals	Unknown	Yes
		Rare/protected species habitat	Improvement/expansion	Yes
	Improved water quality	Benthic biotic indices	Decrease (= improve)	Yes
		AMS dissolved oxygen data	Increase within former Site Impoundment (must be ≥ 4.0 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)	Ongoing, Improving
		Fish, Mussel, and Snail community data	Demonstrated shifts in communities from lentic to lotic character	Improving, 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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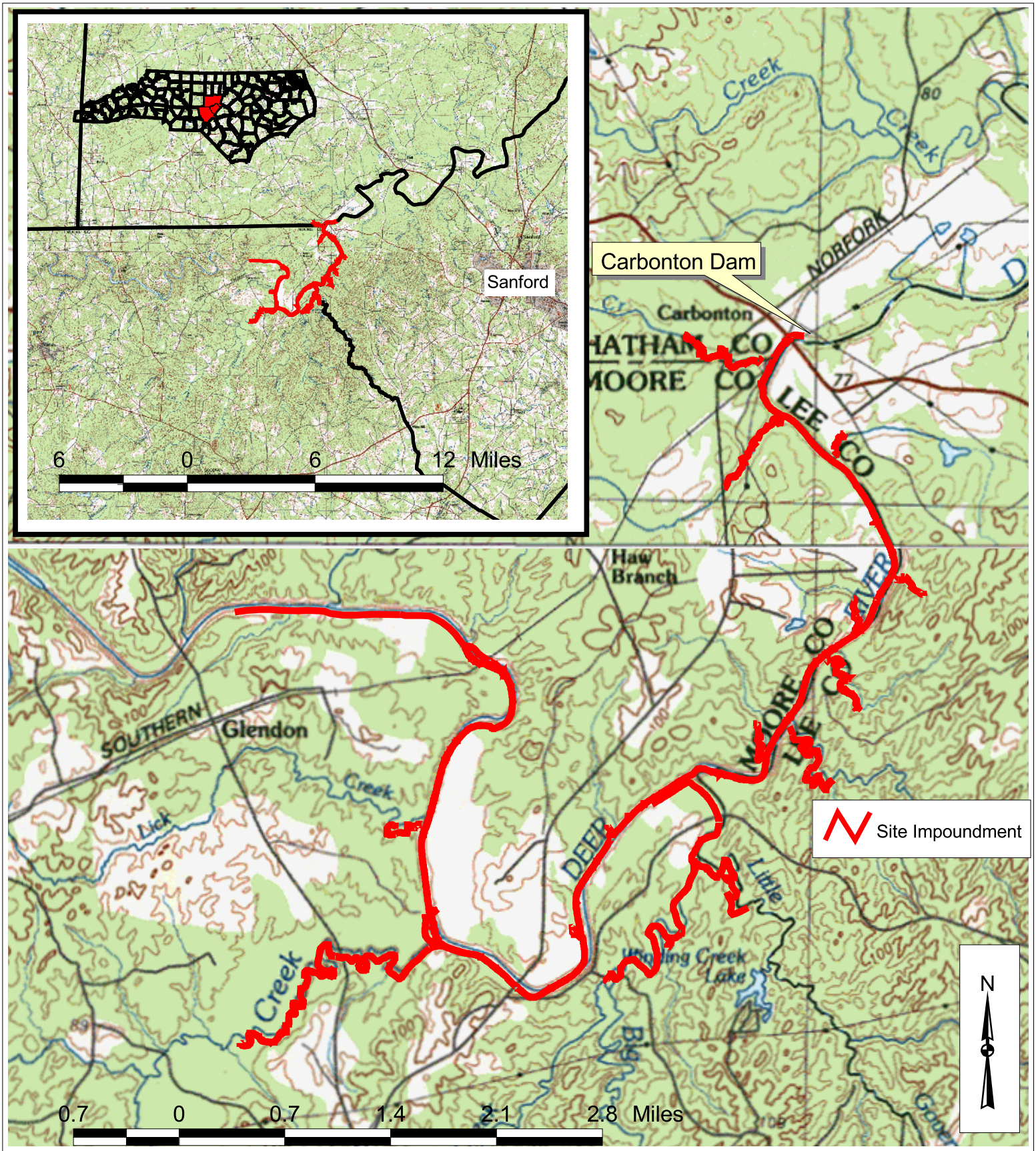
APPENDIX A: FIGURES



Site Location

Deep River- Carbonton Dam Restoration Site

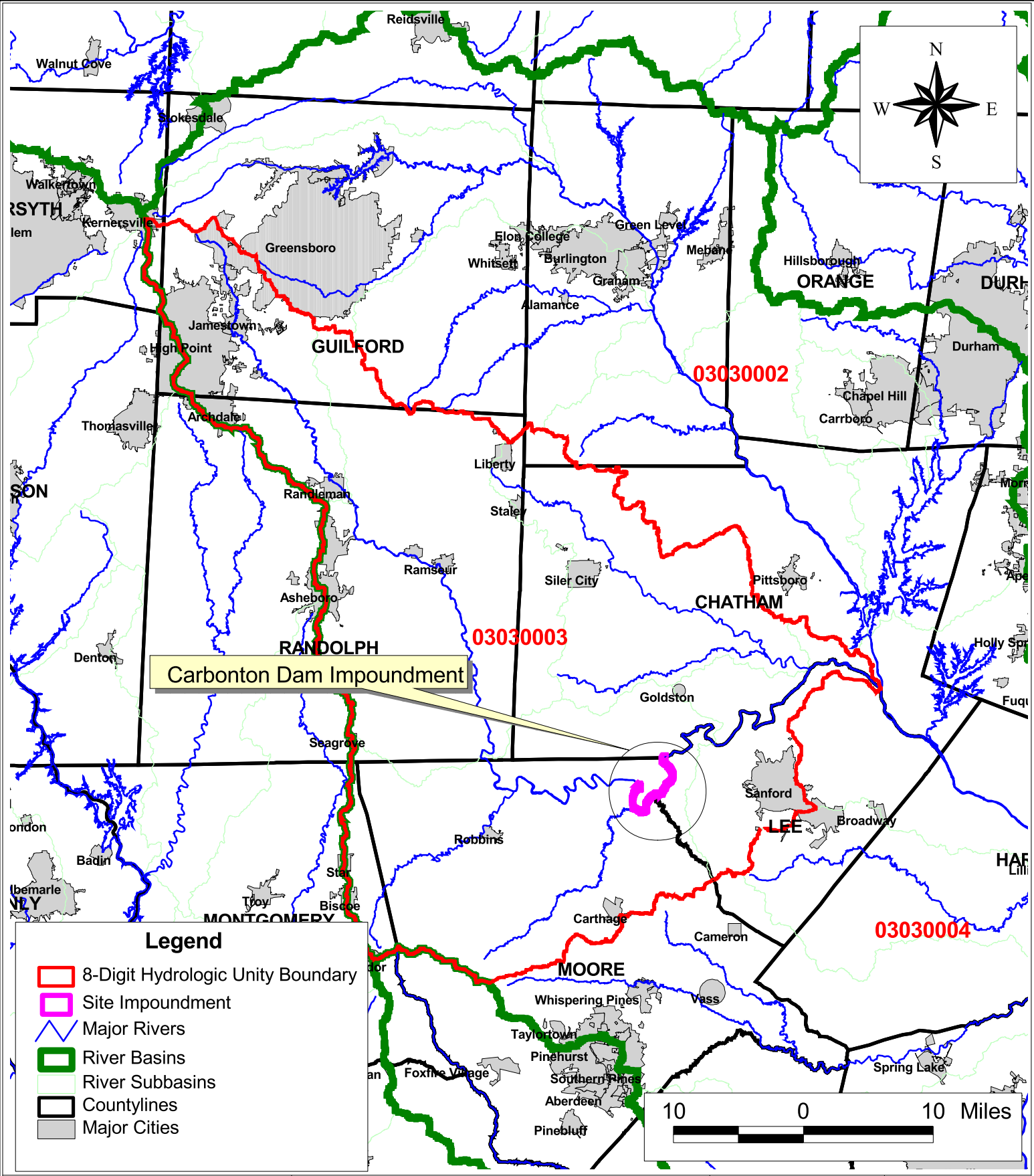
Lee, Chatham, and Moore Counties, North Carolina

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

FIGURE 1

Drawn By: MTC	Date: SEP 2006
Chkd By: APS	Project No: 06-288.03

SCALE: AS SHOWN



EcoScience Corporation
Raleigh, North Carolina

Hydrologic Units

Deep River-Carbonton Dam Restoration Site

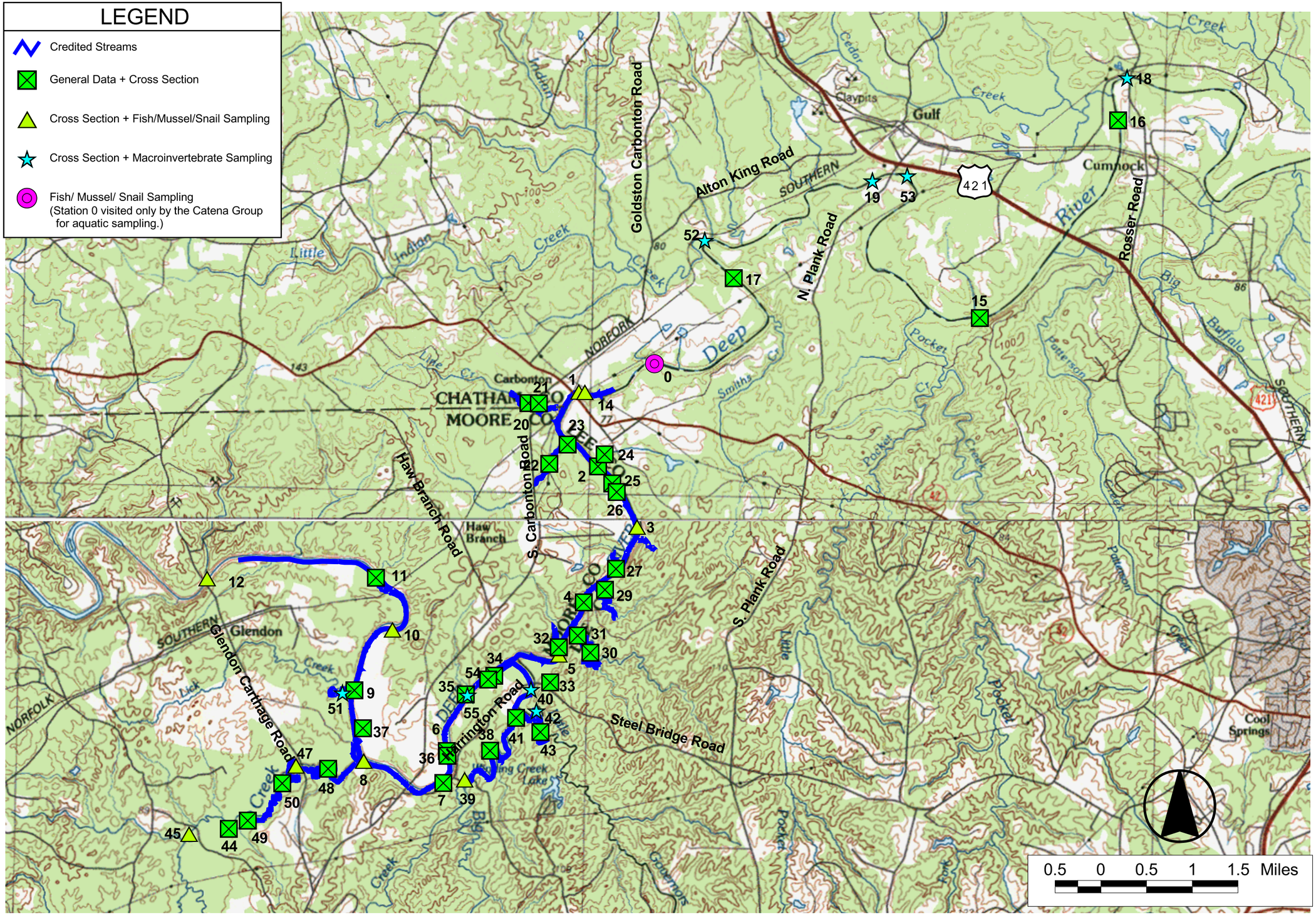
Chatham, Lee, and Moore Counties, North Carolina

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.)



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:

MONITORING STATION LOCATIONS

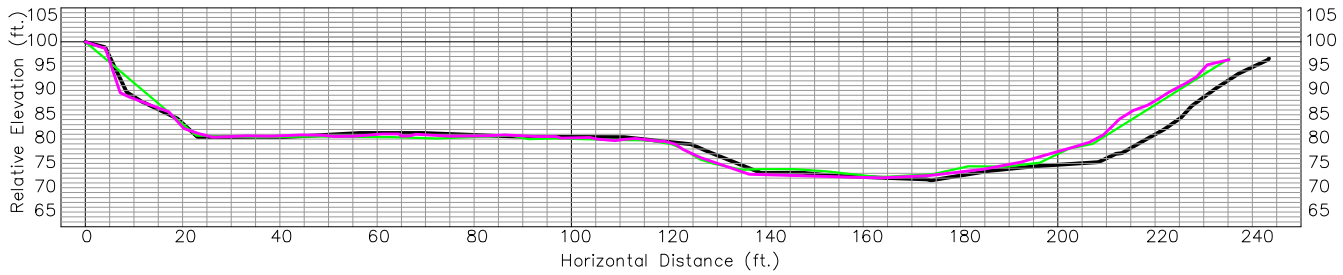
Dwn By:	Date:
MCG	SEPT 2006
Ckd By:	Scale:
MTC	AS SHOWN

ESC Project No.: 06-288

FIGURE

3

STATION 1



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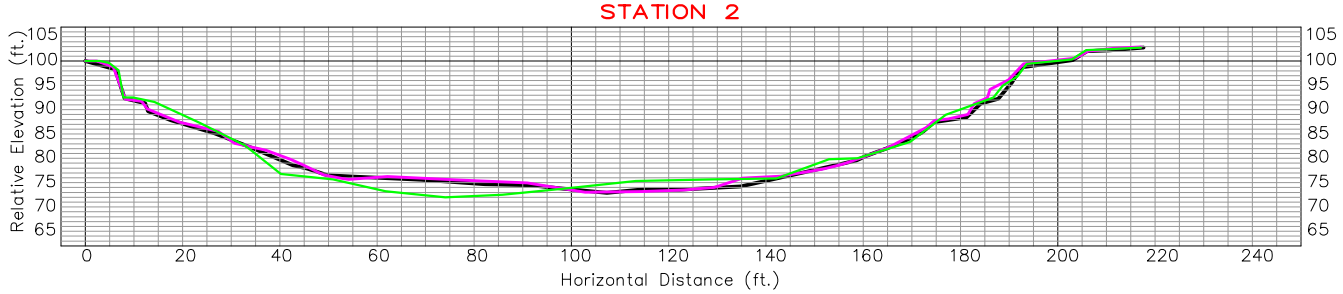

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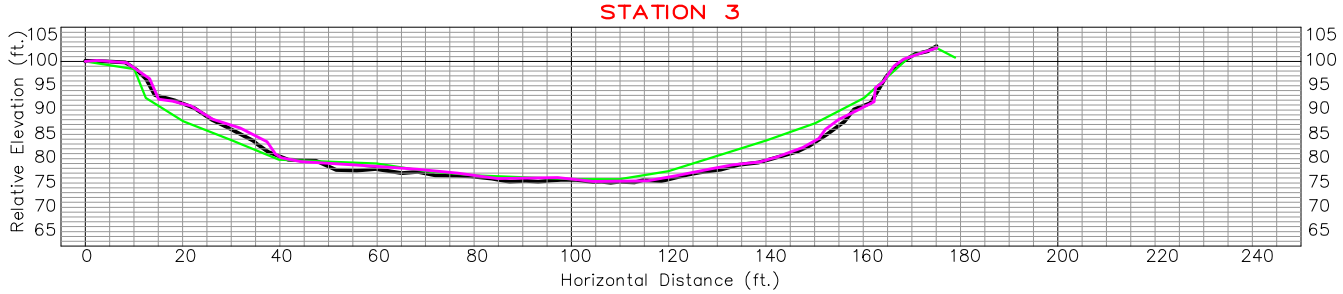

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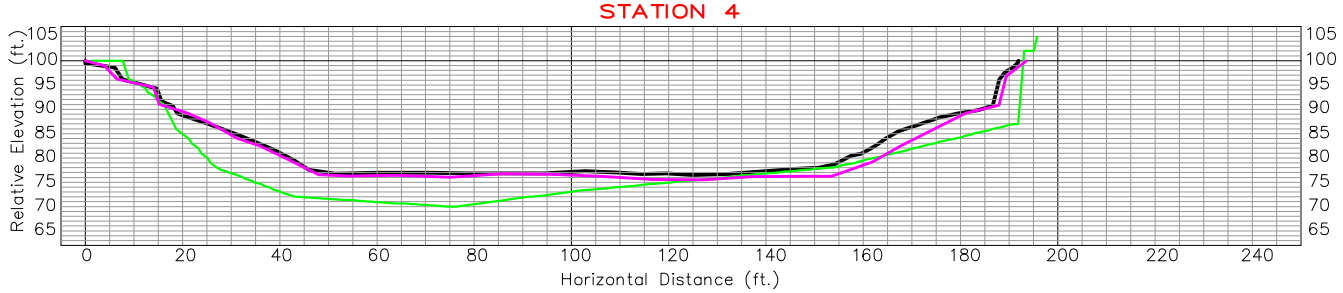

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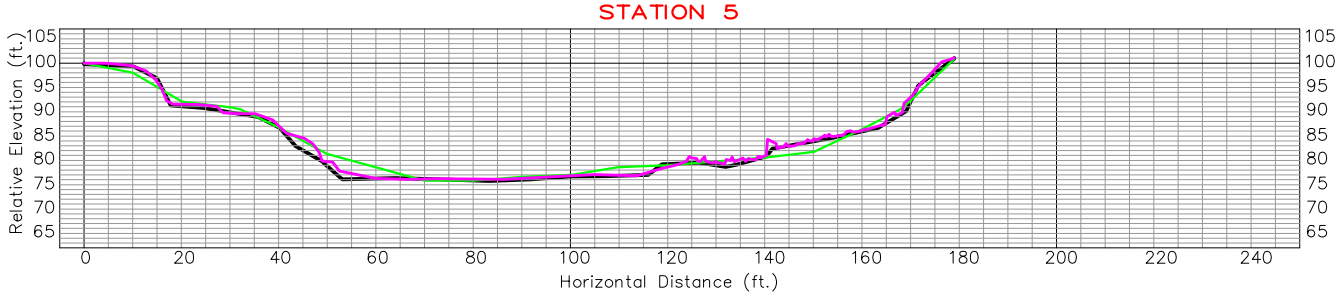

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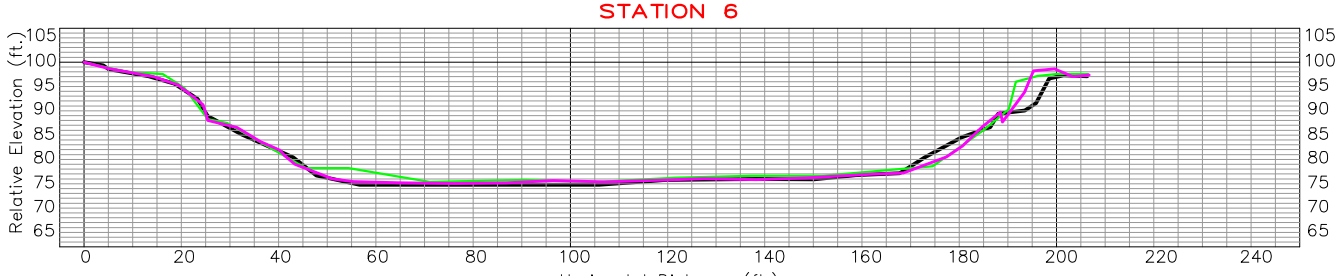

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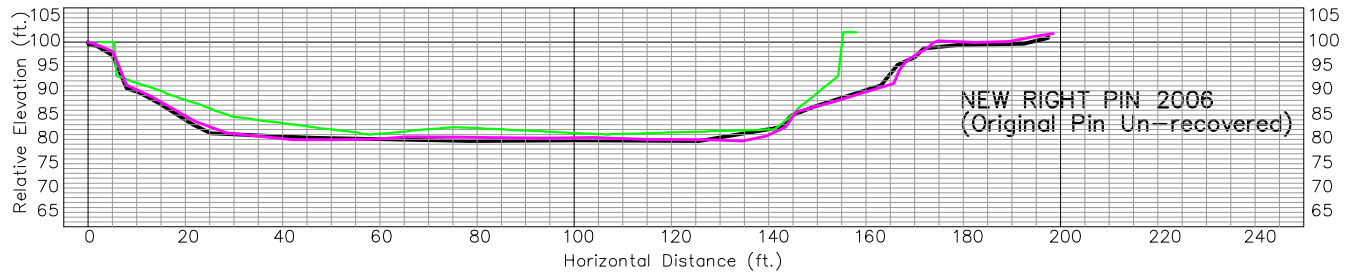

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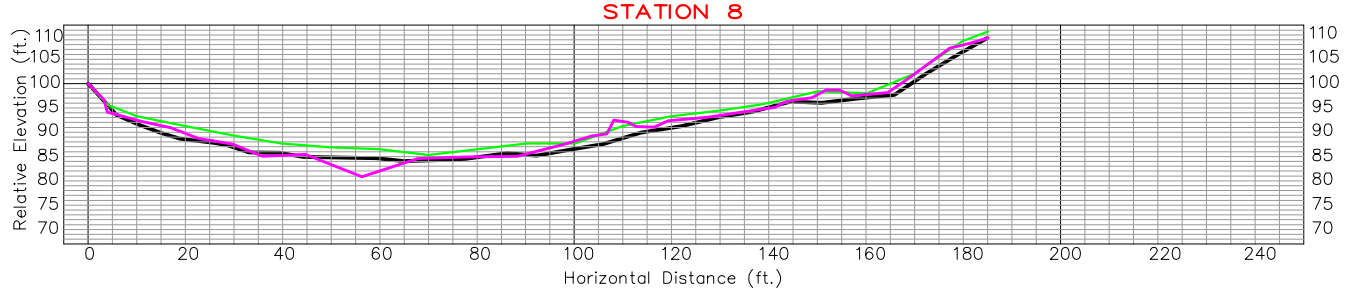

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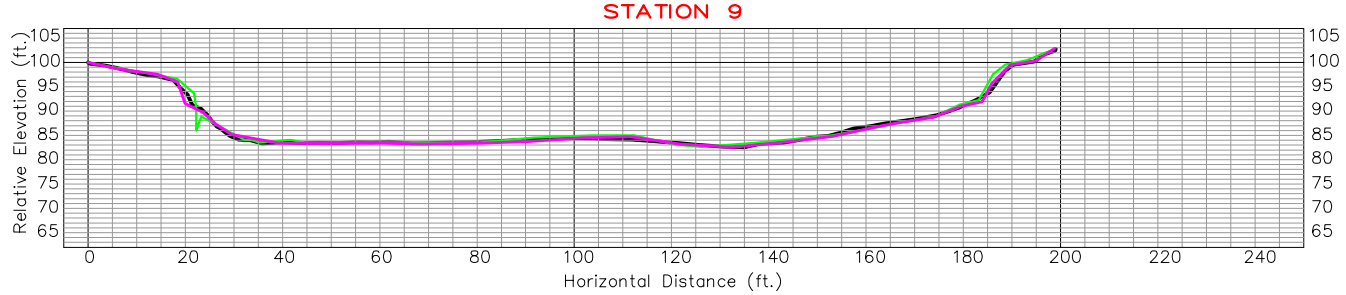

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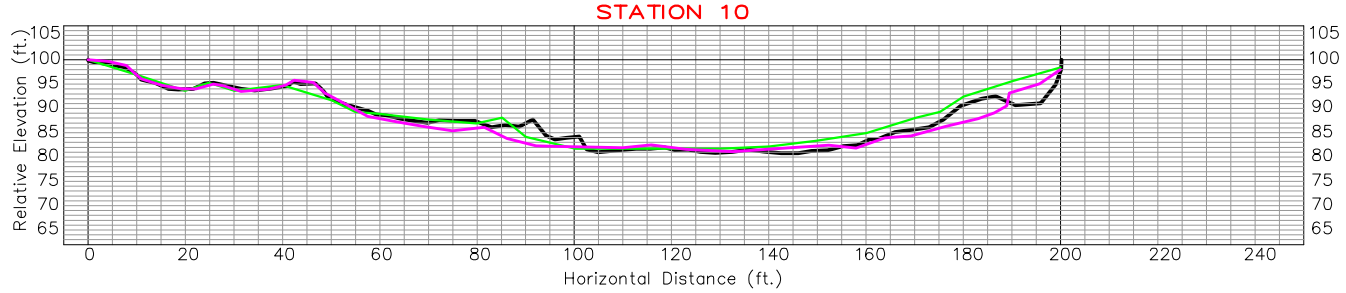

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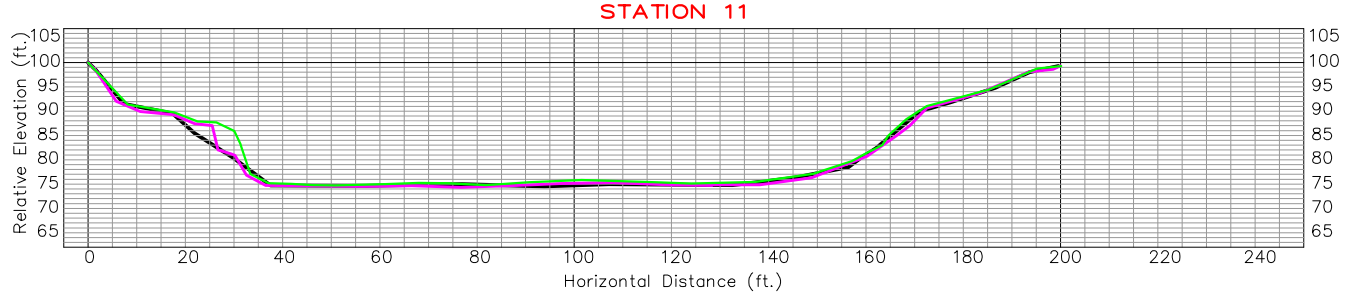

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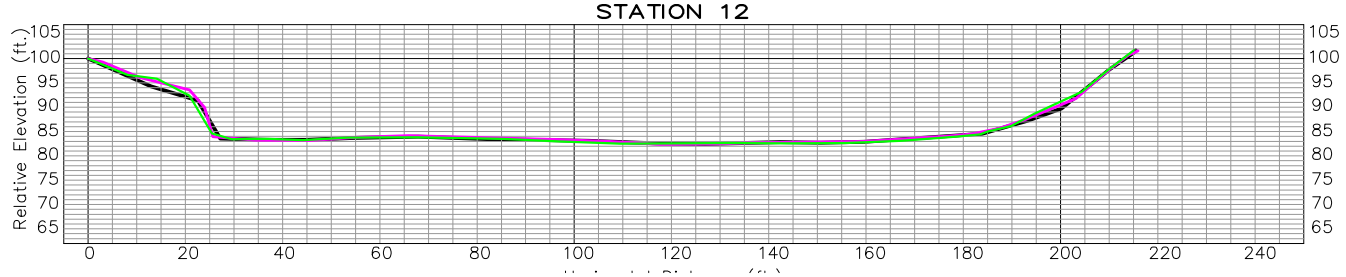

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Natural Resources Restoration & Conservation

EcoScience Corporation
Raleigh, North Carolina

Client:
Ecosystem Enhancement

LEGEND:
- YEAR 2005 PRE-DAM REMOVAL
- YEAR 2006 MONITORING
- YEAR 2007 MONITORING
- STATION 1 — STATION-REFERENCE
- STATION 1 — STATION-FORMERLY IMPOUNDED

Project:
CARBONTON DAM
DEEP RIVER WATERSHED RESTORATION SITE
CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

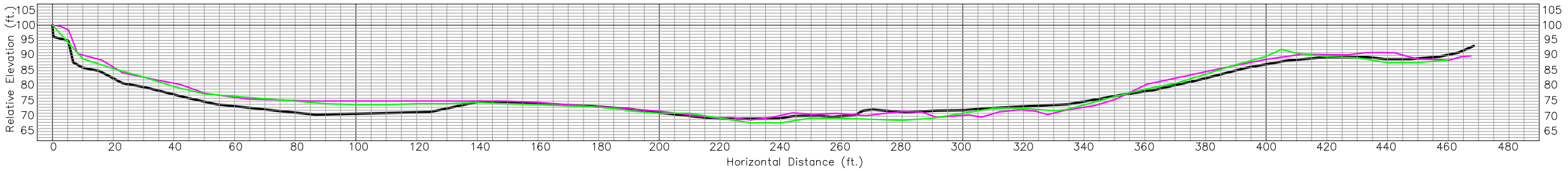
Title:
MONITORING CROSS-SECTIONS

Dwn. By:	Ckd. By:
MTD	MCG
Date:	Scale:
07/26/07	AS SHOWN

ESC Project No.: 07-341

SHEET
4A

STATION 14



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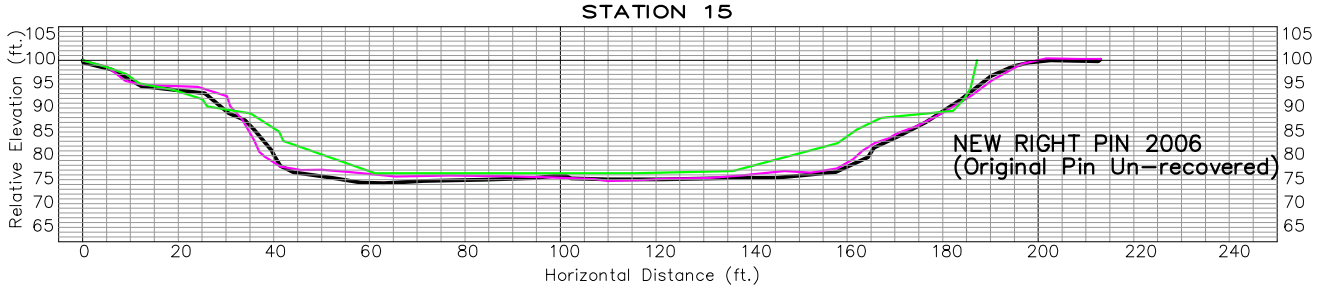

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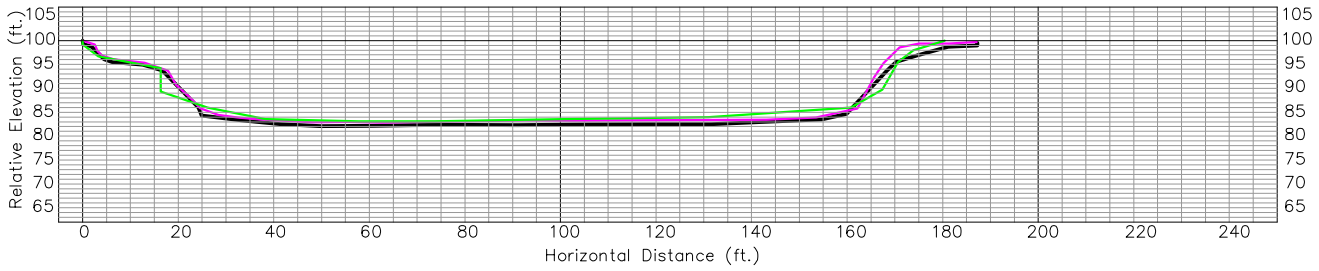

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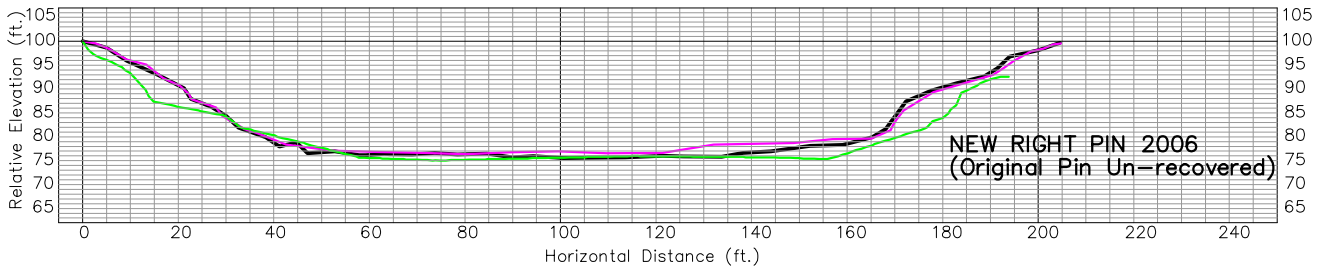

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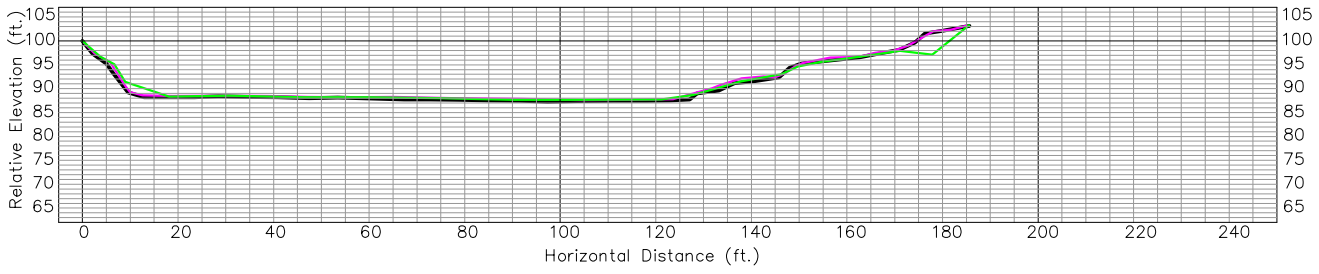

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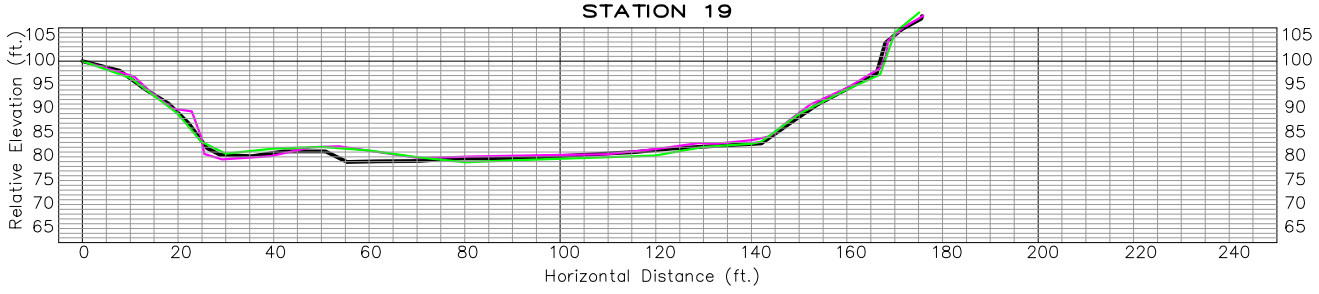

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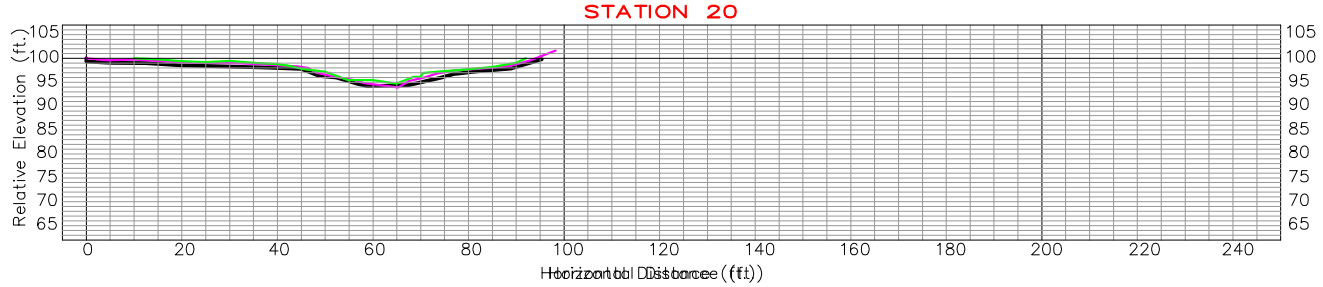

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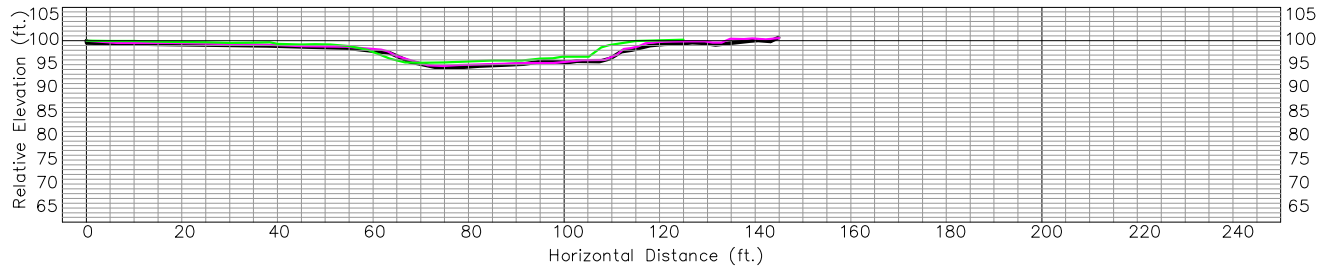

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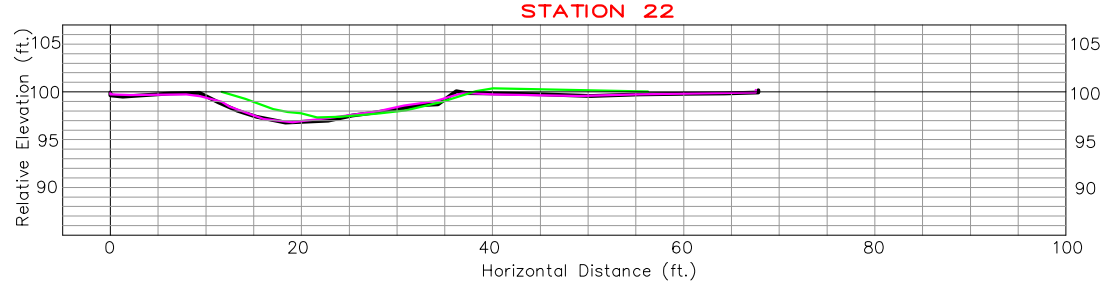

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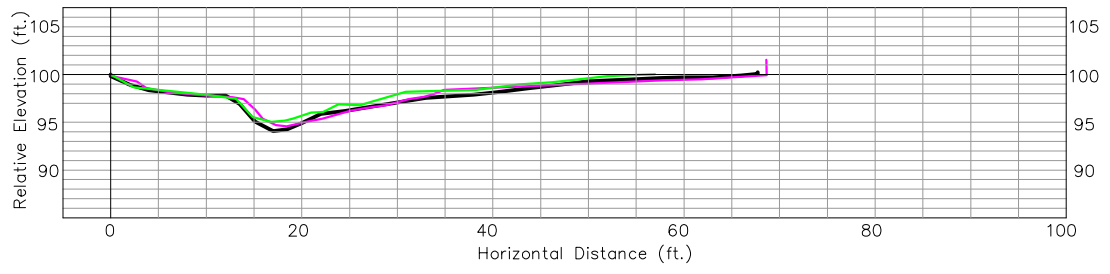

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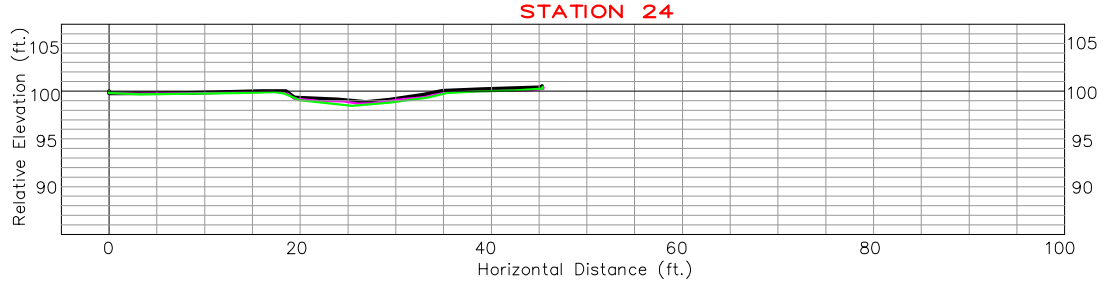

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- STATION 1 — STATION-FORMERLY IMPOUNDED

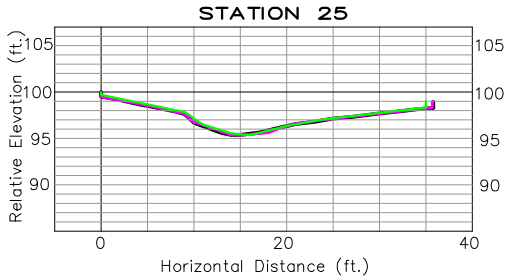
Project:
CARBONTON DAM
DEEP RIVER WATERSHED RESTORATION SITE
CHATHAM, LEE, AND MOORE COUNTIES, NORTH CAROLINA

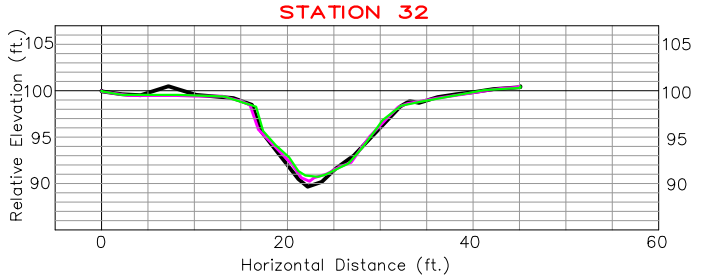
Title:
MONITORING CROSS-SECTIONS

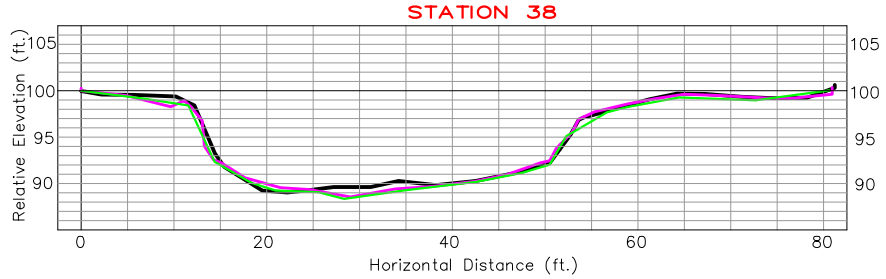
Dwn. By:	Ckd. By:
MTD	MCG
Date:	Scale:
07/26/07	AS SHOWN

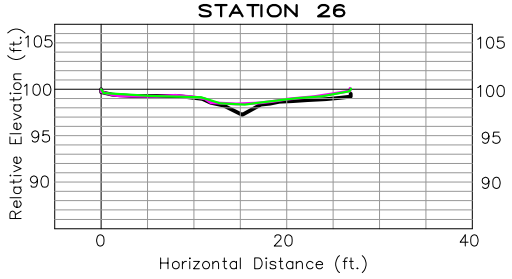
ESC Project No.: 07-341

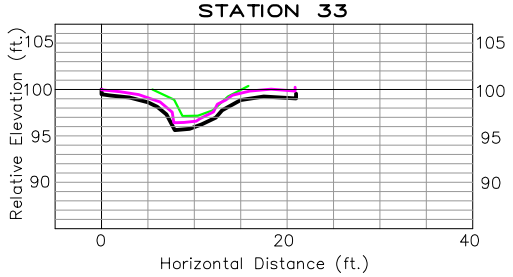
SHEET
4B

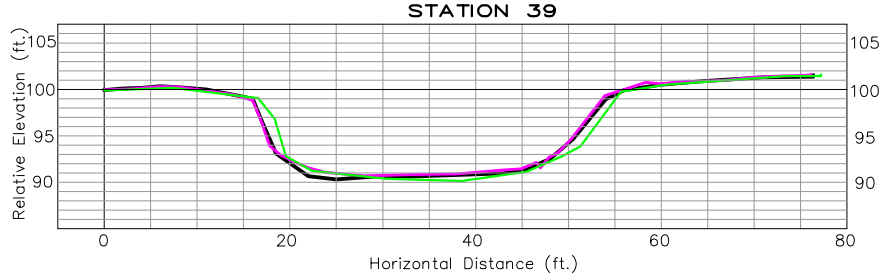


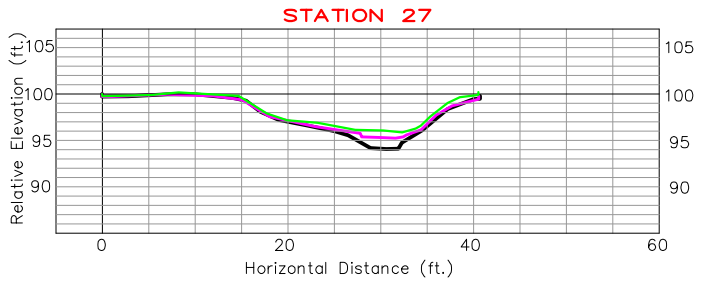


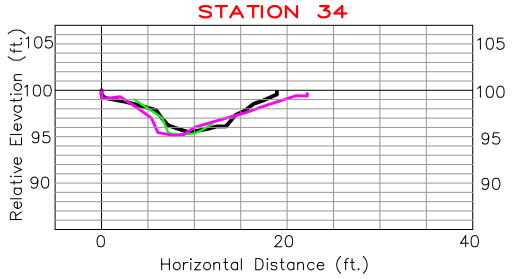


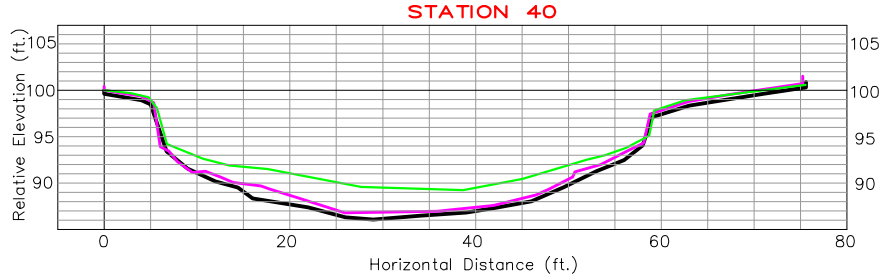


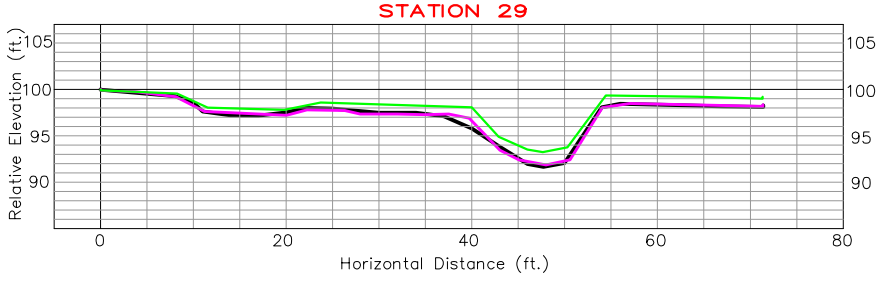


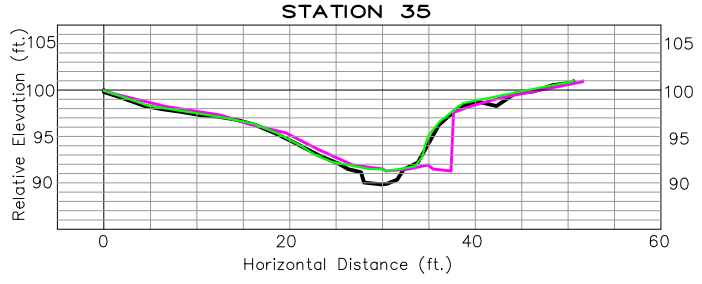


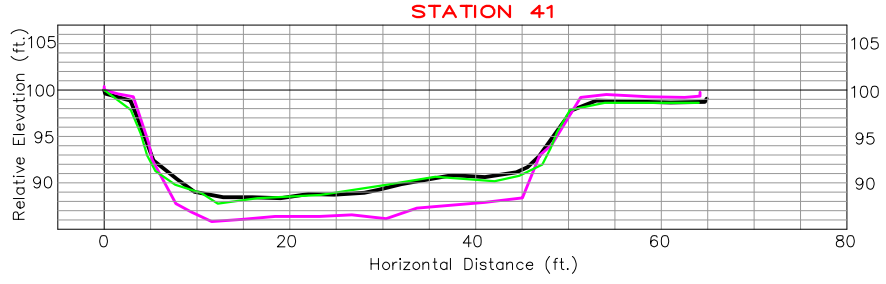


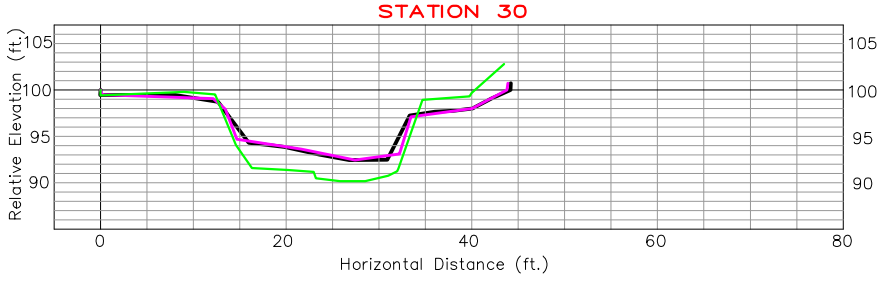


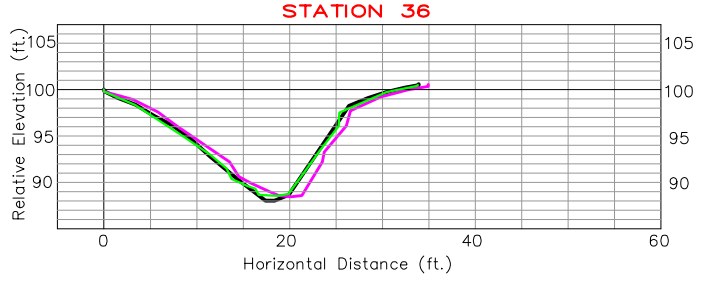


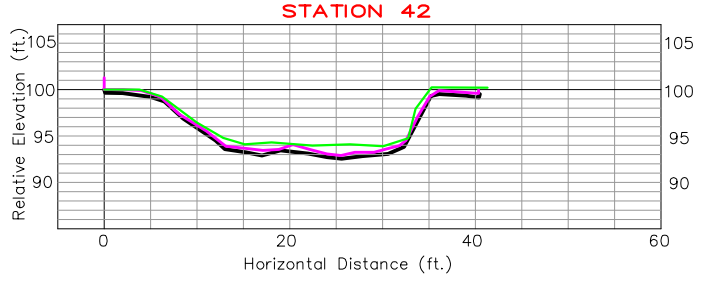


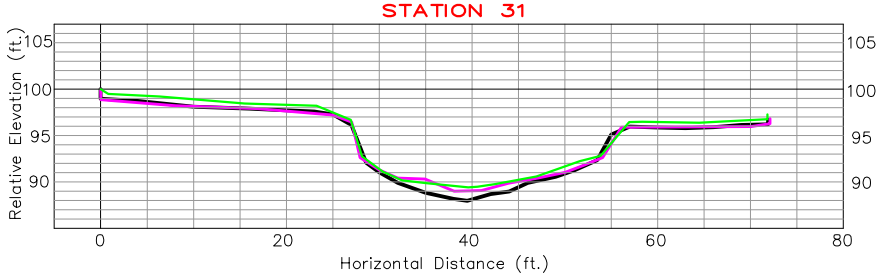


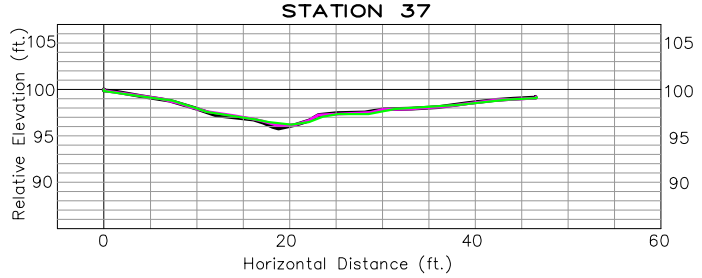


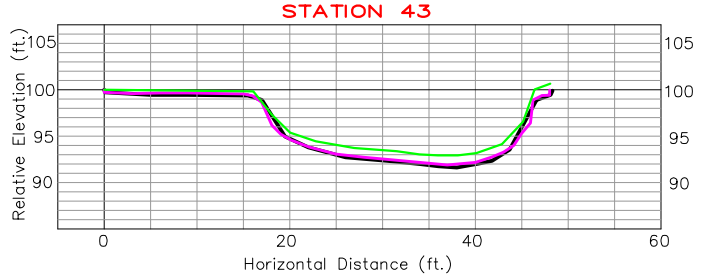












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Raleigh, North Carolina

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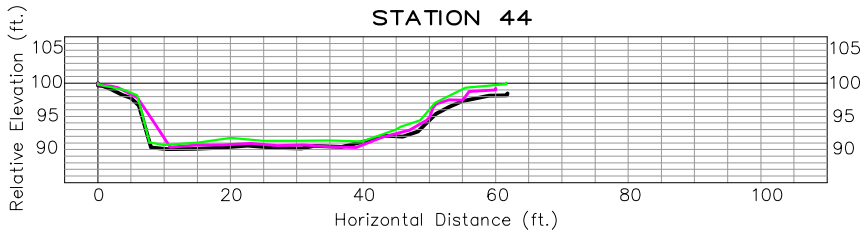

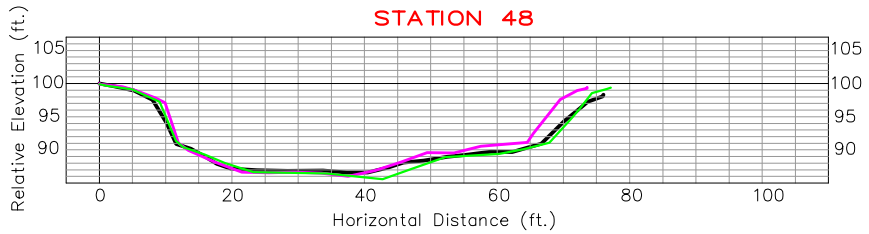

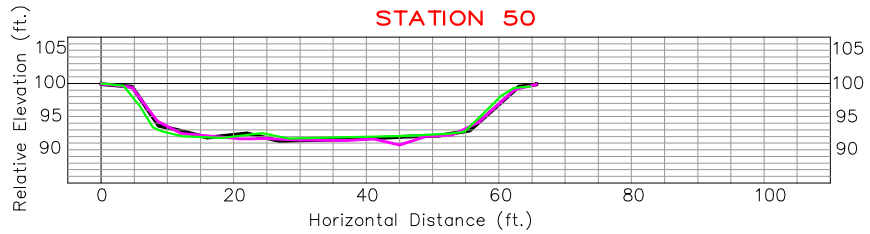

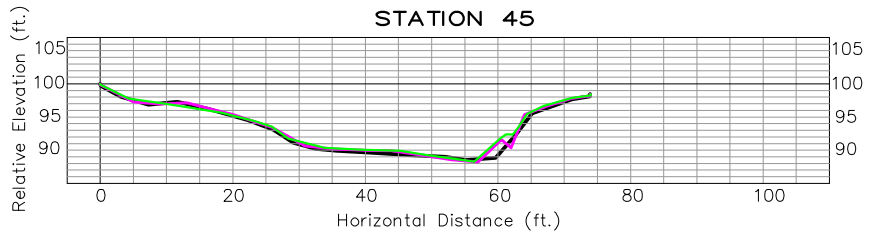

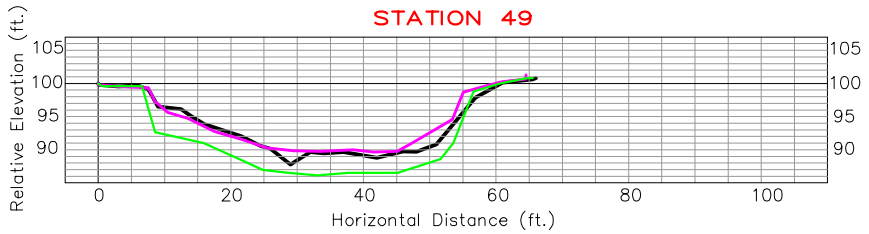

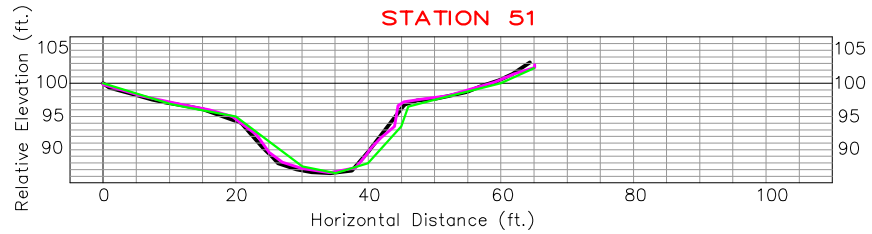

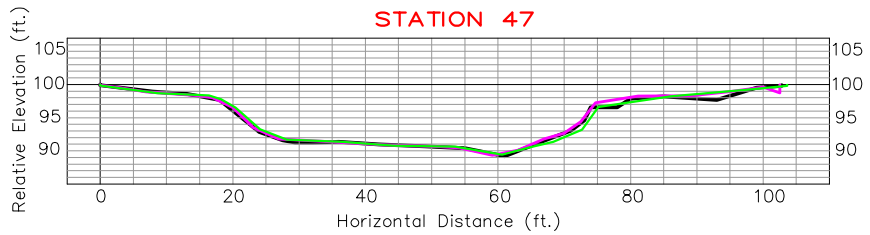

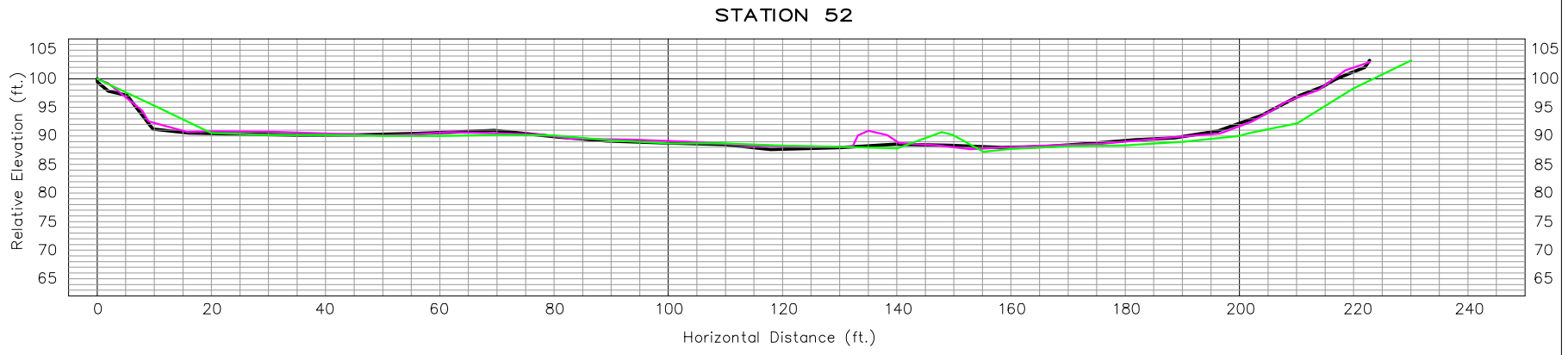

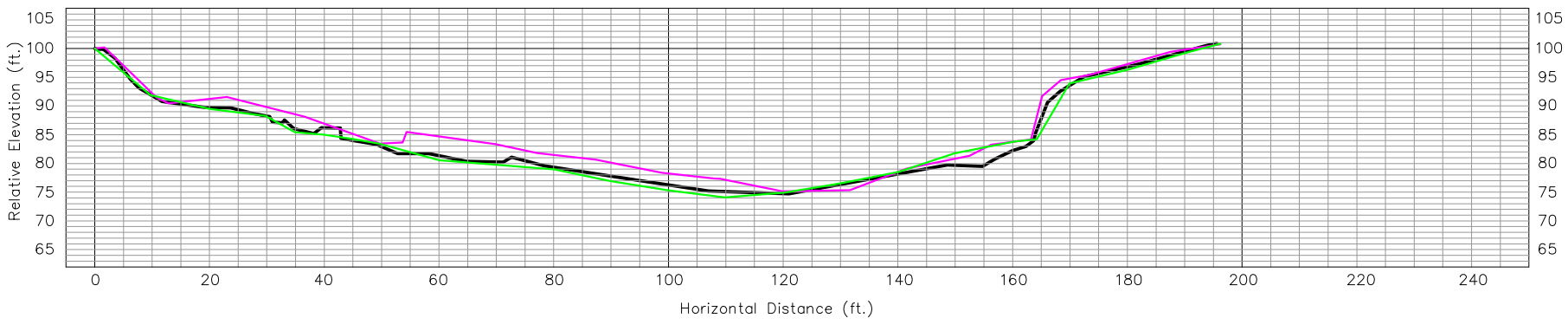

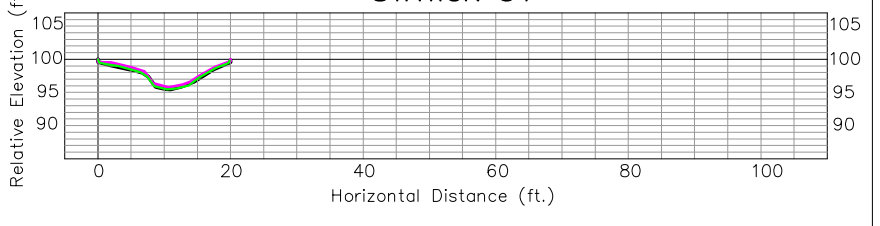

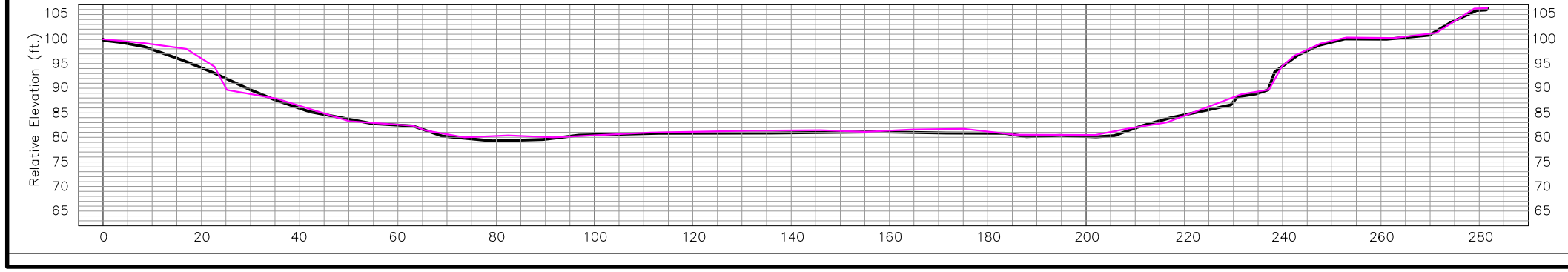

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APPENDIX B: BENTHIC MACROINVERTEBRATE DATA

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**							5				1
NEMERTEA												
Enopla												
Tertastemmatidae												
Prostoma sp.												
NEMATODA	**6**											
MOLLUSCA												
Bivalvia												
Veneroida												
Corbiculidae												
Corbicula fluminea	**6.12**	**FC**										
Sphaeriidae	**6.6**	**FC**										
Musculium sp.	**7.5**	**FC**						1				
Sphaerium sp.	**7.6**	**FC**									1	
Gastropoda												
Mesogastropoda												
Hydrobiidae	**5.78**	**SC**										
Amnicola sp.	**5.2**	**SC**						1				
Somatogyrus sp.	**6.4**	**SC**										
Pleuroceridae	**3.4**											
Elimia sp.	**2.46**	**SC**										
Viviparidae												
Campeloma decisum	**6.5**	**SC**								1		
Basommatophora												
Ancylidae		**SC**										
Ferrissia rivularis	***6**	**SC**										
Physidae												
Physella sp.	**8.8**	**CG**							4			
ANNELIDA												
Oligochaeta		**CG**										
Tubificida												
Enchytraeidae	**9.8**	**CG**										
Lumbricidae		**CG**				1		2				2
Naididae	***8**	**CG**									3	
Dero sp.	**10**	**CG**									1	
Nais sp.	**8.9**	**CG**				3	3					
Slavina appendiculata	**7.1**	**CG**				1						
Stylaria lacustris	**9.4**	**CG**									1	
Tubificidae w.h.c.	**7.1**	**CG**	1	1							28	
Tubificidae w.o.h.c.	**7.1**	**CG**	8						2	4	3	3
Quistadrilus multisetosus	**3.9**	**CG**										
Branchiura sowerbyi	**8.28**	**CG**										
Limnodrilus hoffmeisteri	**9.5**	**CG**									1	
Lumbriculida												
Lumbriculidae	**7.03**	**CG**	1		2	1		5	9	8	2	4
Branchiobdellida												
Hirudinea		**P**										
Arhynchobdellida												
Erpobdellidae		**P**		1						1		
Rhynchobdellida												
Glossiphoniidae		**P**	1	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**
Rhynchobdellida												
Helobdella stagnalis	**8.6**	**P**						4				
Placobdella papillifera	**9**	**P**								1		
Helobdella triserialis	**9.2**	**P**							1			
ARTHROPODA												
Arachnoidea												
Acariformes				1								
Hygrobatidae												
Atractides sp.	**5.5**											
Lebertiidae	**5.5**											
Lebertia sp.	**5.5**				1	1				6		
Pionidae	**5.5**						2					
Crustacea												
Ostracoda												1
Copepoda			1								1	
Cladocera												
Daphnidae												
Ceriodaphnia sp.												
Isopoda												
Asellidae		**SH**										
Caecidotea sp.	**9.1**	**CG**	90	1	6		1	35		3	47	2
Amphipoda												
Crangonyctidae												
Crangonyx sp.	**7.9**	**CG**	2	1	3	1	1	18	40		13	2
Hyalellidae												
Hyalella azteca	**7.75**	**CG**										
Decapoda												
Cambaridae	**7.5**				1	1		2	1	4		
Cambarus sp.	**7.62**	**CG**		1							2	1
Procambarus sp.	**7**	**SH**									2	
Palaemonidae												
Palaemonetes kadiakensis	**7.1**	**CG**		2		2	1			1		3
Insecta												
Collembola								1	1		1	
Ephemeroptera												
Ameletidae		**CG**										
Ameletus sp.		**CG**	2									
Baetidae		**CG**			1		1					
Acerpenna pygmaea	**3.9**		1			1				2		1
Acerpenna sp.										1		
Baetis intercalaris	**7**	**CG**	3	3	1							66
Callibaetis sp.	**9.8**	**CG**										
Centroptilum sp.	**6.6**	**CG**										1
Heterocloeon sp.	**3.5**	**SC**										7
Plauditus sp.	***4**	**CG**	3	8	9	22	10			1		
Pseudocloeon sp.	**4**	**CG**		5	5							94
Caenidae		**CG**										
Caenis sp.	**7.4**	**CG**	2	2			8	2				5
Ephemeridae		**CG**										
Hexagenia sp.	**4.9**	**CG**		1						1		
Ephemerellidae		**SC**	4									2
Ephemerella sp.	**2.04**	**SC**		1	1		1					7
Ephemerella needhami	**0**	**CG**										
Eurylophella sp.	**4.34**	**SC**	4	2	2				1			
Eurylophella funeralis	**2.1**							6		1		
Serratella sp.		**SC**	1	1	5		7					19
Timpanoga sp.		**CG**		10	30	12	14			1		10

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Ephemeroptera												
Heptageniidae					1		3					
Heptagenia sp.	**2.6**	**SC**			1							
Leucrocuta sp.	**2.4**	**SC**	2			1						88
Maccaffertium sp.	***4**	**SC**	196	80	75	20	195			26		108
Maccaffertium exiguum	**3.8**	**SC**		2	2		2					16
Maccaffertium integrum	**5.8**	**SC**		1								
Maccaffertium modestum	**5.5**	**SC**	27	30	20		51			74		47
Maccaffertium pudicum	**2**	**SC**		30	54		40					15
Stenacron interpunctatum	**3.58**	**SC**		48	24	5				27		4
Stenonema femoratum	**7.2**	**SC**										
Isonychiidae		**FC**										
Isonychia sp.	**3.5**	**FC**	22	3	3		3					25
Leptophlebiidae	***2**	**CG**	1		3							
Leptophlebia sp.	**6.2**	**CG**	2					1	6		1	
Paraleptophlebia sp.	**0.94**	**CG**	12		2		5					
Potamanthidae		**CG**										
Anthopotamus myops	**1.5**	**CG**	5	10	7		5					1
Siphlonuridae												
Siphlonurus sp.	**5.8**	**CG**	9					1				
Tricorythidae	***4**	**CG**										
Tricorythodes sp.	**5.06**	**CG**										1
Odonata												
Aeshnidae	**5.6**	**P**										
Boyeria vinosa	**5.97**	**P**					1					1
Calopterygidae		**P**										
Calopteryx sp.	**7.8**	**P**										
Coenagrionidae	***9**	**P**										
Argia sp.	**8.17**	**P**	3	20	8	2	3			1		7
Enallagma sp.	**8.9**	**P**										
Corduliidae	***5**	**P**										
Epicordulia princeps	**5.6**	**P**									1	
Macromia sp.	**6.16**	**P**	1	1	2		2			8		9
Neurocordulia sp.	**5**			8	2	4	11					
Neurocordulia obsoleta	**5.2**											7
Gomphidae	***1**	**P**		1								
Dromogomphus spinosus	**5.1**	**P**	1		2	1						5
Dromogomphus sp.	**5.9**	**P**										
Gomphus sp.	**5.8**	**P**	1		4	1	1			5		7
Hagenius brevistylus	**4**	**P**	1				1					
Libellulidae	**6.7**	**P**						1				
Pachydiplax longipennis	**9.9**										1	
Somatochlora sp.	**9.2**	**P**										
Plecoptera												
Coenagrionidae		**P**										
Nemouridae		**SH**										
Amphinemura sp.	**3.3**	**SH**	5	3			14		3	12		
Perlidae	***1**	**P**					1		1			
Acroneuria abnormis	**2.1**	**P**										
Acroneuria cf. media				11	19	2	11					11
Agnetina capitata	**0**	**P**	1				1					
Agnetina sp.	**0**											4
Eccoptura xanthenes	**3.7**	**P**		1								
Neoperla sp.	**1.5**	**P**	7		1		5					6
Perlesta placida sp. gp.	**4.7**	**P**	12	4	7	1	15			3		94
Perlesta sp.	**4.7**	**P**	1	1	6		8	1	1			1
Perlodidae	***2**	**P**								1		

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Plecoptera												
Clioperla clio	**4.7**	**P**								3		
Cultus sp.												
Isoperla sp.	***2**	**P**	7			8	2	1		174		1
Pteronarcidae	**1.6**	**SH**										
Taeniopterygidae		**SH**	6	1								
Taeniopteryx sp.	**5.4**	**SH**					8			5		
Taenionema atlanticum			3									
Hemiptera												
Belostomatidae												
Belostoma sp.	**9.8**	**P**										
Corixidae	**9**	**PI**							1	1		
Gerridae												
Aquarius sp.		**P**										
Pleidae												
Neoplea sp.												
Nepidae		**-**										
Ranatra sp.	**7.8**	**P**						1			3	
Notonectidae												
Notonecta sp.	**8.7**	**P**							1			
Veliidae		**P**										
Microvelia sp.		**P**	1							3		
Megaloptera												
Corydalidae		**P**										
Corydalus cornutus	**5.2**	**P**										1
Sialidae		**P**										
Sialis sp.	**7.17**	**P**						1				
Trichoptera												
Glossosomatidae		**SC**										
Protoptila sp.	**2.6**	**SC**										1
Hydropsychidae	***4**	**FC**										13
Cheumatopsyche sp.	**6.2**	**FC**	10	5	10	10	13			5		11
Hydropsyche sp.	**5**	**FC**	4	3	12	15	14					27
Hydropsyche incommoda	**4.8**											
Hydropsyche simulians				5	4	39	11					21
Hydropsyche venularis	**5**	**FC**										
Macrostemum carolina												
Hydroptilidae	***4**	**PI**										
Hydroptila sp.	**6.2**	**PI**										
Leptoceridae	***4**	**CG**		1								
Ceraclea sp.	**2**	**CG**			2							
Nectopsyche sp.	**2.9**	**SH**			4		1					
Nectopsyche exquisita	**4.1**	**SH**										10
Oecetis sp.	**4.7**	**P**	1				1					
Oecetis avara												2
Triaenodes sp.	**4.46**	**SH**	1							1		
Triaenodes injustus	**2.5**	**SH**					1					3
Lepidostomatidae		**SH**										
Lepidostoma sp.	**0.9**	**FC**		1			5					
Limnephilidae												
Ironoquia sp.		**-**							3			
Pycnopsyche sp.	**2.5**	**SH**								1		
Philopotamidae		**FC**										
Chimarra cf. aterrima	**2.8**	**FC**	1									
Chimarra cf. obscura	**2.76**	**FC**	10				11					18
Chimarra cf. socia	**2.76**	**FC**										
Chimarra sp.	**2.8**	**FC**										

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												
Polycentropodidae		**FC**										
Neureclipsis sp.	**4.2**	**FC**										
Polycentropus sp.	**3.5**	**FC**	1	11	3		2					1
Psychomyiidae		**CG**										
Lype diversa	**4.1**	**SC**								1		
Rhyacophilidae		**P**										
Rhyacophila fenestra/ledra		**P**								1		
Uenoidae												
Neophylax consimilis	**1.5**											5
Lepidoptera												
Coleoptera												
Carabidae												
Curculionidae												
Dryopidae												
Helichus sp.	**4.63**	**SC**							1	1		
Dytiscidae		**P**								1		
Hydroporus sp.	**8.62**	**PI**	3	1	1			5	9	3	18	1
Elmidae		**CG**										
Ancyronyx variegata	**6.49**	**SC**	1		1					7		1
Dubiraphia sp.	**5.93**	**SC**					1					
Dubiraphia vittata	**4.1**	**SC**						1		2		1
Macronychus glabratus	**4.58**	**SH**	1	1	2	4	7			5		7
Microcylloepus pusillus	**2.1**	**SC**										3
Optioservus sp.	**2.4**	**SC**										
Optioservus ovalis	**2.4**	**SC**										
Stenelmis sp.	**5.1**	**SC**	11				4					90
Gyrinidae		**P**										
Dineutus sp.	**5.54**	**P**								1		1
Gyrinus sp.	**6.17**	**P**								1		
Haliplidae												
Peltodytes sp.	**8.73**	**SH**	1					1				
Helophoridae												
Helophorus sp.	**7.6**											
Hydrophilidae												
Berosus sp.	**8.43**	**CG**										
Hydrochus sp.	**6.55**	**SH**								1		
Sperchopsis tesselatus	**6.13**	**CG**							3			4
Psephenidae		**SC**										
Ectopria sp.	***4**	**SC**										
Psephenus herricki	**2.35**	**SC**										
Scirtidae		**SC**		1				4			1	3
Staphylinidae		**P**	1		1		4	2			1	1
Diptera												
Blephariceridae		**SC**										
Blepharicera sp.	**2**	**SC**	1									
Ceratopogonidae	***5**	**P**				1			3			4
Atrichopogon sp.	**6.49**	**P**										
Bezzia/Palpomyia gp.	**6.9**	**P**	1		1		1					
Chaboridae												
Chaoborus punctipennis	**8.5**	**P**										
Chironomidae												
Ablabesmyia mallochi	**7.2**	**P**	47	4	4	1	7	1	1	4		10
Ablabesmyia rhamphe gp.	**7.2**	**P**	3	5	5					1	1	
Brillia flavifrons	**5.2**	**SH**										
Cardiocladius obscurus	**5.9**	**P**										2
Chironomus sp.	**9.63**	**CG**				2					42	

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												
Cladotanytarsus sp.	**4.09**	**FC**		5	23		2					
Conchapelopia sp.	**8.4**	**P**	9	6	10	1	2	2	5	4	1	
Corynoneura sp.	**6.01**	**CG**		1								2
Cricotopus sp.	***7**	**CG**		10	2	12	4	1				
Cricotopus bicinctus	**8.5**	**CG**	1	5	11	13	27	2				8
Cricotopus tremulus	***8**	**CG**										
Cryptochironomus sp.	**6.4**	**P**		2	1				1			2
Dicrotendipes neomodestus	**8.1**	**CG**	3	16	4	26	1			1		
Dicrotendipes simpsoni	**10**								3			
Eukiefferiella claripennis gp.	**5.6**	**CG**	15			2	1					
Glyptotendipes sp.	**9.5**	**FC**		1				1				
Kiefferulus sp.	**8**			1				5	13		11	
Labrundinia sp.	**5.9**	**P**		4	2							
Microtendipes pedellus gp.	**5.5**	**CG**					1					
Nanocladius distinctus	**7.07**	**CG**										
Natarsia sp.	**10**		1									
Orthocladius sp.		**CG**	9	4	11	34	2		1	2	1	6
Orthocladius sp.												
Orthocladius lignicola	**5.4**	**CG**										2
Paracladopelma sp.	**5.51**	**CG**		69	4	1	1				1	
Parakiefferiella sp.	**5.4**	**CG**			2		5					
Parametriocnemus sp.	**3.65**	**CG**			2					1		2
Paratendipes sp.	**5.1**	**CG**		1				1	5			
Pentaneura inconspicia					11							
Phaenopsectra punctipes gp.												
Polypedilum fallax	**6.4**	**SH**	1									
Polypedilum flavum	**4.9**	**SH**	10	3	9	8	19					22
Polypedilum halterale gp.	**9**	**SH**	7	1	1	1				4		2
Polypedilum illinoense	**7.3**	**SH**	21			1	19		3			97
Potthastia longimana	**9**	**CG**										
Procladius sp.	**9.1**	**P**	7		1	2			1		2	
Pseudochironomus sp.	**5.4**	**CG**			2				2			
Rheocricotopus robacki	**7.3**	**CG**			1					2		10
Rheocricotpus cf. glabricollis												
Rheotanytartsus exiguus gp.	**5.9**			1	4	2	15					18
Robackia demeijerei	**3.7**	**CG**										2
Stenochironomus sp.	**6.45**	**SH**							1	1		
Stictochironomus devinctus		**CG**										
Tanytarsus sp.	**6.76**	**FC**	40	6	2	2				16		10
Thienemanniella xena	**5.86**	**CG**	3		3	2	7					4
Tribelos jucundum	**6.3**		1			1				43		2
Tvetenia paucunca	**3.7**	**CG**										2
Tvetenia vitracies	**3.6**	**CG**	1	2	4	2	5					24
Xenochironomus xenolabis	**7.1**	**P**			1							
Xylotopus par	**6**	**SH**								1		
Zavrelimyia sp.	**9.11**	**P**						1	11			
Culicidae		**FC**									4	
Empididae	**7.6**	**P**										
Hemerodromia sp.		**P**										
Ptychopteridae												
Bittacomorpha sp.												
Simuliidae	***6**	**FC**										
Prosimulium sp.	**6**	**FC**	1									
Simulium sp.	**6**	**FC**	14	4	2	1	3				1	23
Tabanidae		**PI**										
Chrysops sp.	**6.73**	**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**
Diptera												
Tabanus sp.	**9.2**	**PI**									1	
Tipulidae	***3**	**SH**										
Antocha sp.	**4.3**	**CG**										
Limnophila sp.		**P**										
Pseudolimnophila sp.	**7.22**	**P**							1			
Tipula sp.	**7.33**	**SH**	1					1	1			
TOTAL NO. OF ORGANIMS			**693**	**477**	**473**	**274**	**635**	**117**	**140**	**490**	**197**	**1168**
TOTAL NO. OF TAXA			**73**	**65**	**69**	**45**	**66**	**33**	**33**	**55**	**31**	**83**
EPT INDEX			**32**	**29**	**29**	**12**	**32**	**6**	**6**	**20**	**1**	**36**
BIOTIC INDEX			**5.66**	**4.94**	**4.60**	**5.82**	**4.66**	**7.75**	**7.51**	**4.28**	**8.52**	**4.89**
BIOTIC INDEX VALUE			**5.47**	**5.24**	**5.29**	**5.98**	**4.94**	**7.42**	**7.38**	**5.44**	**8.21**	**4.99**
EPT ABUNDANCE			**366**	**284**	**314**	**136**	**469**	**12**	**15**	**341**	**1**	**746**

REFERENCE STATIONS										
			Sta. 12	Sta. 14	Sta. 18	Sta. 19	Sta. 39	Sta. 45	Sta. 52	Sta. 53
PLATYHELMINTHES										
Turbellaria										
Tricladida										
Dugesiidae										
Planariidae										
Girardia (Dugesia) tigrina	**7.2**									
NEMERTEA										
Enopla										
Tertastemmatidae										
Prostoma sp.				1						
NEMATODA	**6**									
MOLLUSCA										
Bivalvia										
Veneroida										
Corbiculidae										
Corbicula fluminea	**6.12**	**FC**						3		
Sphaeriidae	**6.6**	**FC**	1							
Musculium sp.	**7.5**	**FC**								
Sphaerium sp.	**7.6**	**FC**							1	
Gastropoda										
Mesogastropoda										
Hydrobiidae	**5.78**	**SC**								
Amnicola sp.	**5.2**	**SC**					1			6
Somatogyrus sp.	**6.4**	**SC**			3	1				
Pleuroceridae	**3.4**									
Elimia sp.	**2.46**	**SC**	2							1
Viviparidae										
Campeloma decisum	**6.5**	**SC**					2	1		
Basommatophora										
Ancylidae		**SC**								
Ferrissia rivularis	***6**	**SC**								1
Physidae										
Physella sp.	**8.8**	**CG**					3	1	2	
ANNELIDA										
Oligochaeta		**CG**								
Tubificida										
Enchytraeidae	**9.8**	**CG**								1
Lumbricidae		**CG**	4	3	3					1
Naididae	***8**	**CG**	1		3		2			1
Dero sp.	**10**	**CG**								
Nais sp.	**8.9**	**CG**								
Slavina appendiculata	**7.1**	**CG**			1					
Stylaria lacustris	**9.4**	**CG**								
Tubificidae w.h.c.	**7.1**	**CG**					1			1
Tubificidae w.o.h.c.	**7.1**	**CG**		6		1	4			1
Quistadrilus multisetosus	**3.9**	**CG**		1						
Branchiura sowerbyi	**8.28**	**CG**		3						
Limnodrilus hoffmeisteri	**9.5**	**CG**		3						
Lumbriculida										
Lumbriculidae	**7.03**	**CG**		3	4	7	10	6		5
Branchiobdellida										
Hirudinea		**P**								
Arhynchobdellida										
Erpobdellidae		**P**				1			1	

REFERENCE STATIONS										
			Sta. 12	Sta. 14	Sta. 18	Sta. 19	Sta. 39	Sta. 45	Sta. 52	Sta. 53
Rhynchobdellida										
Glossiphoniidae		**P**								
Helobdella stagnalis	**8.6**	**P**					3			
Placobdella papillifera	**9**	**P**					1			
Helobdella triserialis	**9.2**	**P**								
ARTHROPODA										
Arachnoidea										
Acariformes			2	1			1			
Hygrobatidae										
Atractides sp.	**5.5**					4				1
Lebertiidae	**5.5**									
Lebertia sp.	**5.5**							2		
Pionidae	**5.5**									
Crustacea										
Ostracoda										1
Copepoda								1		
Cladocera										
Daphnidae										
Ceriodaphnia sp.									1	
Isopoda									1	
Asellidae		**SH**								
Caecidotea sp.	**9.1**	**CG**	1	65	1	2	34	1	15	9
Amphipoda										
Crangonyctidae										
Crangonyx sp.	**7.9**	**CG**	3	4	1	3	30	1	6	
Hyalellidae										
Hyalella azteca	**7.75**	**CG**	3			6			3	
Decapoda										
Cambaridae	**7.5**			1		3	1	1		
Cambarus sp.	**7.62**	**CG**								1
Procambarus sp.	**7**	**SH**								
Palaemonidae										
Palaemonetes kadiakensis	**7.1**	**CG**	2					1	1	1
Insecta										
Collembola										
Ephemeroptera										
Ameletidae		**CG**								
Ameletus sp.		**CG**								
Baetidae		**CG**	1	1	3		1			1
Acerpenna pygmaea	**3.9**			1				5		1
Acerpenna sp.										
Baetis intercalaris	**7**	**CG**	11		2	13			23	42
Callibaetis sp.	**9.8**	**CG**					11			
Centroptilum sp.	**6.6**	**CG**								1
Heterocloeon sp.	**3.5**	**SC**								8
Plauditus sp.	***4**	**CG**	60	4	3		2	15	13	
Pseudocloeon sp.	**4**	**CG**	3			16		1	2	21
Caenidae		**CG**								
Caenis sp.	**7.4**	**CG**	3			1	9		3	3
Ephemeridae		**CG**								
Hexagenia sp.	**4.9**	**CG**	1							1
Ephemerellidae		**SC**	4							
Ephemerella sp.	**2.04**	**SC**			6	1			58	7
Ephemerella needhami	**0**	**CG**	16	1	12					
Eurylophella sp.	**4.34**	**SC**				1			13	4
Eurylophella funeralis	**2.1**		3		1		16			
Serratella sp.		**SC**	11			4			3	4

REFERENCE STATIONS										
			Sta. 12	Sta. 14	Sta. 18	Sta. 19	Sta. 39	Sta. 45	Sta. 52	Sta. 53
Ephemeroptera										
Timpanoga sp.		**CG**	10	2	8	2		5	30	4
Heptageniidae					1	1				
Heptagenia sp.	**2.6**	**SC**	1			2				
Leucrocuta sp.	**2.4**	**SC**	18	1	1	11			5	4
Maccaffertium sp.	***4**	**SC**	94	90	264	137		33	147	190
Maccaffertium exiguum	**3.8**	**SC**	4		7	1				6
Maccaffertium integrum	**5.8**	**SC**							1	
Maccaffertium modestum	**5.5**	**SC**	25	33	183	60	26	57	150	96
Maccaffertium pudicum	**2**	**SC**	12	4	51	77			1	44
Stenacron interpunctatum	**3.58**	**SC**	7		9	65	17	39		13
Stenonema femoratum	**7.2**	**SC**				1				
Isonychiidae		**FC**								
Isonychia sp.	**3.5**	**FC**	28	12	30	4			94	7
Leptophlebiidae	***2**	**CG**				2	2			
Leptophlebia sp.	**6.2**	**CG**		1			5			
Paraleptophlebia sp.	**0.94**	**CG**	2		1				20	
Potamanthidae		**CG**								
Anthopotamus myops	**1.5**	**CG**	1			1				
Siphlonuridae										
Siphlonurus sp.	**5.8**	**CG**							1	
Tricorythidae	***4**	**CG**								
Tricorythodes sp.	**5.06**	**CG**				2				1
Odonata										
Aeshnidae	**5.6**	**P**				1				
Boyeria vinosa	**5.97**	**P**						4		
Calopterygidae		**P**								
Calopteryx sp.	**7.8**	**P**						1		
Coenagrionidae	***9**	**P**								
Argia sp.	**8.17**	**P**	7		2	17			1	18
Enallagma sp.	**8.9**	**P**	4			2				
Corduliidae	***5**	**P**								
Epicordulia princeps	**5.6**	**P**				1				
Macromia sp.	**6.16**	**P**	2	1	1	8		1	3	10
Neurocordulia sp.	**5**		3		7	3			1	5
Neurocordulia obsoleta	**5.2**									
Gomphidae	***1**	**P**	2		1					2
Dromogomphus spinosus	**5.1**	**P**	2			1				
Dromogomphus sp.	**5.9**	**P**							1	
Gomphus sp.	**5.8**	**P**	1			1		5		1
Hagenius brevistylus	**4**	**P**								
Libellulidae	**6.7**	**P**								
Pachydiplax longipennis	**9.9**									
Somatochlora sp.	**9.2**	**P**				1	1	1		
Plecoptera										
Coenagrionidae		**P**				1				
Nemouridae		**SH**								
Amphinemura sp.	**3.3**	**SH**	3	8	25		41	31	11	
Perlidae	***1**	**P**	1							
Acroneuria abnormis	**2.1**	**P**				3				
Acroneuria cf. media			6	3	6	3				5
Agnetina capitata	**0**	**P**	3							
Agnetina sp.	**0**									
Eccoptura xanthenes	**3.7**	**P**								
Neoperla sp.	**1.5**	**P**	27	3	1	3			3	4
Perlesta placida sp. gp.	**4.7**	**P**	46	5	27	4	12		148	
Perlesta sp.	**4.7**	**P**		1	6	25		22		50

REFERENCE STATIONS										
			Sta. 12	Sta. 14	Sta. 18	Sta. 19	Sta. 39	Sta. 45	Sta. 52	Sta. 53
Perlodidae	***2**	**P**								
Clioperla clio	**4.7**	**P**						1		
Cultus sp.								1		
Isoperla sp.	***2**	**P**	5	8	27		115	287	26	1
Pteronarcidae	**1.6**	**SH**								
Taeniopterygidae		**SH**								
Taeniopteryx sp.	**5.4**	**SH**	8	5	7		7	4	1	
Taenionema atlanticum										
Hemiptera										
Belostomatidae										
Belostoma sp.	**9.8**	**P**					1			
Corixidae	**9**	**PI**						1		
Gerridae										
Aquarius sp.		**P**	1							
Pleidae										
Neoplea sp.										1
Nepidae		**-**								
Ranatra sp.	**7.8**	**P**	1							
Notonectidae										
Notonecta sp.	**8.7**	**P**								
Veliidae		**P**								
Microvelia sp.		**P**					1			
Megaloptera										
Corydalidae		**P**								
Corydalus cornutus	**5.2**	**P**			1					
Sialidae		**P**								
Sialis sp.	**7.17**	**P**					1			
Trichoptera										
Glossosomatidae		**SC**								
Protoptila sp.	**2.6**	**SC**	1							
Hydropsychidae	***4**	**FC**								7
Cheumatopsyche sp.	**6.2**	**FC**	20	7	47	11		20	51	33
Hydropsyche sp.	**5**	**FC**	106	2	64	5			64	26
Hydropsyche incommoda	**4.8**									1
Hydropsyche simulians			22	3	6					
Hydropsyche venularis	**5**	**FC**								
Macrostemum carolina			1							
Hydroptilidae	***4**	**PI**								
Hydroptila sp.	**6.2**	**PI**							1	
Leptoceridae	***4**	**CG**								
Ceraclea sp.	**2**	**CG**								1
Nectopsyche sp.	**2.9**	**SH**	7		1	1			4	
Nectopsyche exquisita	**4.1**	**SH**								13
Oecetis sp.	**4.7**	**P**	1	1		3			1	
Oecetis avara										10
Triaenodes sp.	**4.46**	**SH**						1		
Triaenodes injustus	**2.5**	**SH**		1		2			7	2
Lepidostomatidae		**SH**								
Lepidostoma sp.	**0.9**	**FC**	46	4						
Limnephilidae										
Ironoquia sp.		**-**					10	2	4	
Pycnopsyche sp.	**2.5**	**SH**								
Philopotamidae		**FC**								
Chimarra cf. aterrima	**2.8**	**FC**								
Chimarra cf. obscura	**2.76**	**FC**	57	10	16			1	16	1
Chimarra cf. socia	**2.76**	**FC**							1	
Chimarra sp.	**2.8**	**FC**			1					

REFERENCE STATIONS									
			Sta. 12	Sta. 14	Sta. 18	Sta. 19	Sta. 39	Sta. 45	Sta. 52	Sta. 53
Trichoptera										
Polycentropodidae		**FC**								
Neureclipsis sp.	**4.2**	**FC**			1				3	
Polycentropus sp.	**3.5**	**FC**		1	2	7				
Psychomyiidae		**CG**								
Lype diversa	**4.1**	**SC**								
Rhyacophilidae		**P**								
Rhyacophila fenestra/ledra		**P**								
Uenoidae										
Neophylax consimilis	**1.5**									
Lepidoptera										
Coleoptera										
Carabidae										
Curculionidae				1						
Dryopidae										
Helichus sp.	**4.63**	**SC**								
Dytiscidae		**P**				2	2		1	
Hydroporus sp.	**8.62**	**PI**					1	1	6	
Elmidae		**CG**								
Ancyronyx variegata	**6.49**	**SC**	1			2	1			2
Dubiraphia sp.	**5.93**	**SC**						1	2	
Dubiraphia vittata	**4.1**	**SC**						7		2
Macronychus glabratus	**4.58**	**SH**	1	2	5	13		2	3	32
Microcylloepus pusillus	**2.1**	**SC**	1							2
Optioservus sp.	**2.4**	**SC**								
Optioservus ovalis	**2.4**	**SC**	1							
Stenelmis sp.	**5.1**	**SC**	32	16	15	2		4	20	4
Gyrinidae		**P**								
Dineutus sp.	**5.54**	**P**						4		
Gyrinus sp.	**6.17**	**P**								
Haliplidae										
Peltodytes sp.	**8.73**	**SH**								
Helophoridae										
Helophorus sp.	**7.6**									1
Hydrophilidae										
Berosus sp.	**8.43**	**CG**	1						1	
Hydrochus sp.	**6.55**	**SH**								
Sperchopsis tesselatus	**6.13**	**CG**					3		6	
Psephenidae		**SC**								
Ectopria sp.	***4**	**SC**	1							
Psephenus herricki	**2.35**	**SC**	1	2						
Scirtidae		**SC**							12	
Staphylinidae		**P**					22	1		
Diptera										
Blephariceridae		**SC**								
Blepharicera sp.	**2**	**SC**								
Ceratopogonidae	***5**	**P**								3
Atrichopogon sp.	**6.49**	**P**								
Bezzia/Palpomyia gp.	**6.9**	**P**	1			10				
Chaboridae										
Chaoborus punctipennis	**8.5**	**P**							1	
Chironomidae										
Ablabesmyia mallochi	**7.2**	**P**	3	2	3	12				
Ablabesmyia rhamphe gp.	**7.2**	**P**								
Brillia flavifrons	**5.2**	**SH**						1		
Cardiocladius obscurus	**5.9**	**P**	1						2	
Chironomus sp.	**9.63**	**CG**								

REFERENCE STATIONS										
			Sta. 12	**Sta. 14**	**Sta. 18**	**Sta. 19**	**Sta. 39**	**Sta. 45**	**Sta. 52**	**Sta. 53**
Chironomidae										
Cladotanytarsus sp.	**4.09**	**FC**	5		2			1	2	
Conchapelopia sp.	**8.4**	**P**	1	19	4	7		4	9	6
Corynoneura sp.	**6.01**	**CG**			2			1		
Cricotopus sp.	***7**	**CG**		2	4	3	3	4	3	
Cricotopus bicinctus	**8.5**	**CG**	6	3		2	6	11	41	2
Cricotopus tremulus	***8**	**CG**	4	2						
Cryptochironomus sp.	**6.4**	**P**	1		1				3	2
Dicrotendipes neomodestus	**8.1**	**CG**	1	2	5	2	9		3	2
Dicrotendipes simpsoni	**10**						31			
Eukiefferiella claripennis gp.	**5.6**	**CG**	4	23	2		5	6	2	
Glyptotendipes sp.	**9.5**	**FC**								
Kiefferulus sp.	**8**						9			
Labrundinia sp.	**5.9**	**P**								
Microtendipes pedellus gp.	**5.5**	**CG**			1					
Nanocladius distinctus	**7.07**	**CG**						3		
Natarsia sp.	**10**									
Orthocladius sp.		**CG**	6	51	2		28	46	7	2
Orthocladius sp.							1			
Orthocladius lignicola	**5.4**	**CG**								2
Paracladopelma sp.	**5.51**	**CG**	1							
Parakiefferiella sp.	**5.4**	**CG**		2						
Parametriocnemus sp.	**3.65**	**CG**			1		3	2		
Paratendipes sp.	**5.1**	**CG**					1			
Pentaneura inconspicia									2	
Phaenopsectra punctipes gp.							6			
Polypedilum fallax	**6.4**	**SH**				2	4			
Polypedilum flavum	**4.9**	**SH**	34	26	52	9	3		41	2
Polypedilum halterale gp.	**9**	**SH**					1	1		6
Polypedilum illinoense	**7.3**	**SH**	4	5	6	127	1	6	15	204
Potthastia longimana	**9**	**CG**			1			1	2	
Procladius sp.	**9.1**	**P**		2			1			
Pseudochironomus sp.	**5.4**	**CG**			1					
Rheocricotopus robacki	**7.3**	**CG**			1		1	18	3	8
Rheocricotpus cf. glabricollis							1			
Rheotanytartsus exiguus gp.	**5.9**		11		1	10		4	70	10
Robackia demeijerei	**3.7**	**CG**								
Stenochironomus sp.	**6.45**	**SH**	1			3	3			
Stictochironomus devinctus		**CG**		3						
Tanytarsus sp.	**6.76**	**FC**		28	16	70	6	33	7	51
Thienemanniella xena	**5.86**	**CG**		5			3		2	2
Tribelos jucundum	**6.3**						3			
Tvetenia paucunca	**3.7**	**CG**					3	2		
Tvetenia vitracies	**3.6**	**CG**	10	2	2	3	1		27	
Xenochironomus xenolabis	**7.1**	**P**								
Xylotopus par	**6**	**SH**								
Zavrelimyia sp.	**9.11**	**P**					3			
Culicidae		**FC**							1	
Empididae	**7.6**	**P**								
Hemerodromia sp.		**P**						1		
Ptychopteridae										
Bittacomorpha sp.										
Simuliidae	***6**	**FC**								
Prosimulium sp.	**6**	**FC**					1			
Simulium sp.	**6**	**FC**	60	4	5		11	9	2	35
Tabanidae		**PI**						1		
Chrysops sp.	**6.73**	**PI**								

			REFERENCE STATIONS							
			Sta. 12	**Sta. 14**	**Sta. 18**	**Sta. 19**	**Sta. 39**	**Sta. 45**	**Sta. 52**	**Sta. 53**
Tabanidae										
Tabanus sp.	**9.2**	**PI**							2	
Tipulidae	***3**	**SH**								
Antocha sp.	**4.3**	**CG**					2	4		
Limnophila sp.		**P**					1			
Pseudolimnophila sp.	**7.22**	**P**					1			
Tipula sp.	**7.33**	**SH**	1						2	
TOTAL NO. OF ORGANIMS			**911**	**506**	**979**	**812**	**552**	**735**	**1242**	**1060**
TOTAL NO. OF TAXA			**83**	**59**	**65**	**67**	**66**	**61**	**75**	**74**
EPT INDEX			**38**	**26**	**31**	**32**	**14**	**17**	**31**	**33**
BIOTIC INDEX			**4.34**	**5.71**	**4.56**	**5.19**	**5.44**	**3.92**	**4.86**	**5.47**
BIOTIC INDEX VALUE			**4.60**	**5.49**	**4.75**	**5.40**	**6.24**	**5.49**	**5.09**	**5.32**
EPT ABUNDANCE			**675**	**212**	**819**	**470**	**274**	**525**	**905**	**612**

APPENDIX C: CARBONTON DAM REMOVAL YEAR 2 FISH MONITORING REPORT
PROVIDED BY THE CATENA GROUP

The Catena Group

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

CARBONTON DAM REMOVAL YEAR-2 MONITORING REPORT

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

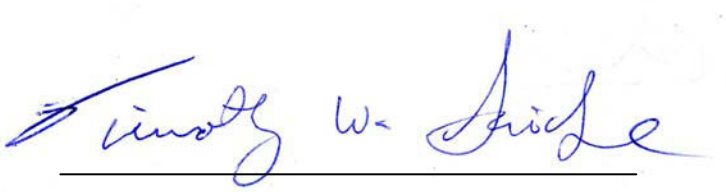
Prepared For:

Restoration Systems LLC

Prepared By:

The Catena Group
Hillsborough, North Carolina

October 01, 2007



Timothy W. Savidge

EXECUTIVE SUMMARY

The Carbonton dam removal project performed by Restoration Systems LLC (RS) is projected to result in the restoration of more than 10 river miles of the mainstem Deep River, as well as portions of three major tributaries (McLendons Creek, Big Governors Creek and Little Governors Creeks) and 15 smaller tributaries. One of the goals of the restoration effort is to restore habitat for the federally Endangered Cape Fear shiner *(Notropis mekistocholas)*, several species of rare mussels, and other riverine aquatic species, including fish and mollusks. Restoring this stretch of river will also re-connect the upstream and downstream populations of the Cape Fear shiner, which have been essentially isolated[1] since the dam was constructed in the early 1900's.

The restoration success criteria established by the interagency Dam Removal Task Force (DRTF) and the goals of RS require documenting the diversity of aquatic fauna and characterizing habitat within the reservoir pool created by the dam, and then monitoring changes in faunal composition and habitat following the dam's removal. The Catena Group Inc. (TCG) was retained by RS in 2005, to conduct the pre-dam removal aquatic species surveys. Eighteen sites were surveyed for freshwater mussels and clams, aquatic snails, and freshwater fish, the results of which are provided in the Pre-removal Survey Report (August 07, 2006). The thrust of the Year-2 monitoring effort is to document whether the Cape Fear shiner is recolonizing habitats previously impounded by the dam, and to document the evolving habitats at each of the monitoring stations.

In addition to documenting the aquatic fauna within the reservoir pool, the pre-removal surveys also established "targeted aquatic communities" (TACs) by sampling locations outside the impoundment effects. Two TACs were established for the Deep River, as well as one each for McLendons Creek and Big Governors Creek. The species occurring at these respective TACs are depicted in Tables 1-4 and are discussed in further detail in Section 4.0 of the Year-1 Monitoring Report submitted to RS on September 06, 2006 (Year-1 Monitoring Report). Documentation of the Cape Fear shiner's recolonization of the former impounded reach of the river is a primary measure of success; emergence of communities that emulate TACs within the former impoundment is further evidence of success.

A five-year monitoring plan has been initiated to evaluate the success of the dam removal. Molluscan fauna will be monitored beginning in the third year (post dam removal) when it is reasonable to expect to observe evidence of mussel dispersal and recruitment into the restored lotic habitats.

Fish community surveys were conducted by TCG in the first year following the dam removal, and the results reported in the Year-1 Monitoring Report. The Year-1 study monitored aquatic species at the six stations within the former reservoir pool that were

[1] In the strictest sense, the isolation has been substantial, but not total, since fish from upstream groups can transit over the dam during full flows. This would theoretically enable some genetic exchange between upstream and downstream groups.

sampled during the pre-removal surveys, as well as nine other stations that were selected based on field observations.

The Year-2 monitoring effort focused primarily on the Cape Fear shiner, although data for by-catch of other species are also reported. (General fish community surveys will be conducted again in years 3 and 5.) Surveys targeting the Cape Fear shiner were conducted at each of the 13 established Deep River impoundment monitoring stations. General observations of in-stream habitat conditions and bank stability were recorded throughout the former reservoir pool and at each of the monitoring stations. Additional Cape Fear shiner surveys were conducted in areas where high quality riffle habitat had formed, or was in the process of forming, since the Year-1 monitoring effort. These riffle locations were recorded via GPS.

A combination of seine netting and hand-held dip netting, electro-shocking (in McClendons Creek and Big Governors Creek only), visual observations, and hook and line methods were used to document fish species. Seine netting was the primary method used to sample, as it is the most effective survey method for the targeted Cape Fear shiner since electro-shocking is prohibited where the Cape Fear shiner is likely to occur.

Based on field observations and fish surveys during the Year-2 monitoring studies, it appears that the habitats within the former reservoir pool are continuing to transition to habitats more typical of lotic conditions. Riffle/run/pool habitats have continued to develop at varying intervals throughout the former impounded reaches.

At least 12 substantial riffle habitats have developed. 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 Cape Fear shiner and various rare mussel species such as the brook floater (*Alasmidonta varicosa*). Cursory surveillance for freshwater mussels indicates that mussels are beginning to return to some of the newly established riffle habitats. These cursory efforts indicate that mussel recruitment is already beginning to occur in some areas and should be widespread three to four years post removal.

The results of the Year-2 fish surveys demonstrate that riffle-adapted species have become established and continue to colonize 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 34 fish species were collected at the 15 monitoring sites. The targeted Cape Fear shiner was located at eight of the sites and favorable habitat conditions for this species appear to be developing at most of the surveyed sites. Additionally, at least ten of the 13 sampled sites appear to have fish faunal components approaching those of their respective TAC.

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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 10 river miles (RM) of the mainstem Deep River, as well as portions of three major tributaries (McLendons Creek, Big Governors Creek and Little Governors Creeks), and 15 smaller tributaries, all within the Cape Fear River Basin. Specific goals of the project are to restore habitat for the federally Endangered Cape Fear shiner *(Notropis mekistocholas)*, several species of rare mussels, and other riverine aquatic species. Restoring this stretch of river will also re-connect the upstream and downstream populations of Cape Fear shiner, which have been essentially isolated* since the dam was constructed in the early 1900's (* see footnote on page i).

The restoration success criteria established by the interagency Dam Removal Task Force (DRTF) and the goals of RS require documenting the diversity of aquatic fauna and characterizing habitat within the reservoir pool created by the dam, and then monitoring changes in faunal composition and habitat following the dam's removal. The Catena Group Inc. (TCG) was retained by RS in 2005, to conduct the pre-dam removal aquatic species surveys. Eighteen sites were surveyed for freshwater mussels and clams, aquatic snails, and freshwater fish, the results of which are provided in the Pre-removal Survey Report (August 07, 2006). The thrust of the Year-2 monitoring effort is to document whether the Cape Fear shiner is recolonizing habitats previously impounded by the dam, and to document the evolving habitats at each of the monitoring stations.

In addition to documenting the aquatic fauna within the reservoir pool, the pre-removal surveys also established "targeted aquatic communities" (TACs) by sampling locations outside the impoundment effects. Two TACs were established for the Deep River, as well as one each for McLendons Creek and Big Governors Creek. The species occurring at these respective TACs are depicted in Tables 1-4 and are discussed in further detail in Section 4.0 of the Year-1 Monitoring Report submitted to RS on September 06, 2006 (Year-1 Monitoring Report). Documentation of the Cape Fear shiner's recolonization of the former impounded reach of the river is a primary measure of success; emergence of communities that emulate TACs within the former impoundment is further evidence of success.

Targeted Aquatic Community 1.

This site, which lies upstream of the old reservoir pool, corresponds to Site 3 in the Pre-removal Surveys Report and is near the NC 22 crossing of the Deep River. The site is 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.

Table 1. Targeted Aquatic Community 1 - Fish Species Found

Scientific Name	Common Name	Relative Abundance
Ameiurus natalis	yellow bullhead	rare (2)
Etheostoma flabellare	fantail darter	Common

Scientific Name	Common Name	Relative Abundance
Etheostoma olmstedi	tessellated 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 and represents the first major riffle/run complex below the former Carbonton dam. The river is relatively narrow with swift flow in shallow to moderate depth. Although habitat complexity is less than TAC-1, this habitat type is common throughout the formerly 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 with areas of exposed bedrock.

Table 2. Targeted Aquatic Community 2 - Fish Species Found

Scientific Name	Common Name	Relative Abundance
Cyprinella nivea	whitefin shiner	Uncommon
Etheostoma olmstedi	tessellated 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 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.

Table 3. Targeted Aquatic Community 3 - Fish Species Found

Scientific Name	Common Name	Relative Abundance
Etheostoma olmstedi	tessellated 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).

TAC-4 corresponds to Site 17 in the Pre-removal Survey Report. 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 - Fish Species Found

Scientific Name	Common Name	Relative Abundance
Esox americanus	redfin pickerel	Common
Etheostoma olmstedi	Tessellated darter	Common
Etheostoma serriferum	Sawcheek darter	Uncommon
Lepomis macrochirus	Bluegill	Common
Micropterus salmoides	Largemouth bass	Uncommon
Nocomis leptocephalus	bluehead chub	Common

Monitoring Plan.

A five-year monitoring plan has been initiated to evaluate the success of the dam removal. Documentation of Cape Fear shiner recruitment into the formerly impounded reach of the river is a primary measure of restoration success. However, success criteria also include establishment of similar fish faunal composition between the sampled sites within the former impoundment and their respective TACs. Success is not necessarily measured by an exact replication of the TAC, but rather to have similar numbers of species that occupy similar niches (i.e. similar number of darter, shiner and sunfish species).

This five-year monitoring plan involves conducting aquatic species (fish, freshwater mussels and aquatic snails) surveys at 15 permanent monitoring stations within the former reservoir pool, that were established in the pre-removal surveys. Thirteen stations are in the Deep River and one each in McClendons Creek and Big Governors Creek.

TCG conducted Year-1 fish monitoring surveys in August 2006, at 15 permanent monitoring locations in the former reservoir pool in the Deep River, McClendons Creek, and Big Governors Creek. These surveys indicated that riffle/run habitats were beginning to form and expected lotic fish communities were becoming established. However, the targeted Cape Fear shiner was not recorded during these surveys. The results of these surveys were presented in the Year-1 Monitoring Report.

The Year-2 monitoring component consisted of conducting fish surveys at the 15 permanent monitoring stations established during the pre-removal surveys and the Year-1 monitoring surveys. The results of the Year-2 monitoring are presented in this report and will factor into the decision for future monitoring efforts.

Changes in freshwater mussel fauna will likely not be evident for at least three 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 three years post removal. The results of the Year-3 monitoring will determine if future monitoring of these species is warranted.

2.0 SURVEY EFFORTS

Fish surveys were conducted for the Year-2 monitoring effort at 15 monitoring locations (Table 5), with the exception of Site 10 (too deep to adequately survey), by the following TCG personnel on the listed dates:

Tom Dickinson – August 15, 16 & September 5, 13
Fred C. Rhode* – August 15, 16
Tim Savidge – September 5, 13
Chris Sheats – August 15, 16
Shay Garriock – August 15 & September 5, 13
Jennifer Logan – August 16

* Contracted by TCG to assist field crew

In addition to sampling at the permanent monitoring stations, an additional site (Site 1.5) was sampled due to the exceptional riffle/run habitat that has developed. The locations of the sampled sites are depicted in Figure 1. Very brief surveys (≤5 minutes per site) were also conducted for freshwater mussels in select newly formed riffle habitats.

Table 5. Permanent Monitoring Survey Locations - Carbonton Dam Reservoir Pool

Site #	Site Location	GPS Location
1	Deep River (impoundment)	35.49298ºN, -79.41518ºW
1.5	Deep River (impoundment)	35.49315 ºN, -79.40278ºW
2	Deep River (impoundment)	35.48996ºN, -79.38668ºW
3	Deep River (impoundment)	35.48269ºN, -79.38307ºW
4	Deep River (impoundment)	35.46404ºN, -79.39042ºW
5	Deep River (impoundment)	35.46126ºN, -79.38965ºW
6	Deep River (impoundment)	35.45722ºN, -79.38024ºW

Site #	Site Location	GPS Location
7	Deep River (impoundment)	35.47221ºN, -79.36856ºW
8	Deep River (impoundment)	35.47767ºN, -79.36000ºW
9	Deep River (impoundment)	35.47855ºN, -79.35072ºW
10*	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	McLendons Creek (impoundment)	35.45894ºN, -79.39803ºW
15	Big Governors Creek (impoundment)	35.47434ºN, -79.3564ºW

*not sampled during year-1 or year-2 monitoring due to water depth

2.1 SurveyMethodology

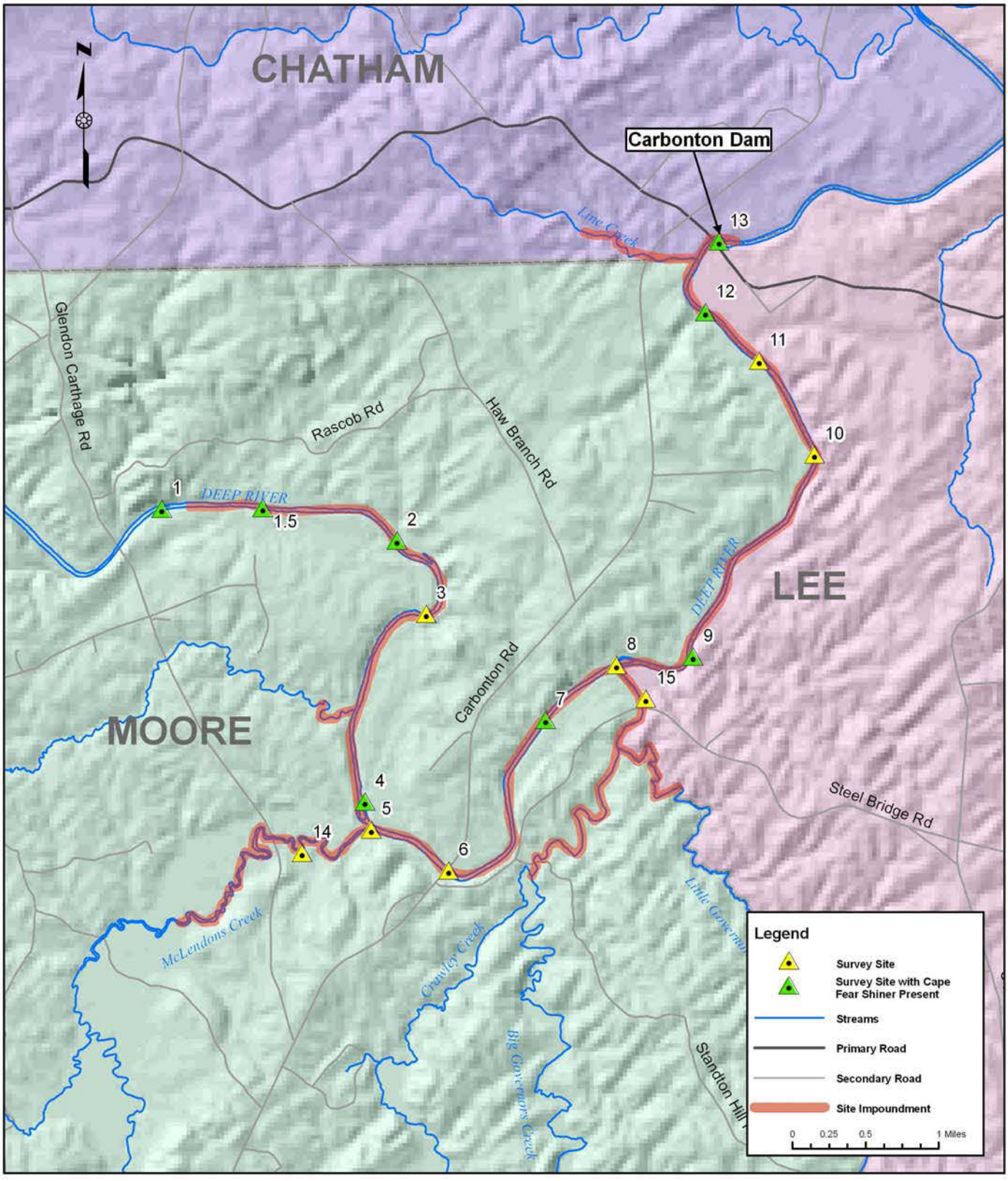
The surveys had two components, habitat reconnaissance and fish sampling.

2.1.1 Habitat Reconnaissance

Habitat reconnaissance was conducted in the entire restored reach of the Deep River by canoeing from the upper limits of the former reservoir pool downstream to the former dam. Observations of in-stream habitat conditions and bank stability were recorded. Cape Fear shiner surveys were conducted at the monitoring stations, as navigated to with GPS and in additional areas where riffles have formed, or are in the process of forming. The additional survey station (Site 1.5) was recorded with GPS in the event it becomes a permanent survey station for the five-year monitoring protocol (Table 5 and Figure 1).

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, hand-held dip netting, visual observations, and hook and line methods were used to document fish species. In McClendons Creek and Big Governors Creek, it was decided to employ electro-shocking in conjunction with dip netting and seine netting due to the amount of heavy woody debris that precluded the effectiveness of seine netting for the target species (shiners). For each survey, the survey team began at the downstream point of the survey site and proceeded upstream. Seine netting was the primary sample method, as it is the most effective survey method for the targeted Cape Fear shiner. Two people pulled the seine net upstream while a third person herded fish into the net by walking downstream towards the seine and kicked the substrate. This 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.



The Catena Group

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

Date: September 2007

Scale: As Shown

Job No.: 3202

Figure 1

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 and their condition. Any fish that did not recover from the sampling were preserved in 95% ethanol. Habitat notes were recorded and a relative abundance was assigned to each species captured or observed.

3.0 RESULTS

Based on field observations and fish surveys, it appears that much of the habitat within the former reservoir pool has reverted to lotic conditions. Riffle/run/pool habitats have formed, or appear to be in the process of forming, at varying intervals throughout the restored reaches.

3.1 Habitat Reconnaissance

The Year-1 monitoring report questioned whether riffle habitat would form at Sites 9 and 10 which were characterized by moderate to deep rocky run habitats; however, Year-2 sampling indicates that cobble/gravel bars are forming near Site 9, which suggests that Site 10 may also develop these habitat characteristics over time as initially predicted during the pre-removal surveys. Currently, Site 10 is 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.

Habitat at Site 15 and throughout Big Governors Creek continues to be dominated by slack-water pools, runs with sluggish flow, and silt-mud substrate with a large amount of woody debris. Year-2 observations noted some very small areas of riffles and shallow runs with limited gravel substrate developing to a greater degree than previously observed during the Year-1 monitoring; however, it is likely 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 in areas that are still wetted. One exception to this was noted at Site 7 in the Deep River where several young mussels, including the state endangered yellow lampmussel (*Lampsilis cariosa*) and state threatened creeper (*Strophitus undulatus*), estimated to be approximately 1-2 years old, were observed in gravel riffle habitats, suggesting recruitment into this area following dam removal. Further sampling, which is planned for the Year-3 monitoring component is needed to draw any definitive conclusions.

In general, vegetation has colonized the newly exposed river banks fairly quickly and overall the banks appear to be stable with very little scour and erosion noted. The exception to this occurs below Site 10 and is especially evident in the general vicinity of the WRC boat landing where patches of moderate stream-bank erosion and scour were observed. A potential concern for early stability of the stream banks in these areas is the

dominance of the invasive Japanese hops (*Humulus japonica*). This species was observed to be covering most stream banks in the lower reaches of the former impoundment. The plant is considered to be an invasive species and can be spread by wind, water, and soil movement to an area where it quickly forms dense thickets that exclude native vegetation and greatly alter the natural ecosystem. The species has a shallow root system; therefore, in the absence of other native vegetation, sites overgrown by Japanese hops could become susceptible to erosion following winter dieback of leaf material. Measures to control this species include manually pulling up the plants or use of herbicides (http://www.na.fs.fed.us/fhp/invasive_plants/weeds/japanese-hop.pdf).

3.2 Fish Surveys

A total of 34 fish species were collected at the 15 sites (Figure 1). Relative abundance was 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 survey methodologies. 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 old mill site. Some of the dam material (rock and timbers) remain in the river and a riffle run sequence has continued to develop below the former mill site. The substrate is dominated by rock (from the old dam) and cobble. Coarse sand and gravel have accumulated in the shallow areas at the head and base of the riffle. Cobble-gravel bars are forming below the old mill site and have been colonized by various species of herbaceous vegetation. Shiner species, including 13 individuals of Cape Fear Shiner, were located throughout the site in shallow riffle/runs and in nearby slack water habitats along the bars.

Table 6. Site 1: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella analostana	satinfin shiner	Common
Cyprinella niveus	whitefin shiner	Common
Fundulus rathbuni	speckled killifish	Common
Lepomis auritus	redbreast sunfish	Uncommon
Lepomis macrochirus	bluegill	Rare
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Common
Nocomis leptocephalus	bluehead chub	Common
Notropis altipinnis	highfin shiner	Common

Scientific Name	Common Name	Relative Abundance
Notropis amoenus	comely shiner	Very Abundant
Notropis hudsonius	spottail shiner	Abundant
Notropis mekistocholas	Cape Fear shiner	Common (13)
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Abundant

A total of 13 species were found at this site compared to nine found during the Year-1 monitoring and 18 found at the target site (TAC-1), showing that this site is close to meeting the targeted fish species diversity. Eight species, bluegill, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, Cape Fear shiner and bluehead chub are shared with the TAC-1 site (Table 1). Additionally, the lotic-adapted satinfin shiner, whitefin shiner, and comely shiner, all previously undocumented at the site during the Year-1 monitoring, were found. Species richness is expected to continue to increase at this location over time as the habitat continues to develop.

3.2.2 Site 1.5 (Deep River-Impoundment):

A large gravel/cobble riffle has formed at this site, providing excellent habitat for target species and was thus sampled as an additional survey station. The substrate is dominated by cobble/gravel and coarse sand, which extends across most of the river's width as a shallow riffle. Cobble-gravel bars are forming along each of the river banks. Nine shiner species, including two individuals of Cape Fear shiner, were located at the site in or close to the riffle areas.

Table 7. Site 1.5*: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella analostana	satinfin shiner	Uncommon
Cyprinella niveus	whitefin shiner	Uncommon
Lepomis auritus	redbreast sunfish	Uncommon
Gambusia holbrookii	eastern mosquitofish	Abundant
Moxostoma pappillosum	v-lip redhorse	Rare
Luxilus albeolus	white shiner	Very Abundant
Nocomis leptocephalus	bluehead chub	Very Abundant
Notropis altipinnis	highfin shiner	Very Abundant
Notropis amoenus	comely shiner	Very Abundant
Notropis hudsonius	spottail shiner	Very Abundant
Notropis mekistocholas	Cape Fear shiner	Rare (2)
Notropis procne	swallowtail shiner	Very Abundant
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Uncommon

*Site 1.5 is an additional site, located between Sites 1 & 2.

A total of 14 species were found at this site compared to 18 found at the target site (TAC-1), suggesting that this site is close to the targeted fish species diversity. Many lotic species such as the targeted Cape Fear shiner, 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, Cape Fear shiner and V-lip redhorse are shared with the TAC-1 site.

3.2.3 Site 2 (Deep River-Impoundment):

This site is situated within a long riffle/pool/riffle run sequence, with a rocky/cobble island bar forming from the center of the river to the left descending bank, creating a long run 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 providing habitats for lotic and lentic adapted fish species. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-1. Seven shiner species, including two individuals of Cape Fear shiner were located in or close to the run and riffle areas.

Table 8. Site 2: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella niveus	whitefin shiner	Uncommon
Fundulus rathbuni	speckled killifish	Abundant
Gambusia holbrookii	Eastern mosquitofish	Common
Lepomis auritus	redbreast sunfish	Abundant
Lepomis macrochirus	Bluegill	Uncommon
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Abundant
Moxostoma pappillosum	v-lip redhorse	Common
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis amoenus	Comely shiner	Very Abundant
Notropis hudsonius	spottail shiner	Common
Notropis mekistocholas	Cape Fear shiner	Rare (2)
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Common

A total of 15 species were found at this site compared to 14 found during the Year-1 monitoring and 18 found at the target site (TAC-1), showing that this site is close to meeting the targeted fish species diversity. Ten species, Cape Fear shiner, 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.

3.2.4 Site 3 (Deep River-Impoundment):

This site was selected prior to dam removal due to the presence of large rock outcroppings in an area of constricted channel. 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. A cobble/gravel bar is starting to form at the upstream extent of this formation. 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 thoroughly 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	Relative Abundance
Cyprinella niveus	whitefin shiner	Common
Etheostoma olmstedi	tessellated darter	Rare
Fundulus rathbuni	speckled killifish	Uncommon
Lepiostteus osseus	longnose gar	Uncommon
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Common
Moxostoma pappillosum	v-lip redhorse	Uncommon

A total of eight species were found at this site compared to seven found during the Year-1 monitoring and 11 found at the target site (TAC-2). Bluegill, largemouth bass, bluehead chub, tessellated darter, whitefin shiner, and V-lip redhorse are shared with the TAC-2 site.

3.2.5 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. A large bar of this material is present at the site with flow in a run along the left descending side of the river. Eight species of shiner were collected at the site including two individuals of the Cape Fear shiner. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-1.

Table 10. Site 4: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella analostana	satinfin shiner	Abundant
Etheostoma olmstedi	tessellated darter	Common
Fundulus rathbuni	speckled killifish	Abundant
Lepomis auritus	redbreast sunfish	Rare
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Common
Moxostoma pappillosum	v-lip redhorse	Uncommon
Nocomis leptocephalus	bluehead chub	Very Abundant
Notropis altipinnis	highfin shiner	Uncommon
Notropis amoenus	comely shiner	Very Abundant
Notropis hudsonius	spottail shiner	Very Abundant
Notropis mekistocholas	Cape Fear shiner	Rare (2)
Notropis procne	swallowtail shiner	Abundant
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Uncommon

A total of 15 species were found at this site compared to 13 found during the Year-1 monitoring and 18 found at the target site (TAC-1), showing that this site is close to meeting the targeted fish species diversity. Ten species, largemouth bass, bluehead chub,

highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, Cape Fear shiner, tessellated darter and V-lip redhorse are shared by these two sites.

3.2.6 Site 5 (Deep River-Impoundment):

This site 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 site is essentially contiguous with Site 4. This station is situated adjacent to a boulder/gravel/sand bar. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-2.

Table 11. Site 5: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella niveus	whitefin shiner	Common
Etheostoma olmstedi	tessellated darter	Rare
Fundulus rathbuni	speckled killifish	Common
Gambusia holbrookii	eastern mosquitofish	Common
Lepiostteus osseus	longnose gar	Rare
Lepomis auritus	redbreast sunfish	Uncommon
Micropterus salmoides	largemouth bass	Rare
Nocomis leptocephalus	bluehead chub	Common
Notropis scepticus	sandbar shiner	Abundant

A total of eight species were found at this site compared to seven found during the Year-1 monitoring and 11 found at the target site (TAC-2), showing that this site is close to meeting the targeted fish species diversity. Bluegill, largemouth bass, bluehead chub, tessellated darter, whitefin shiner, and V-lip redhorse are shared with the TAC-2 site.

3.2.7 Site 6 (Deep River-Impoundment):

This sampling station occurs in a small riffle/ run sequence just below the SR 1621 (Carbonton Road) bridge. Large accumulations of woody debris have been trapped at the bridge creating a bar and riffle/run in an otherwise homogenous 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, but may be less diverse due to less amount of riffle habitat.

Table 12. Site 6: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella niveus	whitefin shiner	Uncommon
Etheostoma olmstedi	tessellated darter	Uncommon
Fundulus rathbuni	speckled killifish	Common
Gambusia holbrookii	eastern mosquitofish	Common
Lepomis auritus	redbreast sunfish	Common
Lepomis macrochirus	bluegill	Common
Micropterus salmoides	largemouth bass	Common

Scientific Name	Common Name	Relative Abundance
Nocomis leptocephalus	bluehead chub	Common
Notropis amoenus	comely shiner	Uncommon
Notropis scepticus	sandbar shiner	Common
Percina crassa	Piedmont darter	Uncommon

A total of 11 species were found at this site compared to five found during the Year-1 monitoring and 11 found at the target site (TAC-2), showing that this site has met its targeted fish species diversity. Bluegill, largemouth bass, bluehead chub, tessellated darter, whitefin shiner, sandbar shiner, and Piedmont darter are shared with the TAC-2 site.

3.2.8 Site 7 (Deep River-Impoundment):

This site is characterized by a large gravel/sand bar island in the center of the channel that has created a shallow riffle along the right descending bank and a riffle/ run of moderate depth along the left descending bank and there are several small depressions near the island. The island is being colonized by herbaceous and woody vegetation. 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. Seven shiner species, including 17 Cape Fear shiner (most found at any of the monitoring sites), were captured. Juvenile mussels were also observed during cursory evaluation of habitat. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-1.

Table 13. Site 7: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella niveus	whitefin shiner	Rare
Etheostoma olmstedi	tessellated darter	Common
Etheostoma flabellare	fantail darter	Common
Fundulus rathbuni	speckled killifish	Abundant
Gambusia holbrookii	eastern mosquitofish	Abundant
Ictalurus punctatus	channel catfish	Rare
Lepomis auritus	redbreast sunfish	Common
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Uncommon
Moxostoma pappillosum	V-lip redhorse	Rare
Moxostoma macrolepidotum	shorthead redhorse	Rare
Nocomis leptocephalus	bluehead chub	Very Abundant
Notropis amoenus	comely shiner	Uncommon
Notropis hudsonius	spottail shiner	Abundant
Notropis mekistocholas	Cape Fear shiner	Abundant (17)
Notropis procne	swallowtail shiner	Common
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Uncommon

A total of 18 species were found at this site compared to 15 found during the Year-1 monitoring and 18 found at the target site (TAC-1), showing that this site has essentially met its targeted fish species diversity. Eleven species, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, Cape Fear shiner, tessellated darter, fantail darter, eastern mosquitofish, v-lip redhorse, and bluehead chub are shared with the TAC-1 site. Additionally, the lotic-adapted whitefin shiner, comely shiner, and shorthead redhorse, all previously undocumented at the site were found. Species richness is expected to continue to increase at this location over time as the habitat continues to develop.

3.2.9 Site 8 (Deep River-Impoundment):

This site occurs at the mouth of Big Governors Creek and is dominated by a shallow sand/gravel riffle in a 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	Relative Abundance
Cyprinella analostana	satinfin shiner	Common
Cyprinella niveus	whitefin shiner	Uncommon
Etheostoma olmstedi	tessellated darter	Common
Fundulus rathbuni	speckled killifish	Uncommon
Gambusia holbrookii	eastern mosquitofish	Abundant
Ictalurus punctatus	channel catfish	Rare
Lepomis auritus	redbreast sunfish	Common
Lepomis cyanellus	green sunfish	Rare
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Common
Moxostoma pappillosum	v-lip redhorse	Uncommon
Nocomis leptocephalus	bluehead chub	Very Abundant
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Very Abundant
Notropis petersoni	coastal shiner	Rare
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Common

A total of 18 species were found at this site compared to nine found during the Year-1 monitoring and 18 found at the target site (TAC-1), showing that this site has essentially met its targeted fish species diversity, with the exception of the presence of Cape Fear shiner. Eleven species, highfin shiner, Piedmont darter, sandbar shiner, spottail shiner, swallowtail shiner, tessellated darter, green sunfish, largemouth bass, eastern mosquitofish, v-lip redhorse, and bluehead chub are shared with the TAC-1 site. Additionally, the lotic-adapted coastal shiner was found. While Cape Fear shiner was not captured at this site during the Year-2 efforts, the habitat is very similar to other areas where it was located and it is likely that the species will become established here.

3.2.10 Site 9 (Deep River-Impoundment):

This site was selected due to the presence of large boulder and bedrock rock outcroppings just upstream. Since dam removal much more of the rock outcropping is exposed and as of Year-2, gravel/sand bars have begun to form adjacent to river banks. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-2. Six shiner species, including one individual of the Cape Fear shiner, were found during the Year-2 efforts at this site.

Table 15. Site 9: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella analostana	satinfin shiner	Common
Cyprinella niveus	whitefin shiner	Uncommon
Lepiostteus osseus	longnose gar	Uncommon
Lepomis auritus	redbreast sunfish	Common
Luxilus albeolus	white shiner	Very Abundant
Micropterus salmoides	largemouth bass	Common
Notropis hudsonius	spottail shiner	Abundant
Notropis mekistocholas	Cape Fear shiner	Rare (1)
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Rare

A total of 11 species were found at this site compared to five found during the Year-1 monitoring and 11 found at the target site (TAC-2), showing that this site has met the targeted fish species diversity. Eight species, bluegill, largemouth bass, tessellated darter, whitefin shiner, sandbar shiner, swallowtail shiner, spottail shiner, and Piedmont darter are shared with the TAC-2 site.

3.2.11 Site 10 (Deep River-Impoundment):

This site 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, largemouth bass, and sunfish species were observed. The TAC-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. Although the relatively unchanged conditions from the Year-1 monitoring may further suggest the anticipated change at this site may not occur, significant habitat changes were not evident at Site 9 until this year. It is thus possible that the river may still be adjusting in this area and riffle habitats may develop in the future.

Table 16. Site 10: Fish Species Observed

Scientific Name	Common Name	Abundance
Lepiostteus osseus	longnose gar	~
Lepomis sp	sunfishes	~
Micropterus salmoides	largemouth bass	~

3.2.12 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 area with a bar developing along the right descending side of the river. Species diversity is fairly low, likely a reflection of habitat homogeneity; however, shiners, particularly sandbar, white, and comely shiners, are abundant. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-2.

Table 17. Site 11: Fish Species Observed

Scientific Name	Common Name	Relative Abundance
Etheostoma flabellare	fantail darter	Uncommon
Etheostoma olmstedi	tessellated darter	Rare
Luxilus albeolus	white shiner	Very Abundant
Nocomis leptocephalus	bluehead chub	Common
Notropis amoenus	comely shiner	Very Abundant
Notropis hudsonius	spottail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant

A total of seven species were found at this site compared to eight found during the Year-1 monitoring and 11 found at the target site (TAC-2). Four species, tessellated darter, sandbar shiner, spottail shiner, and bluehead chub are shared with the TAC-2 site.

3.2.13 Site 12 (Deep River-Impoundment):

This site occurs in a long straight reach of the Deep River and is characterized by a gravel/cobble riffle/run transitioning into a boulder fall. Six shiner species, including one individual of the Cape Fear shiner, were located. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-2.

Table 18. Site 12: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella niveus	whitefin shiner	Rare
Etheostoma flabellare	fantail darter	Abundant
Etheostoma olmstedi	tessellated darter	Abundant
Fundulus rathbuni	Speckled killifish	Rare
Gambusia holbrookii	eastern mosquitofish	Common
Luxilus albeolus	white shiner	Abundant
Micropterus salmoides	largemouth bass	Uncommon
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis amoenus	comely shiner	Abundant
Notropis hudsonius	spottail shiner	Uncommon
Notropis mekistocholas	Cape Fear shiner	Rare (1)
Notropis scepticus	sandbar shiner	Very Abundant

Scientific Name	Common Name	Relative Abundance
Percina crassa	Piedmont darter	Uncommon

A total of 13 species were found at this site compared to six found during the Year-1 monitoring and 11 found at the target site (TAC-2), indicating this site has exceeded the targeted species diversity. Seven species, tessellated darter, Piedmont darter, whitefin shiner, sandbar shiner, spottail shiner, largemouth bass, and bluehead chub are shared with the TAC-2 site.

3.2.14 Site 13 (Deep River-Impoundment):

This site occurs in a shallow riffle/run consisting of shifting sand and gravel beginning just below the location of the former Carbonton dam and extending upstream. The area in the immediate area surrounding the dam site was sampled on August 16, 2007, and the species found during this effort are listed in the table below. The aquatic community anticipated to develop at this site is expected to be similar to the TAC-2.

Table 19. Site 13: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Cyprinella niveus	whitefin shiner	Uncommon
Fundulus rathbuni	Speckled killifish	Uncommon
Gambusia holbrookii	eastern mosquitofish	Common
Lepomis auritus	redbreast sunfish	Uncommon
Luxilus albeolus	white shiner	Abundant
Micropterus salmoides	largemouth bass	Common
Nocomis leptocephalus	bluehead chub	Uncommon
Notropis amoenus	comely shiner	Abundant
Notropis hudsonius	spottail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Uncommon

A total of 11 species were found compared to six found during the Year-1 monitoring and 11 found at the target site (TAC-2). Six species, Piedmont darter, whitefin shiner, sandbar shiner, spottail shiner, largemouth bass, and bluehead chub are shared with the TAC-2 site. The Cape Fear shiner, which was found just below the former dam during the pre-removal surveys, was not located during this survey effort.

This site was revisited on September 13, 2007, in another attempt to determine if Cape Fear shiner still inhabited the reach immediately below the former dam site. The area immediately surrounding the old dam site and downstream bars were sampled. Most of the effort was concentrated in the same area previously sampled, although some seine sweeps were also conducted along gravel bars approximately 300 meters downstream of the survey site. The table below details these efforts, during which three individuals of the Cape Fear shiner were located.

Table 20. Site 13: Fish Species Collected September 13, 2007

Scientific Name	Common Name	Relative Abundance
Cyprinella analostana	whitefin shiner	Common

Scientific Name	Common Name	Relative Abundance
Etheostoma olmstedi	tessellated darter	Uncommon
Fundulus rathbuni	Speckled killifish	Uncommon
Gambusia holbrookii	eastern mosquitofish	Common
Ictalurus punctatus	channel catfish	Common
Lepomis auritus	redbreast sunfish	Common
Luxilus albeolus	white shiner	Abundant
Micropterus salmoides	Largemouth bass	Common
Notropis altipinnis	highfin shiner	Rare
Notropis hudsonius	spottail shiner	Uncommon
Notropis mekistocholas	Cape Fear shiner	Rare (3)
Notropis procne	swallowtail shiner	Uncommon
Notropis scepticus	sandbar shiner	Very Abundant
Percina crassa	Piedmont darter	Uncommon

A total of 14 species were found at the old dam area on September 13, 2007, compared to six found during the Year-1 monitoring and eleven found at the target site (TAC-2). Nine species, tessellated darter, Piedmont darter, whitefin shiner, sandbar shiner, spottail shiner, highfin shiner, swallowtail shiner, largemouth bass, and eastern mosquitofish are shared with the TAC-2 site.

3.2.15 Site 14 (McLendons Creek-Impoundment):

It appears that natural riffle/run/pool sequences with pea gravel over clay substrate continue to form at this site. 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 and mud/silt areas persist in deeper pools. Electro-shocking was conducted for 1887 seconds of shock time. The aquatic community anticipated to develop should be similar to the TAC-3 (Table 3), which occurs in the upstream reaches of McClendons Creek.

Table 21. Site 14: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Ameiurus brunneus	snail bullhead	Uncommon
Ameiurus natalis	yellow bullhead	Rare
Ameiurus platycephalus	flat bullhead	Rare
Anguilla rostrata	American eel	Rare
Aphredoderus sayanus	pirate perch	Rare
Erimyzon oblongus	creek chubsucker	Abundant
Esox americanus	redfin pickerel	Rare
Etheostoma olmstedi	tessellated darter	Common
Fundulus rathbuni	speckled killifish	Uncommon
Gambusia holbrookii	eastern mosquitofish	Abundant
Ictalurus punctatus	channel catfish	Rare
Lepomis auritus	redbreast sunfish	Abundant
Lepomis cyanellus	green sunfish	Rare
Lepomis gulosus	warmouth	Uncommon
Lepomis macrochirus	bluegill	Abundant
Lepisosteus osseus	longnose gar	Rare
Luxilus albeolus	white shiner	Very Abundant

Scientific Name	Common Name	Relative Abundance
Minytrema melanops	spotted sucker	Rare
Moxostoma pappillosum	v-lip redhorse	Uncommon
Nocomis leptocephalus	bluehead chub	Abundant
Notropis altipinnis	highfin shiner	Abundant
Notropis petersoni	coastal shiner	Common
Notropis scepticus	sandbar shiner	Abundant
Percina crassa	Piedmont darter	Rare
Semotilus lumbee	Sandhills chub	Uncommon

A total of 25 species were found at this site compared to the seven collected during Year-1 and the nine found at the target site (TAC-3). Some of this discrepancy can be attributed to the use of electro-shocking methods during the Year-2 efforts, which allowed for a much more complete sampling of the species present versus only seining efforts used during the year one monitoring. However, many of the shiner species were easily captured with seine netting. Bluegill, white shiner, bluehead chub and Piedmont darter are shared with the TAC-3 site.

3.2.16 Site 15 (Big Governors Creek-Impoundment):

This site appears to be in the process of developing limited riffle/run/pool habitats. Below the boulder fall, downstream from the Underwood Road crossing, there is a deeper, mud/silt substrate pool, however further downstream, sand and pebble riffle areas are developing. Woody debris and fine sediments are still common through the reach but are anticipated to continue to washout over time. The aquatic community anticipated to develop is expected to be similar to the TAC-4 (Table 4), which occurs in the upstream reaches of Big Governors Creek. Electro-shocking was conducted through the site for 523 seconds of shock time.

Table 22. Site 15: Fish Species Collected

Scientific Name	Common Name	Relative Abundance
Aphredoderus sayanus	pirate perch	Rare
Erimyzon oblongus	creek chubsucker	Uncommon
Esox americanus	redfin pickerel	Rare
Etheostoma olmstedi	tessellated darter	Uncommon
Gambusia holbrookii	eastern mosquitofish	Abundant
Hybognathus regius	eastern silvery minnow	Abundant
Lepomis auritus	redbreast sunfish	Uncommon
Lepomis cyanellus	green sunfish	Common
Lepomis macrochirus	Bluegill	Uncommon
Micropterus salmoides	largemouth bass	Common
Moxostoma sp.	redhorse sp.	Rare
Notemigonus crysoleucas	golden shiner	Abundant
Nocomis leptocephalus	bluehead chub	Abundant
Notropis altipinnis	highfin shiner	Rare
Semotilus lumbee	Sandhills chub	Uncommon

A total of 15 species were found compared to six found during the Year-1 monitoring and six found at the target site (TAC-4). Again, some of this discrepancy can be attributed to the use of electro-shocking methods during the Year-2 monitoring, which allowed for a much more thorough sampling of the species present versus only seining efforts used during Year-1 monitoring. However, many of the shiner species found at this site were easily captured with seine netting. Five species, tessellated darter, bluegill, largemouth bass, redfin pickerel, and bluehead chub are shared with the TAC-4 site.

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 12 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*). It is anticipated that mussel recruitment will occur and should be evident and established three to four years post removal. The results of the fish surveys demonstrate that riffle-adapted species have colonized the newly restored riffle habitats and that the target Cape Fear shiner has colonized the former impoundment in the Deep River at more that half of the monitored sites. 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, as these pools are likely natural river features.

4.2 Fish Surveys

As discussed above (Section 2.2.1), electro-fishing was not used during the Deep River portion of the study in recognition of the "Collection Sensitive Waters" designation of the Deep River by the WRC, though it is a more effective sampling technique, as is evident in the Year-1 to Year-2 differences in number of species collected at McClendons and Big Governors Creeks where species richness doubled. Future monitoring of these two sites will continue to incorporate electro-fishing methods and the TAC will be adjusted to reflect this change in methodologies. Seine netting methods will continue to be employed in the Deep River, as the data is adequate for establishing fish fauna targeting the Cape Fear shiner, the main target species for this study.

The results of the habitat reconnaissance and Year-2 monitoring fish surveys demonstrate further re-establishment of lotic conditions and many lotic-adapted species, including the target Cape Fear shiner, within the former reservoir pool. As riffle habitats and habitat complexity continue to develop, it is anticipated that Cape Fear shiner will continue to colonize these areas in greater numbers.

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. However, severe drought conditions during the Year-2 monitoring efforts likely hindered the potential colonization of Cape Fear shiner in these sites.

4.3 Future Fish Survey Monitoring

The results of the Year-2 monitoring fish survey demonstrate that the fish community component of the success criteria that were developed for this project (establishment of lotic fish communities, including the Cape Fear shiner) has been met. Lotic habitat conditions and numerous riffle-adapted species were found in high densities at various localities throughout the former reservoir pool of the Deep River. Compared to the Year-1 monitoring surveys, species diversity and abundances were higher at all sites but Site 11. Additionally, the targeted Cape Fear shiner was located at eight of the 13 sites sampled in the Deep River, where it was not found at any site during the Year-1 monitoring.

While lotic habitat conditions and riffle-adapted species are becoming established in McClendons Creek, the success criteria for improved aquatic habitat and colonization by the Cape Fear shiner have not been fully met at this point, but should be achieved in the future. Future monitoring efforts in this stream should take place during spring flows when shiner species are moving to new territory. This will allow for the best potential to capture Cape Fear shiner in this stream.

As discussed above, significant riffle habitats are unlikely to develop in Big Governors Creek, and colonization by the Cape Fear shiner is questionable. 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. As with McClendons Creek, any future monitoring of Big Governors Creek should take place during spring flows. This recommendation is under consideration.

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

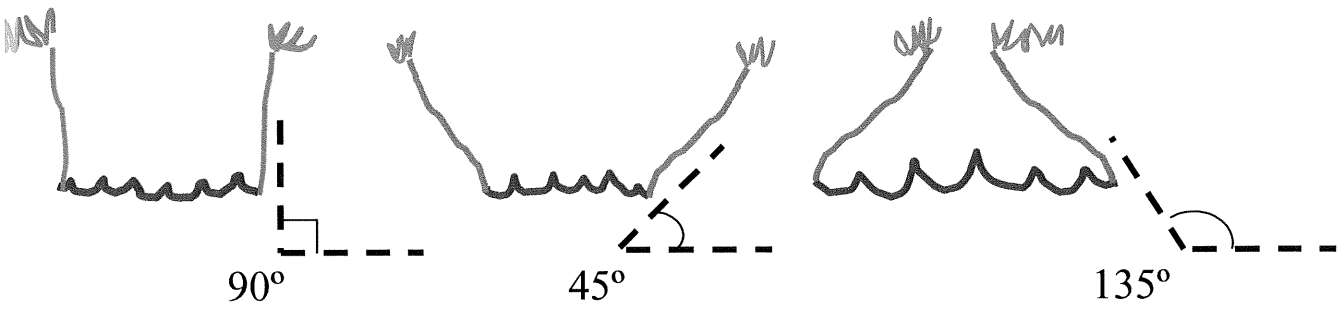
Remarks_____ Total_____

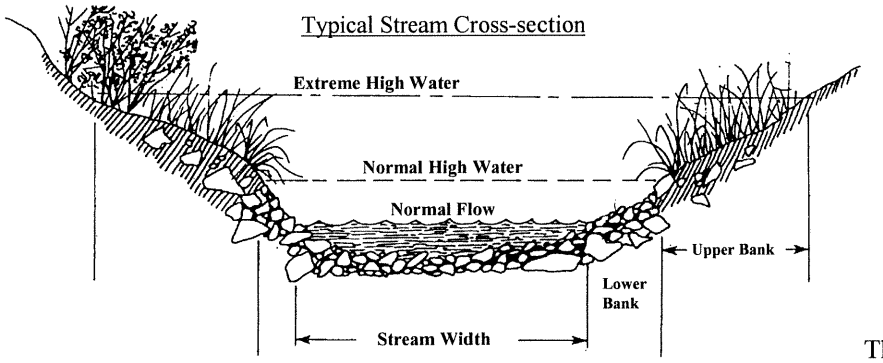
Page Total_____

☐ 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: MONITORING PICTURES AND VIDEOS (DATA DVD)

APPENDIX F: 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:	Michael Gloden	
DATE:	January 10, 2007	
RE:	Erosion Evaluation No. 3 (11-27-2006)	**06-277.03**

The purpose of this memorandum it to provide you with the results of the most recent erosion evaluation 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 headcuts, 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 greater than or equal to one-inch rain events 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

Following a rainfall event ranging from 1-3 inches in the upstream watershed (Figure 3), a peak in river stage of over 2270 cubic feet per second (cfs) was recorded at the USGS Ramseur river gage on November 16, 2006 (Figure 1). While the Deep River stage was still elevated, a second rainfall event resulting in a peak rainfall of 4 inches occurred within the upper Deep River watershed on November 20, 2006 (Figure 3A). Included in the storm's 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 November 22, 2006 of 7050 cubic feet per second (cfs) **(**Figure 1). The "initiation threshold" from this storm occurred on November 21 and the "evaluation threshold" on November 24. An erosion evaluation was conducted within the formerly impounded reaches of the Deep River on November 27, 2006. The activities on November 27 included observation points along the main stem of the Deep River and at accessible points along tributaries that comprised the former site impoundment. Additional activities on November 29 included a survey assessment of the substrate bar located between NC 42 and the former dam location within the Deep River. 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 Carbonton Dam Park (Figure 2). The team stopped at the mouth of all credited tributaries as described in the Mitigation Plan as well as at points along the river where notable conditions occurred. At each observation point, GPS data was collected for the location, photographs were taken, and notes were recorded to describe the conditions. Observation points previously evaluated during the last erosion evaluation (June 26, 2006) that showed no signs of change are not documented by this current evaluation. Additionally, observation points occurring at confluences to the Deep River that appeared stable are not described in this report. The numeric labels assigned to each observation point are unique to only this evaluation. Observation points from the previous erosion evaluation (June 26, 2006) that were revisited during this evaluation have been noted in the text.

River Observation Point 1

River Observation Point 1 (previously evaluated on June 26, 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 here. Trees undercut by the erosion have also fallen from the bank. 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 1-2).

River Observation Point 2

River Observation Point 2 is located on the Deep River approximately 1.0 mile downstream of the Norfolk-Southern rail bridge (Figure 2). At this location the left bank of the Deep River is experiencing significant loss of bank material due to a general lack of vegetation. A narrow buffer between the river and adjacent agriculture, combined with inadequate herbaceous vegetation, has allowed for erosion to occur along this 150-200 foot stretch of bank (Photo 3-4).

River Observation Point 3

River Observation Point 3 (previously evaluated on June 26, 2006) is located on the Deep River at the confluence with the upstream end of an oxbow near McClendon's Creek (Figure 2). At this location vegetation was observed to have been scoured due to an increase in storm surge. Most of the vegetation appeared to be intact, however stream banks did show signs of erosion (Photo 5). During the storm event this area was inundated as noted by sediment deposition on vegetation surrounding the oxbow channel. A moderate layer of fine sediment was observed on streamside vegetation signifying some erosion/sedimentation in the upstream watershed.

River Observation Point 4

River Observation Point 4 is located on the Deep River at the bridge crossing of Carbonton Road (Figure 2). At this location a massive logjam has formed on the upstream side of the bridge with

woody debris spanning the entire width of the channel (Photo 6-7). Just below the bridge, the right bank of the Deep River has experienced erosion possibly as a result of the redirection of water from the logjam. The resulting erosion has left an approximately 50-foot reach of the right bank nearly vertical (Photo 8).

River Observation Point 5

River Observation Point 5 is located on the right bank of the Deep River at the confluence with an unnamed tributary (Figure 2). At this location the rise in water level has eroded bank material, and widened the tributary channel width. A small headcut has also formed from the increased flow velocity. An accumulation of woody debris has collected at the confluence (Photo 9).

River Observation Point 6

River Observation Point 6 (previously evaluated on June 26, 2006) is located on the Deep River at the confluence with Big Governor's Creek (Figure 2). A few areas at waters edge showed continued scouring but the majority of the bank material appeared stable and intact despite lacking vegetative cover. A large accumulation of woody debris remains at the confluence (Photo 10).

River Observation Point 7

River Observation Point 7 (previously evaluated on June 26, 2006) is located on the Deep River at the confluence with an unnamed tributary on the Knight Cattle Corporation property (Figure 2). A headcut has continued to migrate up the tributary and bank material continues to erode. Herbaceous vegetation is lacking and banks are steep and incised as a result of storm flow scour. Multiple large trees have fallen across the tributary as a result of undercut banks (Photo 11-13). A thin layer of fine sediment was observed on streamside vegetation, signifying some erosion/sedimentation in the upstream watershed.

River Observation Point 8

River Observation Point 8 (previously evaluated on June 26, 2006) is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 27. A headcut continues to transport sediment from the tributary and has eroded further upstream (Photo 14). At the mouth of the confluence the banks are steep and incised. A scoured pit remains where a tree was uprooted during the last storm on June 26 (Photo15).

River Observation Point 9

River Observation Point 9 (previously evaluated on June 26, 2006) is located on the Deep River at the confluence with an unnamed tributary (Figure 2). A large headcut at the confluence continues to migrate upstream, and bank material continues to slough off. Limited vegetation on the banks of the confluence has allowed for continued erosion of bank material (Photo 16).

River Observation Point 10

River Observation Point 10 (previously evaluated on June 26, 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 are very steep, and the previously observed headcut appears slightly further up the channel (Photo 17). A scour pool has formed at the base of the headcut from higher stormflow velocity (Photo 18). The majoritiy of woody debris inside the tributary has washed into the Deep River.

River Observation Point 11

River Observation Point 11 (previously evaluated on June 26, 2006) is located on the Deep River at the confluence with an unnamed tributary (Figure 2) near Monitoring Station 23. A large headcut

has continued moving sediment out of the tributary and banks remain steep and unvegetated. Only minor signs of bank erosion near the waters edge were observed (Photo 19).

River Observation Point 12

River Observation Point 12 (previously evaluated on June 26, 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. The Norfolk-Southern railroad crosses Line Creek at this location and the banks have eroded further back towards the bridge. Woody debris remains scattered throughout the channel (Photo 20-21).

River Observation Point 13

River Observation Point 13 is located on the Deep River at the bridge crossing of NC 42, just upstream of the former Carbonton dam (Figure 2). At this location another massive logjam has formed on the upstream side of the bridge with woody debris spanning the entire width of the channel (Photo 22). The greatest accumulation of debris occurs between the center spans. Just below the bridge, signs of flooding and increased flow were apparent by woody debris deposited above bankfull (Photo 23). Scouring was observed near top of bank, but exposed bedrock maintained bank stability (Photo 24).

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 Points 1-4 were assessed for erosion during the previous evaluation on June 26, 2006.

Land Observation Point 1

Land Observation Point 1 was taken at the bridge crossing of Carbonton Road over Line Creek, a credited tributary to the Deep River (Figure 2). Signs of flooding and 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 25-26). The banks of Line Creek appear generally stable and well-vegetated, resulting in little to no erosive action (Photo 27). Possible backwater from river flooding resulted in a water table height increase that slowly returned to baseflow elevation without significant flow velocity.

Land Observation Point 2

Land Observation Point 2 was taken at Monitoring Station 45 near the crossing of Cool Springs Road over McClendon's Creek (Figure 2). This section of McClendon's Creek is a non-credited section but was visited so that the stream condition that was observed previously during monitoring station sampling could be compared with current conditions. Stormflow appears to have been 1 to 2 feet above bankfull, though there were no signs of significant bank failure observed. No erosion was noted during time of field visit, however, exposed banks contained moss and appeared stable (Photo 28). 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.

Land Observation Point 3

Land Observation Point 3 was taken at Monitoring Station 47 near the bridge crossing of Glendon-Carthage Road over 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 4 to 8 feet 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 29). 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 bridge crossing of Steel Bridge Road over Little Governor's Creek, a credited tributary to the Deep River (Figure 2). This section of Little Governor's Creek received significant stormflow with overbank flooding apparent in multiple locations. Many stretches of streambank along this reach of Little Governor's Creek are vegetated, but in several areas, portions of the banks have sloughed off (Photo 30). Just downstream from the Steel Bridge Road bridge, a large riffle complex contained severe erosion along the left streambank, where water becomes restricted by the floodplain width at the bridge (Photo 31-32).

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 8 feet to 10 feet above bankfull; however, there were no signs of significant bank failure observed (Photo 33). A thin layer of fine sediment was observed on streamside vegetation signifying some erosion/sedimentation in the upstream watershed (Photo 34). For additional details, see River Observation Point 7 of this document.

Summary

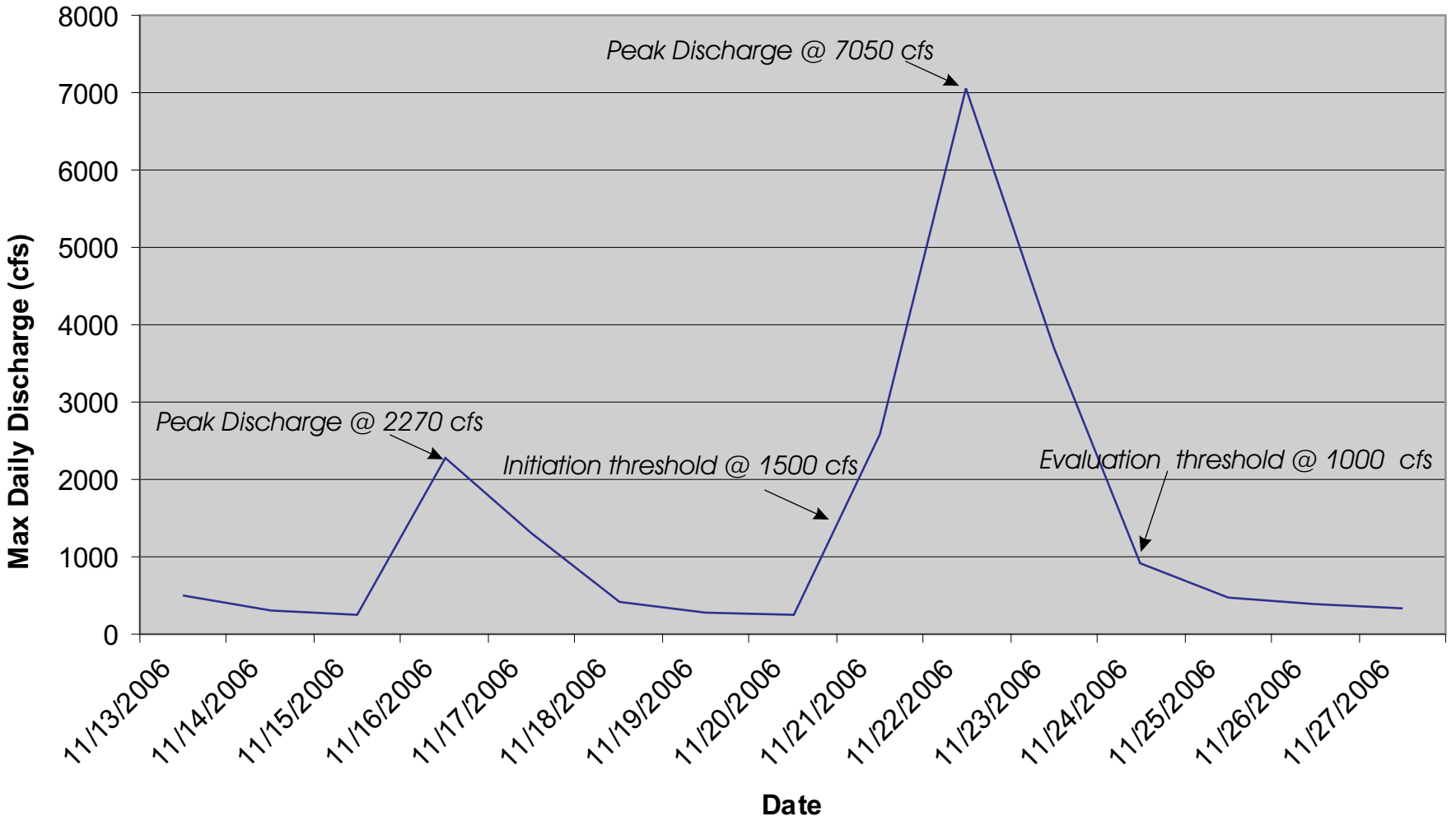
The rain event which triggered this erosion evaluation caused the USGS gauge at Ramseur to register a peak discharge on November 22, 2006 of 7050 cubic feet per second (cfs). Despite the high rainfall totals and peak discharge associated with this storm, the Deep River and its tributaries were observed to experience similar levels of sediment erosion as those observed during previous evaluations. Headcuts observed during the first evaluation continue to transport sediment from the tributaries into the Deep River. Scouring and erosion of tributary banks was problematic in areas where herbaceous vegetation has never established, or has seasonally diminished. Banks of the Deep River are generally stable, with a few areas of undercutting observed. Woody debris was still evident throughout the former impoundment, and bridge spans at Carbonton Road and NC 42 accumulated much of the woody debris that was washed into the Deep River.

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 November 29, 2006. Three 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 at the site of the former Carbonton Dam. Figure 4A compares the cross-sectional survey from November 29, 2006 to the dimensions

from previous cross-sections (05/02/06 and 06/27/06). No significant change in the substrate island was observed from the monitoring cross-sections. Cross-sections 1, 2 and 3 show only minor signs of sediment transport from within the channel and limited signs of change at the river banks. Cross-section 4 shows a minor fluctuation in channel form as bed material moves from the site of the former dam. Overall, the cross-section surveys show that increased flow conditions following dam removal have had only minor impact on the substrate island and surrounding banks.

DEEP RIVER EROSION EVALUATION FIGURES

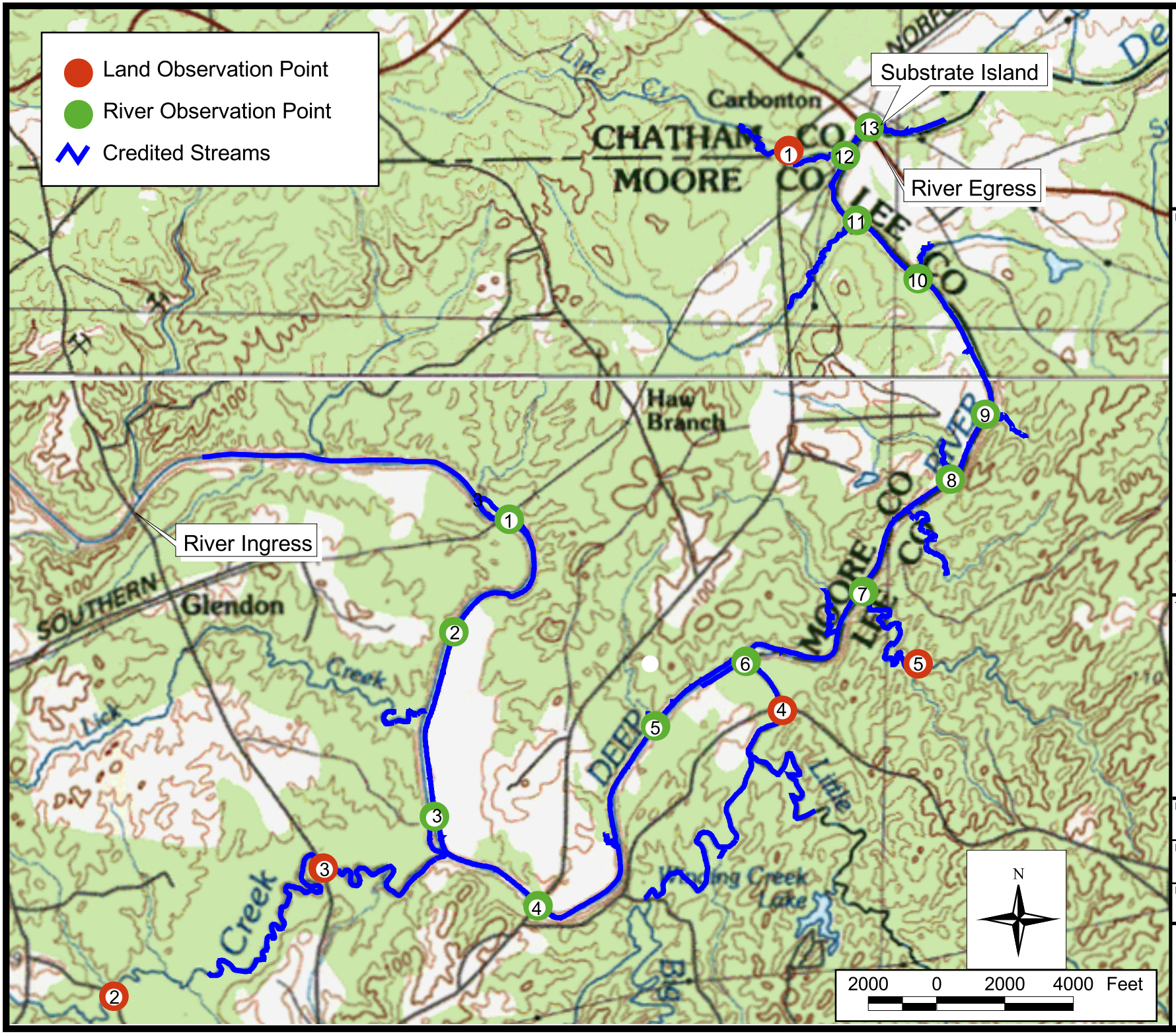


EcoScience Corporation
Raleigh, North Carolina

EVENT DISCHARGE AT GAUGE NEAR RAMSEUR, NC
CARBONTON DAM RESTORATION SITE
Erosion Evaluation (11-27-2006)

Dwn. by:	MCG
Ckd by:	MCG
Date:	DEC 2006
Project:	06-277.03

FIGURE
1



EcoScience Corporation
Raleigh, North Carolina

Project:

Deep River-Carbonton Dam Restoration Site

Chatham, Lee and Moore Counties, North Carolina

Title:

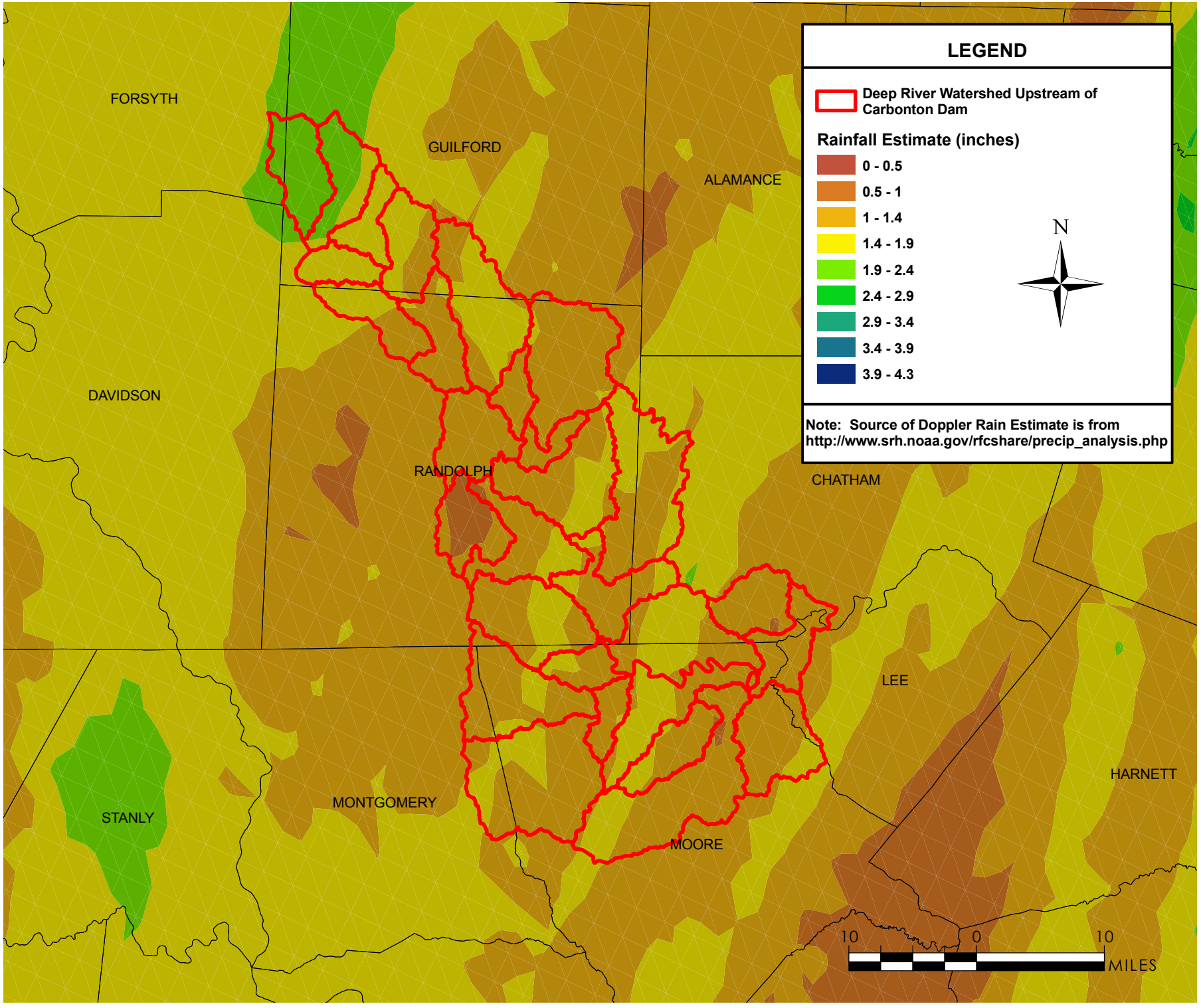
Erosion Evaluation Observation Points 11-27-2006

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

ESC Project No.: 06-277.03

FIGURE

2



EcoScience Corporation
Raleigh, North Carolina

CLIENT:

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

PROJECT:

CARBONTON DAM EROSION EVALUATION

Chatham, Lee and Moore Counties, North Carolina

TITLE:

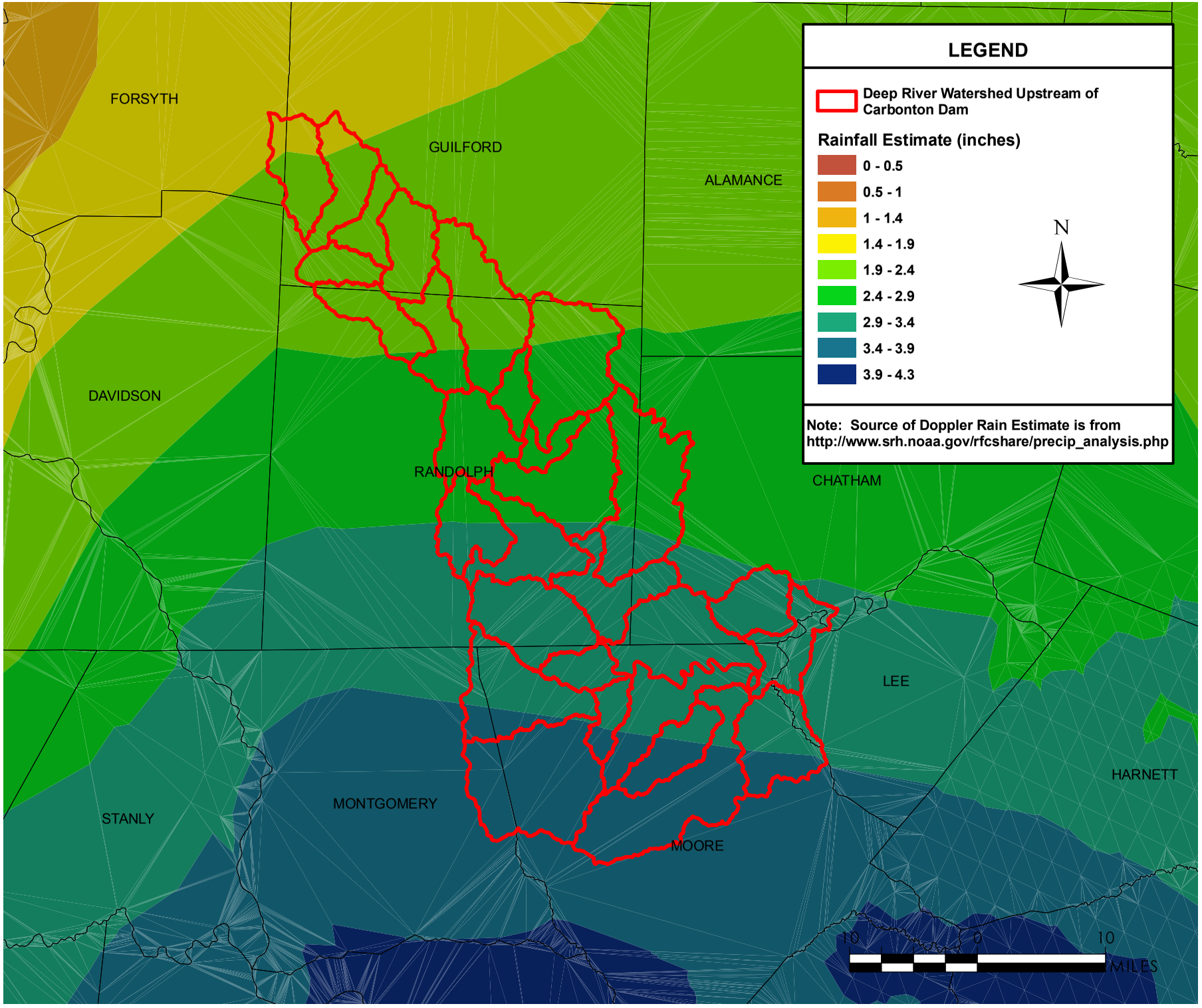
Total Rainfall Estimate for 11-16-06 Rain Event

Dwn By:	Ckd By:
MG	MC
Date:	Scale:
JAN 2007	AS SHOWN

ESC Project No. 06-277

FIGURE

3



EcoScience Corporation
Raleigh, North Carolina

CLIENT:

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

PROJECT:

CARBONTON DAM EROSION EVALUATION

Chatham, Lee and Moore Counties, North Carolina

TITLE:

Total Rainfall Estimate for 11-20-06 Rain Event

Dwn By:	Ckd By:
MG	MC
Date:	Scale:
JAN 2007	AS SHOWN

ESC Project No. 06-277

FIGURE

3A

DEEP RIVER EROSION EVALUATION PHOTOS

Photo 1. River Observation Point 1

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

6/26/2006:
Erosion
Evaluation 2

Photo 2. River Observation Point 1

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

Photo 3. River Observation Point 2

Location: Deep River
Description: Bank failure and erosion into the Deep River

Photo 4. River Observation Point 2

Location: Deep River
Description: Bank failure and erosion into the Deep River

6/26/2006:
Erosion
Evaluation 2

Photo 5. River Observation Point 3

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

Description: Overland flow and sediment transport resulting from storm surge

Photo 6. River Observation Point 4

Location: Carbonton Road crossing of the Deep River
Description: Log jam behind bridge spans

Photo 7. River Observation Point 4

Location: Carbonton Road crossing of the Deep River
Description: Log jam behind bridge spans

Photo 8. River Observation Point 4

Location: Carbonton Road bridge crossing of the Deep River
Description: Sloughing of bank material downstream of the bridge

Photo 9. River Observation Point 5

Location: Confluence of the Deep River and an unnamed tributary

Description: Stream headcut and erosion of bank material

6/26/2006:
Erosion
Evaluation 2

Photo 10. River Observation Point 6

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

6/26/2006:
Erosion
Evaluation 2

Photo 11. River Observation Point 7

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

Photo 12. River Observation Point 7

Location: Confluence of the Deep River and an unnamed tributary
Description: Multiple trees fallen over as a result of undercut banks

Photo 13. River Observation Point 7

Location: Confluence of the Deep River and an unnamed tributary
Description: Multiple trees fallen over as a result of undercut banks

6/26/2006:
Erosion
Evaluation 2

Photo 14. River Observation Point 8

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

Photo 15. River Observation Point 8

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 27
Description: Erosion of bank material from stormflow

6/26/2006:
Erosion
Evaluation 2

Photo 16. River Observation Point 9

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

6/26/2006:
Erosion
Evaluation 2

Photo 17. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 2
Description: Continued headcutting and sluffing of bank material

Photo 18. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 2
Description: Continued headcutting and erosion of bank material

6/26/2006:
Erosion
Evaluation 2

Photo 19. River Observation Point 11

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

6/26/2006:
Erosion
Evaluation 2

Photo 20. River Observation Point 12

Location: Confluence of the Deep River and Line Creek
Description: Continued erosion of bank material and woody debris (looking from above)

Photo 21. River Observation Point 12

Location: Confluence of the Deep River and Line Creek
Description: Continued scouring of bank material (looking from above)

Photo 22. River Observation Point 13

Location: NC 42 bridge crossing of the Deep River

Description: Log jam behind bridge spans

Photo 23. River Observation Point 13

Location: Deep River above the site of the former Carbonton Dam

Description: Woody debris deposition

Photo 24. River Observation Point 14

Location: Deep River above the site of the former Carbonton Dam

Description: Scouring of banks above a bedrock foundation

Photo 25. Land Observation Point 1

Location: Line Creek downstream of the bridge crossing of Carbonton Road

Description: Overbank flooding and sediment deposition

Photo 26. Land Observation Point 1

Location: Line Creek upstream of the bridge crossing of Carbonton Road

Description: Overbank flooding and sediment deposition

Photo 27. Land Observation Point 1

Location: Line Creek upstream of the bridge crossing of Carbonton Road
Description: Stable banks with limited erosion

Photo 28. Land Observation Point 2

Location: McClendon's Creek near Monitoring Station 45
Description: Stable banks with limited erosion

Photo 29. Land Observation Point 3

Location: McClendon's Creek near Monitoring Station 47
Description: Steep, exposed banks

Photo 30. Land Observation Point 4

Location: Little Govenor's Creek upstream of the bridge crossing of Steel Bridge Road
Description: Steep, exposed banks

Photo 31. Land Observation Point 4

Location: Little Govenor's Creek downstream of the bridge crossing of Steel Bridge Road
Description: Steep, eroded banks

Photo 32. Land Observation Point 4

Location: Little Govenor's Creek downstream of the bridge crossing of Steel Bridge Road
Description: Steep, eroded banks

Photo 33. Land Observation Point 5

Location: Unnamed tributary on the Knight Cattle Corporation property
Description: Steep, vegetated banks

Photo 34. Land Observation Point 5

Location: Unnamed tributary on the Knight Cattle Corporation property
Description: Stable banks with signs of overbank flooding and sediment deposition

EcoScience

EcoScience Corporation

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

MEMORANDUM

TO:	George Howard,	
	Restoration Systems, LLC (RS)	
FROM:	Michael Gloden	
DATE:	January 31, 2007	
RE:	Erosion Evaluation No. 4 (12-28-2006)	**06-277.04**

The purpose of this memorandum it to provide you with the results of the most recent erosion evaluation 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 through 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 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 as 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

A rainfall event ranging from 1 to 3 inches occurred in the upstream watershed between December 22 and December 26, 2006 (Figure 1). A peak in river stage of over 3,210 cubic feet per second (cfs) was recorded at the USGS Ramseur river gage on December 25, 2006 as a result of this storm (Figure 2). The "initiation threshold" from this storm occurred on December 25 and the "evaluation threshold" on December 27. An erosion evaluation was conducted within the formerly impounded reaches of the Deep River on December 28, 2006. The activities on December 28 included

observation points along the main stem of the Deep River and at accessible points along tributaries that comprise the former site impoundment. Activities on January 4, 2007 included a survey assessment of the substrate bar located between NC Highway 42 (NC42) and the former dam footprint within the Deep River. 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 Resources Commission boat ramp (Figure 3). The team stopped at the mouth of all credited tributaries as described in the Mitigation Plan as well as at points along the river where notable conditions occurred. At each observation point, GPS data was collected for the location, photography was taken, and notes were recorded to describe the condition. Observation points previously evaluated during the last erosion evaluation (November 27, 2006) that showed no signs of change are not documented by this current evaluation. Additionally, observation points occurring at confluences to the deep river that appeared stable are not described in this report. Observation points are mapped on Figure 3.

River Observation Point 1

River Observation Point 1 is located on the Deep River at the Norfolk-Southern rail bridge. No change was observed relative to the assessment recorded on November 27, 2006 (Photo 1). Bank failure and sloughing continues on both banks directly below the bridge.

River Observation Point 2

River Observation Point 2 is located on the Deep River approximately 1.0 mile downstream of the Norfolk-Southern rail bridge. At this location the left bank of the Deep River is experiencing significant loss of bank material due to a general lack of vegetation. A narrow buffer between the river and adjacent agriculture, combined with poor herbaceous vegetation, has allowed for erosion to occur along this 150-200 foot stretch of bank (Photo 2).

River Observation Point 3

River Observation Point 3 is located on the Deep River at the confluence with the upstream end of an oxbow near McClendon's Creek. Most of the vegetation appeared to be intact, and stream banks show no new signs of erosion (Photo 3).

River Observation Point 4

River Observation Point 4 is located on the Deep River at the bridge crossing of Carbonton Road. On November 27, 2006 this location had a massive logjam on the upstream side of the bridge with woody debris spanning the entire width of the channel. This logjam has been flushed out between the two left-most bridge supports (Photo 4). Just below the bridge, the right bank of the Deep River has experienced erosion possibly as a result of the redirection of water from the upstream logjam (Photo 5).

River Observation Point 5

River Observation Point 5 is located on the right bank of the Deep River at the confluence with an unnamed tributary. At this location well established herbaceous vegetation had previously maintained stream bank stability. As a result of seasonal vegetation loss, the rise in storm surge has eroded bank material and down cut the tributary (Photo 6).

River Observation Point 6

River Observation Point 6 is located on the Deep River at the confluence with Big Governors Creek. A few areas at waters edge showed continued scouring but the majority of the bank material appeared stable and still intact. Both banks of Big Governors Creek lack vegetative cover. An accumulation of woody debris remains at the confluence (Photo 7).

River Observation Point 7

River Observation Point 7 is located on the Deep River at the confluence with an unnamed tributary on the Knight Cattle Corporation property. At this location, significant erosion has allowed a piece of the bank to break off and slide into the center of the channel (Photo 8). A head-cut has continued to migrate up the tributary and bank material continues to erode (Photo 9).

River Observation Point 8

River Observation Point 8 is located on the Deep River at the confluence with an unnamed tributary near Monitoring Station 27. A head-cut continues to transport sediment from the tributary and has eroded further upstream. Significant sloughing and freshly exposed roots are present on the left bank (Photo 10).

River Observation Point 9

River Observation Point 9 is located on the Deep River at the confluence with an unnamed tributary. A large head-cut at the confluence continues to migrate upstream, and bank material continues to erode. A significant area of new sloughing was observed on the right bank of the tributary (Photo 11).

River Observation Point 10

River Observation Point 10 is located on the Deep River at the confluence with an unnamed tributary near Monitoring Station 2. Down cutting of the tributary was observed and large amounts of sediment has built up at the confluence with the Deep River (Photo 12).

River Observation Point 11

River Observation Point 11 is located on the Deep River at the confluence with an unnamed tributary near Monitoring Station 23. A large head-cut has continued moving sediment out of the tributary while the banks remain steep and unvegetated. A large piece of the bank with a tree growing on it has broken off the bank and slid into the tributary (Photo 13).

River Observation Point 12

River Observation Point 12 is located on the Deep River at the confluence with Line Creek. Line Creek continues to experience severe bank erosion. Banks on Line Creek are deeply incised and sediment accumulation at the confluence has increased. The Norfolk-Southern railroad crosses Line Creek at this location and the banks have eroded further back towards the bridge. Woody debris remains scattered throughout the channel (Photo 14-15).

River Observation Point 13

River Observation Point 13 is located on the Deep River at the bridge crossing of NC 42, just upstream of the former Carbonton dam. At this location the massive logjam seen on November 27, 2006 has broken apart between the right-most two bridge supports. An accumulation of debris remains between the center-most spans. Below the bridge and above the old dam site scouring was observed near top of bank, but exposed bedrock maintains bank stability (Photo 16).

River Observation Point 14

River Observation Point 14 is a new point located approximately 1 mile downstream of the Glendon Carthage Road bridge over the Deep River. Limited erosion and bank sloughing was observed on the right bank (Photo 17).

River Observation Point 15

River Observation Point 15 is a new point located approximately 1.5 miles downstream of the Glendon Carthage Road Bridge on the Deep River. Bank sloughing and freshly exposed roots were observed in several places (Photo 18).

River Observation Point 16

River Observation Point 16 is a new point located on the Deep River at the mouth of Lick Creek. Heavy erosion and incision of the banks was observed on both sides of the creek (Photo 19)

River Observation Point 17

River Observation Point 17 is a new point located approximately 2500 ft downstream of the Carbonton Road bridge. Large scale erosion has occurred on the right bank in the form of a massive separation of bank material into the Deep River. The approximately 45 by 20 foot piece of the bank remains intact and has numerous live trees on it, including a 14 inch diameter sweetgum tree (Photo 20).

River Observation Point 18

River Observation Point 18 is located at the confluence of an unnamed tributary on the left bank of the Deep River. This location occurs approximately 2500 ft below the confluence with Big Governor's Creek, and was documented for erosion on the June 26, 2006 evaluation. The headcut at this location appears unchanged, but an increase in bank erosion was observed, particularly on the right bank (Photo 21).

River Observation Point 19

River Observation Point 19 is a new point located at the confluence with an unnamed tributary on the right bank of the Deep River. Significant sloughing has occurred on the right bank and a small headcut is present (Photo 22).

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. All Land Observation Points were assessed for erosion during the previous evaluation on November 27, 2006. Land Observation Point 5 was not assessed for erosion during this evaluation because the landowners were not able to be reached for property access. Observation points are mapped on Figure 3.

Land Observation Point 1

Land Observation Point 1 is located at the crossing of Carbonton Road over Line Creek, a credited tributary to the Deep River. At this location drift lines and sediment deposition were observed on both banks as evidence of overbanking (Photo 23). Upstream of Carbonton Road, Line Creek is restricted by three culverts and the deposition on streamside vegetation was significant. The large

entrenchment ratio of Line Creek supports a well developed floodplain and relieves stormflow stress on stream banks (Photo 24). Both reaches above and below Carbonton Road have very low flow and the banks appear stable. Limited erosion and scouring of bank material was observed (Photo 25).

Land Observation Point 2

Land Observation Point 2 is located at Monitoring Station 45 near the crossing of Cool Springs Road over McClendon's Creek. This section of McClendon's Creek is a non-credited reach but was visited for a comparison to stream conditions further downstream. On the day of observations, McClendon' Creek still had a high river stage and flow velocity. River stage had fallen below bankfull but was still elevated such that a full erosion evaluation of the banks was not possible (Photo 26). Stormflow had exceeded bankfull, and a moderate layer of fine sediment was observed on streamside vegetation. Both banks showed signs of scouring as trees were undercut and bare roots were exposed (Photo 27). No trees were undercut to the point of falling, but a few were leaning significantly.

Land Observation Point 3

Land Observation Point 3 is located at Monitoring Station 47 near the bridge crossing of Glendon-Carthage Road over McClendon's Creek, a credited tributary to the Deep River. 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. Evaluating banks for erosion was again made difficult by high river stage and flow velocity (Photo 28). Stormflow had exceeded 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 (Photo 29). A moderate layer of fine sediment was observed on streamside and floodplain vegetation.

Land Observation Point 4

Land Observation Point 4 was taken at Monitoring Station 40 near the bridge crossing of Steel Bridge Road over Little Governor's Creek, a credited tributary to the Deep River. This section of Little Governor's Creek received significant stormflow with overbank flooding apparent in multiple locations. Many stretches of streambank along this reach of Deep Governor's Creek are vegetated, but in several areas, portions of the banks have experienced significant scouring and erosion (Photo 30-31). Just downstream from the Steel Bridge Road bridge, a large riffle complex continues to erode along the left streambank, where stream flow becomes restricted by the bridge (Photo 32-33).

Summary

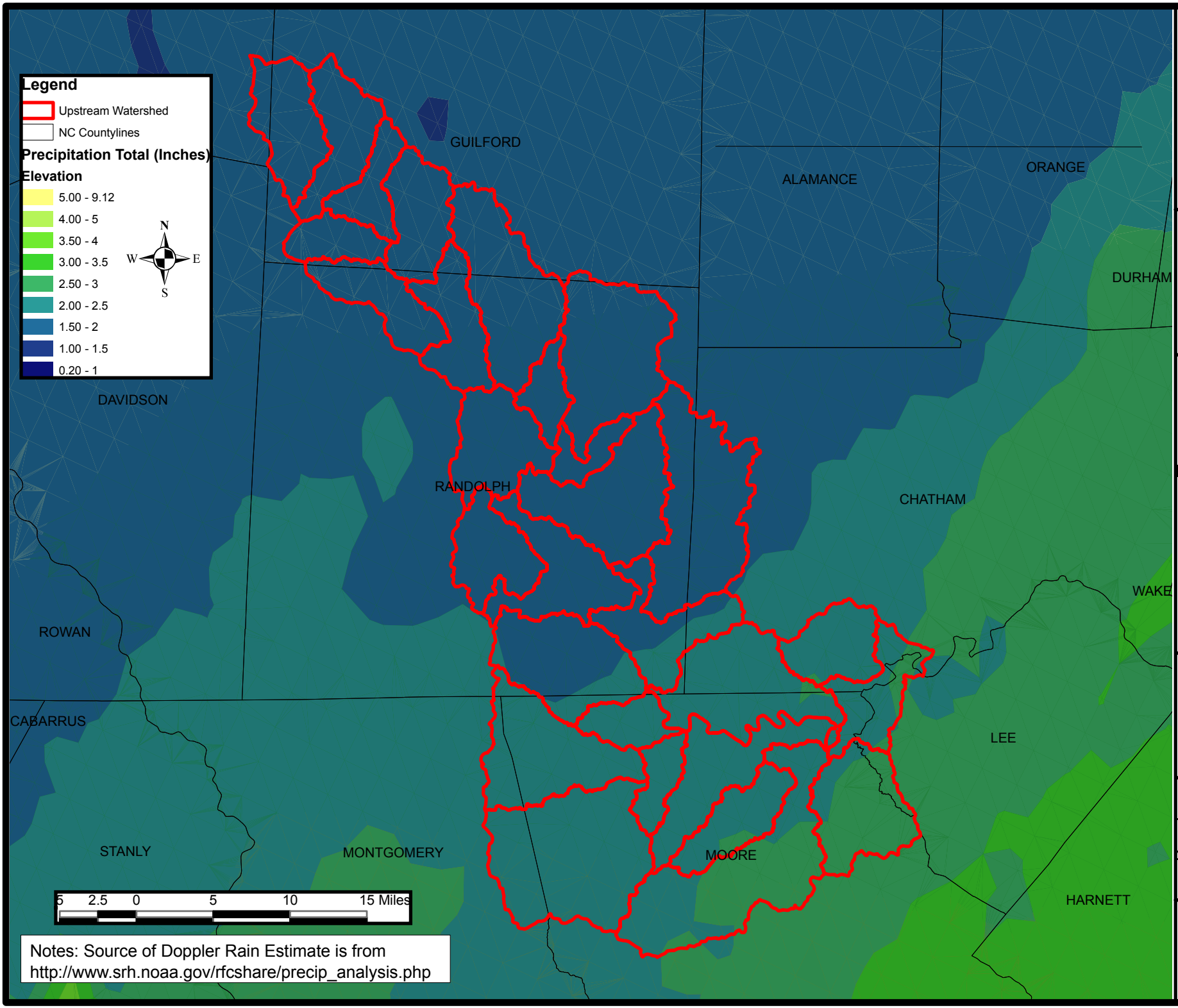
The rain event which triggered this erosion evaluation caused the USGS gauge at Ramseur to register a peak discharge on December 25, 2006 of 3210 cubic feet per second (cfs). Despite the high rainfall totals and peak discharge associated with this storm, the Deep River and its tributaries were observed to experience erosion consistent with previous evaluations. Head-cuts identified at tributaries to the Deep River continue to slowly migrate. Scouring and erosion of tributary banks continues to be problematic in areas where herbaceous vegetation has never established, or has seasonally diminished. The banks of the Deep River are generally stable, with a few areas experiencing storm flow scour and erosion.

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 January 4, 2007.

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 at the site of the former Carbonton Dam. Figure 4A compares the cross-sectional survey from January 4, 2007 to the dimensions from the previous survey on 11-29-06, and the first survey on 06-27-06. No significant change in the substrate island was observed from the monitoring cross-sections. Cross-sections 1, 2 and 3 show only minor signs of sediment transport from within the channel, with the most noticeable change along the right bank. Since the first survey, the right bank has gradually experienced erosion as noted from the 01-04-07 survey lines (black) departure from the 06-27-06 survey line (red). Cross-section 4 shows an initial degradation of channel bed form after the first survey, with stability in recent surveys. Overall, the cross-section surveys show that increased flow conditions following dam removal have had almost no impact on the substrate island, and minor effect on surrounding banks.

DEEP RIVER EROSION EVALUATION FIGURES



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

EcoScience

EcoScience Corporation
Raleigh, North Carolina

CLIENT:

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

PROJECT:

CARBONTON DAM EROSION EVALUATION

Chatham, Lee and Moore Counties, North Carolina

TITLE:

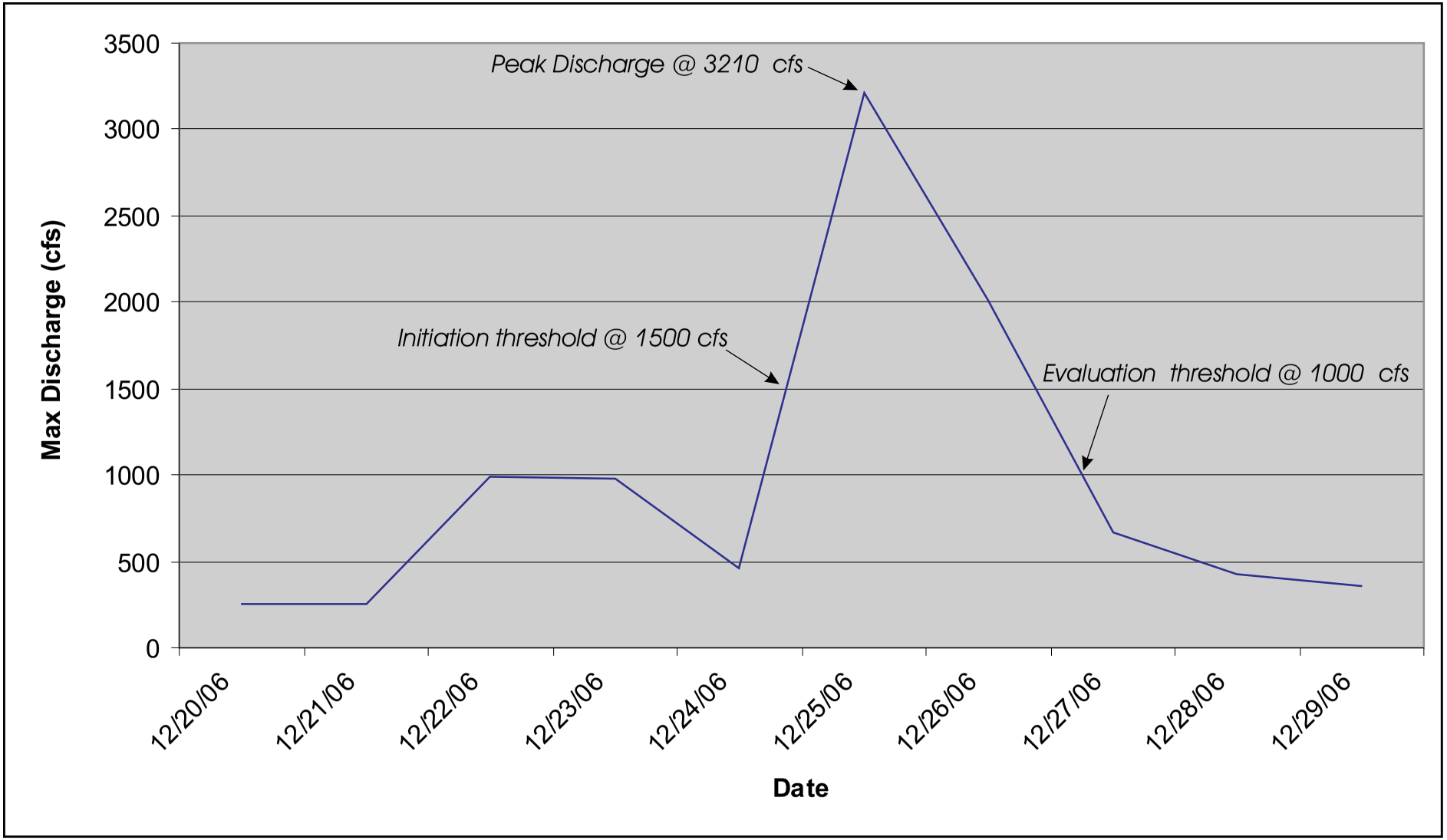
Total Rainfall Estimate for 12-22 to 12-26 Rain Event

Dwn By:	Ckd By:
MG	MC
Date:	Scale:
JAN 2007	SHOWN

ESC Project No.: 06-277

FIGURE

1

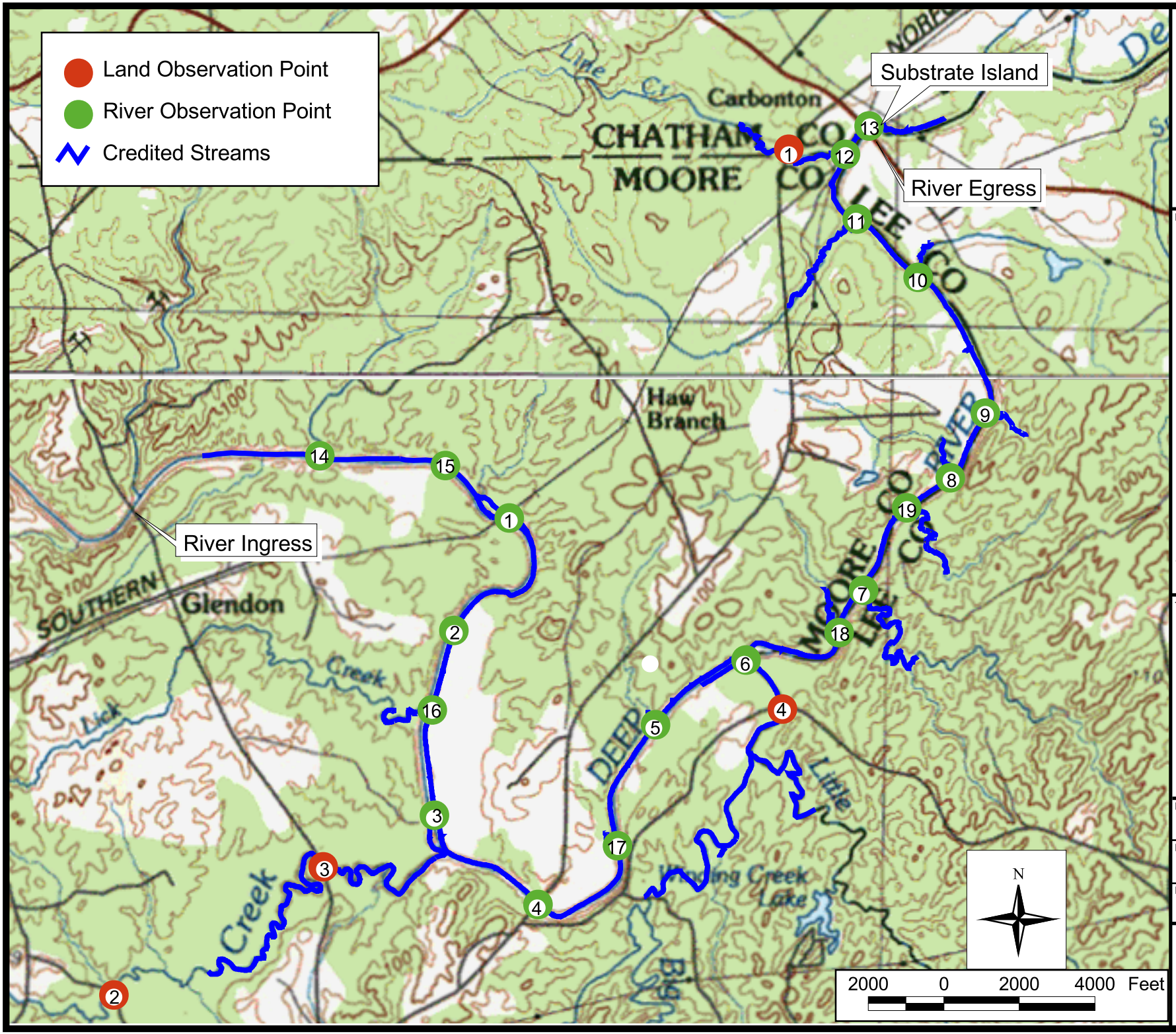


EcoScience Corporation
Raleigh, North Carolina

EVENT DISCHARGE AT GAUGE NEAR RAMSEUR, NC
CARBONTON DAM RESTORATION SITE
Erosion Evaluation (12-28-2006)

Dwn. by:	MCG
Ckd by:	MCG
Date:	JAN 2007
Project:	06-277.04

FIGURE 2



EcoScience Corporation
Raleigh, North Carolina

Project:

Deep River-Carbonton Dam Restoration Site

Chatham, Lee and Moore Counties, North Carolina

Title:

Erosion Evaluation Observation Points 12-28-2006

Dwn By:	Ckd By:
MCG	MTC
Date:	Scale:
JAN 2007	AS SHOWN

ESC Project No.: 06-277.04

FIGURE

3

DEEP RIVER EROSION EVALUATION PHOTOS

Photo 1. River Observation Point 1

Location: Deep River downstream of the Norfolk-Southern rail bridge
Description: Continued bank failure and sloughing into the Deep River

11/27/2006:
Erosion
Evaluation 3

Photo 2. River Observation Point 2

Location: Approximately 1 mile downstream of Norfolk-Southern rail bridge, Deep River
Description: Bank failure and erosion from adjacent agricultural fields

11/27/2006: Erosion Evaluation 3

Photo 3. River Observation Point 3

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

Description: Overland flow and sediment transport resulting from storm surge

11/27/2006:
Erosion
Evaluation 3

Photo 4. River Observation Point 4

Location: Carbonton Road crossing of the Deep River
Description: Cleared log jam

11/27/2006:
Erosion
Evaluation 3

Photo 5. River Observation Point 4

Location: Carbonton Road bridge crossing of the Deep River
Description: Sloughing of bank material downstream of the bridge

Photo 6. River Observation Point 5

Location: Confluence of the Deep River and an unnamed tributary

Description: Stream headcut and erosion of bank material

11/27/2006:
Erosion
Evaluation 3

Photo 7. River Observation Point 6

Location: Confluence of the Deep River and Big Governor's Creek
Description: Stable banks with only minor erosion

11/27/2006:
Erosion
Evaluation 3

Photo 8. River Observation Point 7

Location: Confluence of the Deep River and an unnamed tributary
Description: Large scale bank sloughing and continued headcutting

11/27/2006:
Erosion
Evaluation 3

Photo 9. River Observation Point 7

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

11/27/2006:
Erosion
Evaluation 3

Photo 10. River Observation Point 8

Location: Confluence of the Deep River and an unnamed tributary, near Monitoring Station 27
Description: Multiple trees fallen over and roots exposed as a result of bank sloughing

11/27/2006:
Erosion
Evaluation 3

Photo 11. River Observation Point 9

Location: Confluence of the Deep River and an unnamed tributary
Description: Bank sloughing and transporting of debris into the Deep River

11/27/2006:
Erosion
Evaluation 3

Photo 12. River Observation Point 10

Location: Confluence of the Deep River and an unnamed tributary near Monitoring Station 2
Description: Continued movement of sediment and sloughing of bank material

11/27/2006:
Erosion
Evaluation 3

Photo 13. River Observation Point 11

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

11/27/2006:
Erosion
Evaluation 3

Photo 14. River Observation Point 12

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

Photo 15. River Observation Point 12

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

11/27/2006:
Erosion
Evaluation 3

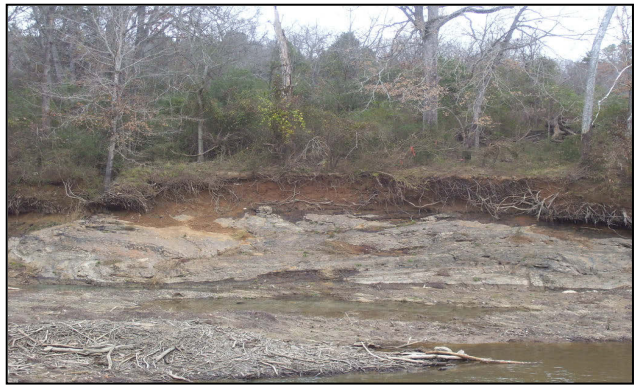


Photo 16. River Observation Point 13

Location: Downstream of the NC 42 bridge crossing of the Deep River

Description: Scouring and erosion of left bank

Photo 17. River Observation Point 14

Location: Deep River downstream of the Glendon-Carthage Road bridge
Description: Bank failure and continued erosion into the Deep River

Photo 18. River Observation Point 15

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

Photo 19. River Observation Point 16

Location: Mouth of Lick Creek on the Deep River
Description: Bank failure and erosion into the Deep River

Photo 20. River Observation Point 17

Location: Approximately 2,500 ft downstream of the Carbonton Road bridge on the Deep River
Description: Bank failure and large scale sloughing into the Deep River

Photo 21. River Observation Point 18

Location: Approximately 2,500 feet downstream of Big Governor's Creek on the Deep River
Description: Erosion on the right bank

Photo 22. River Observation Point 19

Location: Confluence of the Deep River and unnamed tributary
Description: Small headcut with significant erosion of the right bank

Photo 23. Land Observation Point 1

Location: Line Creek upstream of the bridge crossing of Carbonton Road
Description: Sediment deposition as evidence of overbanking

Photo 24. Land Observation Point 1

Location: Line Creek downstream of the bridge crossing of Carbonton Road
Description: Overbanking into floodplain

11/27/2006:
Erosion
Evaluation 3

Photo 25. Land Observation Point 1

Location: Line Creek downstream of the bridge crossing of Carbonton Road

Description: Stable banks with limited erosion

Photo 26. Land Observation Point 2

Location: McClendon's Creek at Cool Springs Road
Description: Elevated stream gage

Photo 27. Land Observation Point 2

Location: McClendon's Creek at Cool Springs Road
Description: Exposed roots on scoured stream bank

Photo 28. Land Observation Point 3

Location: McClendon's Creek at Glendon-Carthage Road
Description: Elevated stream gage

Photo 29. Land Observation Point 3

Location: McClendon's Creek at Glendon-Carthage Road
Description: Steep exposed banks

11/27/2006:
Erosion
Evaluation 3

Photo 30. Land Observation Point 4

Location: Little Govenor's Creek at Steel Bridge Road
Description: Steep, eroded banks

Photo 31. Land Observation Point 4

Location: Little Govenor's Creek at Steel Bridge Road
Description: Steep, undercut banks

Photo 32. Land Observation Point 4

Location: Little Govenor's Creek at Steel Bridge Road
Description: Riffle complex downstream of bridge

Photo 33. Land Observation Point 4

Location: Little Govenor's Creek at Steel Bridge Road
Description: Bank erosion downstream of bridge