ARCADIS

City of Raleigh 2007 Sampling and Monitoring Program Report

Appendix E

City of Raleigh Freshwater Mussel Surveys of the Little River, The Catena Group, April 2008

City of Raleigh Freshwater Mussel Surveys of the Little River

Wake and Johnston Counties, North Carolina

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April 11, 2008

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EXECUTIVE SUMMARY

The City of Raleigh (City) is proposing to construct a water supply reservoir on the Little River near the US 64 crossing in Wake County, North Carolina. The Little River is a major tributary to the Neuse River. The federally endangered dwarf-wedge mussel (*Alasmidonta heterodon*) is known to occur in the Little River in Wake and Johnston Counties, and the federally endangered Tar spinymussel (*Elliptio steinstansana*) is known to occur in the Little River in Johnston County. In addition to these two protected species, several other rare and state listed aquatic species are also known to occur in the Little River.

As a result of this and other projects, the City has agreed to expand its existing sampling and monitoring program. Data obtained from the program will be used to monitor changes in water quality over time and identify problems potentially caused by these projects. The Catena Group (TCG) was been retained by Arcadis G&M of North Carolina, Inc. to conduct Baseline Surveys of the freshwater mussel fauna of the Little River within the proposed reservoir pool as well as downstream into Johnston County.

The objectives of this study were:

- Determine species composition and distribution within the study area
- Determine status/distribution of rare mussel species, particularly the dwarf wedgemussel, Tar spinymussel, Atlantic pigtoe and green floater within the potential impact area.

The Study Area, which generally falls within the transition zone between the Piedmont and Coastal Plain was an approximately 13 mile stretch of the river from SR 2224 (Mitchell Mill Road) crossing in northeast Wake County downstream to the SR 1722 (Mudham Road) crossing in Johnston County (Figure 1). The river in the majority of the Study Area consists of a series of beaver (*Castor canadensis*) dams throughout the channel and adjacent floodplain, creating a large braided-channel, wetland complex. The substrate is highly variable throughout, ranging from muddy silt to sandy-gravel, with occasional granitic outcrops.

Timed qualitative mussel surveys were performed at 36 stations in the Study Area (Figures 1A-D) between April and October 2007. Site numbers (1-36) were assigned sequentially to each area surveyed. Survey sites were accessed via road crossings or by canoeing between road crossings. All habitat types (riffle, run, pool, slack water, etc.) within each site were sampled; however, habitats, as described in the Biological Assessment for the Dempsey E. Benton project (Entrix 2005), were the primary focus as these are most likely to contain the dwarf wedgemussel. Mask/snorkel, bathyscope (glass-bottom view buckets), and tactile (hand grubbing) methodologies were used. Over-wash areas, dewatered sections of the stream, and muskrat (*Ondatra zibethicus*) shell middens were also searched for relict shells. Each survey was timed, the amount of which was determined by survey conditions and concentration of mussels. Survey distances within and between sites varied as sites were chosen based on best suitable habitat for the target species and accessibility. Mussels were collected and brought to the

surface for identification and returned to the substrate. Nomenclature of mussels followed Turgeon et al. (1988). Catch per unit effort (CPUE) for each mussel species were calculated at each site. The presence of relict shells was equated with presence of that species, but was not factored into the CPUE. Representative photographs of each mussel species were taken when possible.

The survey crew varied between dates, and consisted of TCG personnel Tim Savidge (TS), Tom Dickinson (TD), Chris Sheats (CS), Shay Garriock (SG), John Lancaster (JL), Jennifer Logan (JLo), Gary Krieser (GK), Megan Euhliano (ME), Jessie Taylor (JT) and Joshua Jones (JJ). In addition, Rob Nichols (RN) of the NCWRC assisted with survey efforts on April 20.

A total of 9,389 live native freshwater mussels comprising at least eight species were collected during the survey efforts. The total number of individuals, number of sites where located, highest recorded CPUE for the species, and the site number where the highest CPUE was recorded for each species is listed in Table 1. Species numbers and CPUE for each site are provided in Appendix B.

Table 1. Mussel Species Located

Species	**# of Individuals Found**	**# of Sites Where Found**	**Site of Highest # Individuals**	**Site # of Highest CPUE**
Alasmidonta undulata (triangle floater)	4	3	30	30
Elliptio complanata (eastern elliptio)	6,516	35	30	32
Elliptio icterina (variable spike)	209	31	27	27
Elliptio fisheriana (northern lance)	407	32	21	21
Elliptio spp.* (*E. complanata* and *E. icterina* complexes)	2,226	9	10	10
Fusconaia masoni (Atlantic pigtoe)	1	1	7	7
Lasmigona subviridis (green floater)	9	8	6, 7, 34	7
Pyganodon cataracta (eastern floater)	4	2	4	4
Utterbackia imbecillis (paper pondshell)	13	7	5	5

The Asian clam (*Corbicula fluminea*) occurred at all of the sites and was the most abundant mollusk. Three species of aquatic snails were found sporadically throughout the Study Area, these include, in order of frequency of encounter, the pointed campeloma (*Campeloma decisum*), two ridge ram's horn (*Helisoma anceps*), and a physid (*Physa* sp.).

Mussels were very unevenly distributed throughout the study area as well as within a particular site, which is reflective of the distribution and quality of microhabitats, particularly the substrate. In general, mussels were most abundant in compact sand and

clay, which existed in small patches throughout the braided channel system. Although not investigated as part of this study, the size, number and age of beaver dams at a particular site is likely the most important factor determining mussel distribution and abundances. Many of the river sections that were free flowing in the mid 1990's are now inundated by multiple beaver dams, with no discernable channel (Tim Savidge, personal observations). Large concentrations of relict shells, with very few live individuals were observed in many of these areas, suggesting a localized decline in habitat suitability. However, high numbers of mussels were occasionally found in close proximity to beaver dams, in the main channel as well as secondary channels. Although not quantified, mussel abundances appeared to be negatively affected by increasing amount of fine sediments and woody debris.

These surveys provide new and updated mussel distribution for the section of the Little River that will be impacted by the proposed action. Much of the survey effort took place during extreme drought conditions in the region; however, the Little River did not appear to be as significantly impacted with regards to water levels as other streams in the area as the beaver dam complexes appeared to retain water (Tim Savidge, personal observations).

Historically, at least 20 species of freshwater mussels have been reported to occur in the Little River subbasin. This study confirms the high species diversity (for Atlantic Slope drainages) of this stream, as at least 16 species were collected. It is very possible that the *E. complanata* and *E. icterina* complexes are represented by several species, which would further raise the number of species in the subbasin. The only two species reported to occur in Swift Creek that were not found in this study are the green floater (*Lasmigona subviridis*) and the Carolina lance (*Elliptio angustata*). The green floater was reported as occurring in Swift Creek by Walter (1956) and one specimen was found by Alderman (1991); however, it has not been found in Swift Creek in subsequent surveys. Taxonomic uncertainties with lanceolate elliptios exist; thus, specimens reported as the Carolina lance in previous surveys may in fact be the same species as what is reported in this study as the Atlantic spike or the northern lance, two other lanceolate elliptio species.

Based on the survey results, it is apparent that a fairly diverse mussel fauna is present within the potential impact area. However, the study also indicates that there may be trend in reduction of numbers and species diversity within the study area of the Little River. Neither the dwarf wedgemussel, nor the notched rainbow, were found during this study, despite being present in the study area in previous years. Additionally, based on CPUE, some of the rare mussel species like the green floater and Atlantic pigtoe, may be declining within the study area. This apparent trend may be the result of habitat modifications caused by beaver impoundments and may be temporary, unless other anthropogenic or natural factors impact the Little River.

These and previous survey results also indicate that the Little River population of the green floater is largely confined to the area that occurs within the proposed reservoir pool. Inundation of this reach of river may result in further reduction of numbers or the ultimate extirpation of the population.

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1.0 INTRODUCTION

The City of Raleigh (City) is proposing to construct a water supply reservoir on the Little River near the US 64 crossing in Wake County, North Carolina. The Little River is a major tributary to the Neuse River. The federally endangered dwarf-wedge mussel (*Alasmidonta heterodon*) is known to occur in the Little River in Wake and Johnston Counties, and the federally endangered Tar spinymussel (*Elliptio steinstansana*) is known to occur in the Little River in Johnston County. In addition to these two protected species, several other rare and state listed aquatic species are also known to occur in the Little River (Table 1).

Table 1. Rare Aquatic Species Documented from Little River Subbasin*

Scientific Name	Common Name	Taxa Group	Federal Status	NC Status
Alasmidonta heterodon	dwarf wedgemussel	mussel	E	E
Alasmidonta undulate	triangle floater	mussel	~	T
Amboplites cavifrons	Roanoke bass	fish	FSC	SR
Elliptio congaraea	Carolina slabshell	mussel	~	W2, W5
Elliptio lanceolata	yellow lance	mussel	FSC	E
Elliptio roanokensis	Roanoke slabshell	mussel	~	T
Elliptio steinstansana	Tar spinymussel	mussel	E	E
Etheostoma collis	Carolina darter	fish	FSC	SC
Fusconaia masoni	Atlantic pigtoe	mussel	FSC	E
Lampsilis cariosa	yellow lampmussel	mussel	FSC	E
Lampsilis radiata radiata *Lampsilis radiata conspicua*	Eastern lampmussel Carolina fatmucket	mussel	~	T
Lasmigona subviridis	green floater	mussel	FSC	E
Lythrurus matutinus	pinewoods shiner	fish	FSC	W2
Necturus lewisi	Neuse River waterdog	amphibian	~	SC
Nocomis raneyi	bull chub	fish	~	W1
Notropis chalybaeus	ironcolor shiner	fish	~	W5
Noturus furiosus	Carolina madtom	fish	FSC	PT
Strophitus undulates	creeper	mussel	~	T
Villosa constricta	notched rainbow	mussel	~	SC

*Definitions of Federal and State protection status are listed in Appendix A.

As a result of this and other projects, the City has agreed to expand its existing sampling and monitoring program. Data obtained from the program will be used to monitor changes in water quality over time and identify problems potentially caused by these projects. The Catena Group (TCG) was been retained by Arcadis G&M of North Carolina, Inc. to conduct Baseline Surveys of the freshwater mussel fauna of the Little River within the proposed reservoir pool as well as downstream into Johnston County.

1.1 Background and Objectives

Although there is a rich history of freshwater mussel collections in the Neuse River Basin near Raleigh, there are no records of sampling in the Little River prior to the 1950's. Walter (1956) sampled 12 stations in the Little River Subbasin in Wake and Johnston counties, and reported six species. In the early 1980's, Arthur Clarke documented the dwarf wedgemussel and the Tar spinymussel as occurring in the Little River (USFWS

1993, Clarke 1983). Various status/monitoring surveys by the North Carolina Wildlife Resources Commission (NCWRC) from 1989-2007 (NCWRC 2008), as well as project specific surveys (North Carolina Department of Transportation, various municipalities etc) have been conducted throughout the subbasin. These surveys have demonstrated that the Little River contains a diverse mussel fauna including several rare and/or protected species (Table 1). The dwarf wedgemussel was most recently collected in the Little River at the SR 2129 (Woodruff Road) crossing in 2005 (The Catena Group 2005). The most recent record of the species in the Wake County portion of the river was in 1997 at the SR 2352 (Morphus Bridge Road) crossing and the most recent record within the proposed reservoir pool was in 1991 at the SR 2308 (Fowler Road) crossing (NCWRC 2008). Only three individuals of the Tar spinymussel have ever been recorded in the Little River. The first individual was collected in 1983, at the SR 2320 (Raines Crossroads) crossing and the other two were identified in 1998 and 2005, at the SR 2130 (Micro Road) crossing (NCWRC 2008, The Catena Group 2005).

The NCWRC identified the Little River watershed as one of 25 in North Carolina considered essential for the continued survival of endangered or threatened aquatic wildlife species (Alderman et al. 1993). As required by the Nature Preserves Act (NCGS 113A-164 of Article 9), the North Carolina Natural Heritage Program (NHP) compiles the North Carolina Department of Environment and Natural Resources (NCDENR) priority list of "Natural Heritage Areas" in which natural areas (sites) are inventoried and evaluated on the basis of rare plant and animal species, rare or high quality natural communities, and geologic features occurring in the particular site. The sites are rated with regard to national, state and regional significance; Little River is rated as having "National Significance". It is noted that sites on the list should be given priority for protection; however, it does not imply that all of the areas currently receive protection (NCDENR 2005).

The Little River arises near Moore's Millpond in Franklin County approximately 5.5 miles northeast of the town of Wake Forest. The entire drainage basin, from the headwaters at Moore's Millpond in to the confluence with the Neuse River in Wayne County near the city of Goldsboro, comprises Neuse River subbasin 06 as designated by the North Carolina Division of Water Quality (DWQ) (NCDENR 2004).

Land use throughout the subbasin is primarily rural with a combination of agriculture and forestry land use, with scattered, small towns that are growing steadily, particularly in Wake County. Larger farms with small riparian buffer zones characterize the lower part of the watershed in Johnston and Wayne Counties.

The Little River Subbasin has two distinct reaches, the upper reach in the Piedmont and the lower reach in the Coastal Plain. The upper reach flows quickly through the Piedmont with an average slope of 27 feet per mile in the first 1.5 miles and 6 feet per mile in the next 9.5 miles. The lower reach moves more slowly as it meanders through the Coastal Plain with an average slope of 2.6 feet per mile for the downstream 61 miles.

The objectives of this study were:

- Determine species composition and distribution within the study area
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2.0 STUDY AREA

The Study Area, which generally falls within the transition zone between the Piedmont and Coastal Plain was an approximately 13 mile stretch of the river from SR 2224 (Mitchell Mill Road) crossing in northeast Wake County downstream to the SR 1722 (Mudham Road) crossing in Johnston County (Figure 1). The river in the majority of the Study Area consists of a series of beaver (*Castor canadensis*) dams throughout the channel and adjacent floodplain, creating a large braided-channel, wetland complex. The substrate is highly variable throughout, ranging from muddy silt to sandy-gravel, with occasional granitic outcrops.

3.0 METHODS

Timed qualitative mussel surveys were performed at 36 stations in the Study Area (Figures 1A-D) between April and October 2007. Site numbers (1-36) were assigned sequentially to each area surveyed. Survey sites were accessed via road crossings or by canoeing between road crossings. All habitat types (riffle, run, pool, slack water, etc.) within each site were sampled; however, habitats, as described in the Biological Assessment for the Dempsey E. Benton project (Entrix 2005), were the primary focus as these are most likely to contain the dwarf wedgemussel. Mask/snorkel, bathyscope (glass-bottom view buckets), and tactile (hand grubbing) methodologies were used. Over-wash areas, dewatered sections of the stream, and muskrat (*Ondatra zibethicus*) shell middens were also searched for relict shells. Each survey was timed, the amount of which was determined by survey conditions and concentration of mussels. Survey distances within and between sites varied as sites were chosen based on best suitable habitat for the target species and accessibility. Mussels were collected and brought to the surface for identification and returned to the substrate. Nomenclature of mussels followed Turgeon et al. (1988). Catch per unit effort (CPUE) for each mussel species were calculated at each site. The presence of relict shells was equated with presence of that species, but was not factored into the CPUE. Representative photographs of each mussel species were taken when possible.

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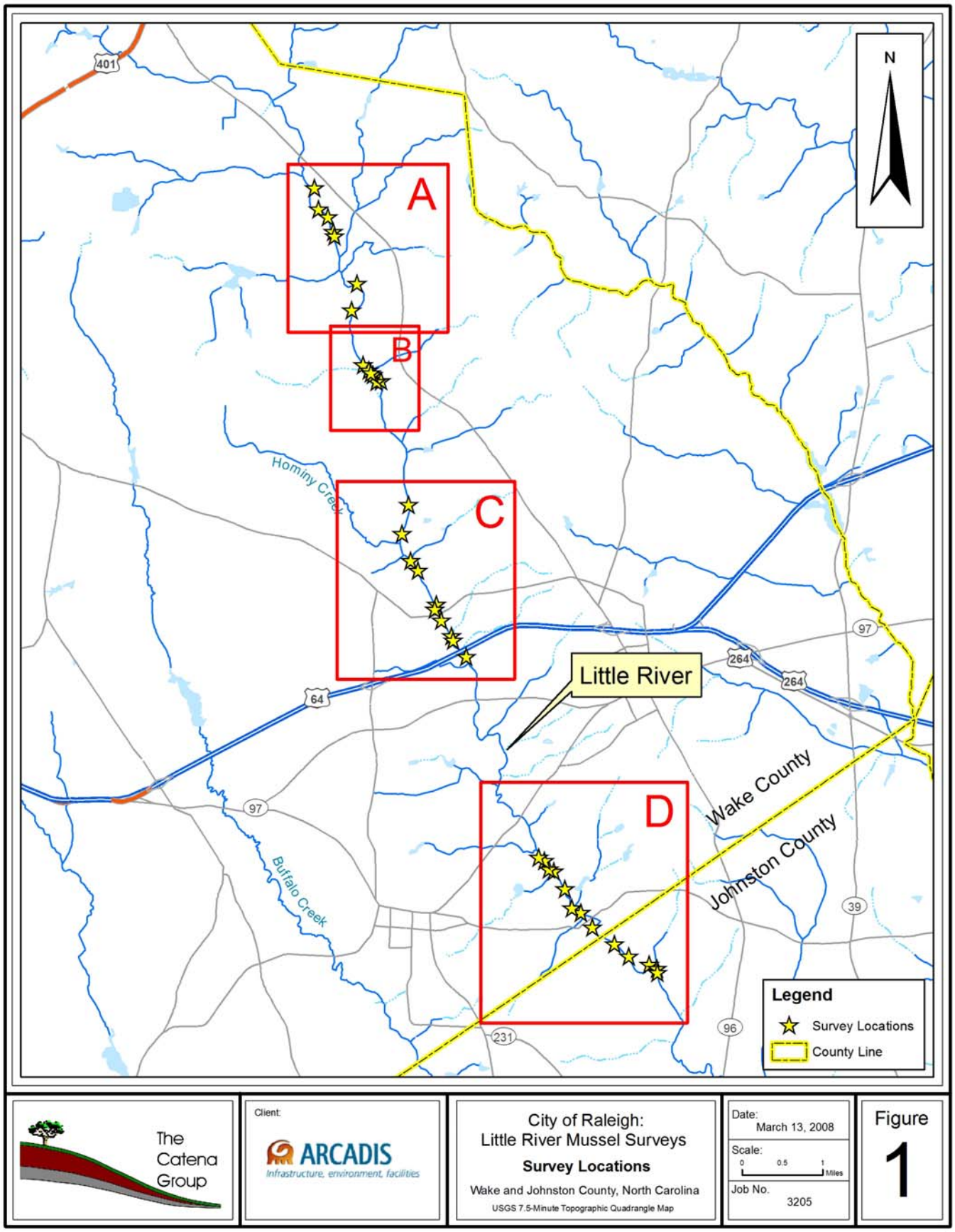
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Little River
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Buffalo Creek
Wake County
Johnston County
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Survey Locations
County Line
The Catena Group
Client:
ARCADIS
Infrastructure, environment, facilities
City of Raleigh:
Little River Mussel Surveys
Survey Locations
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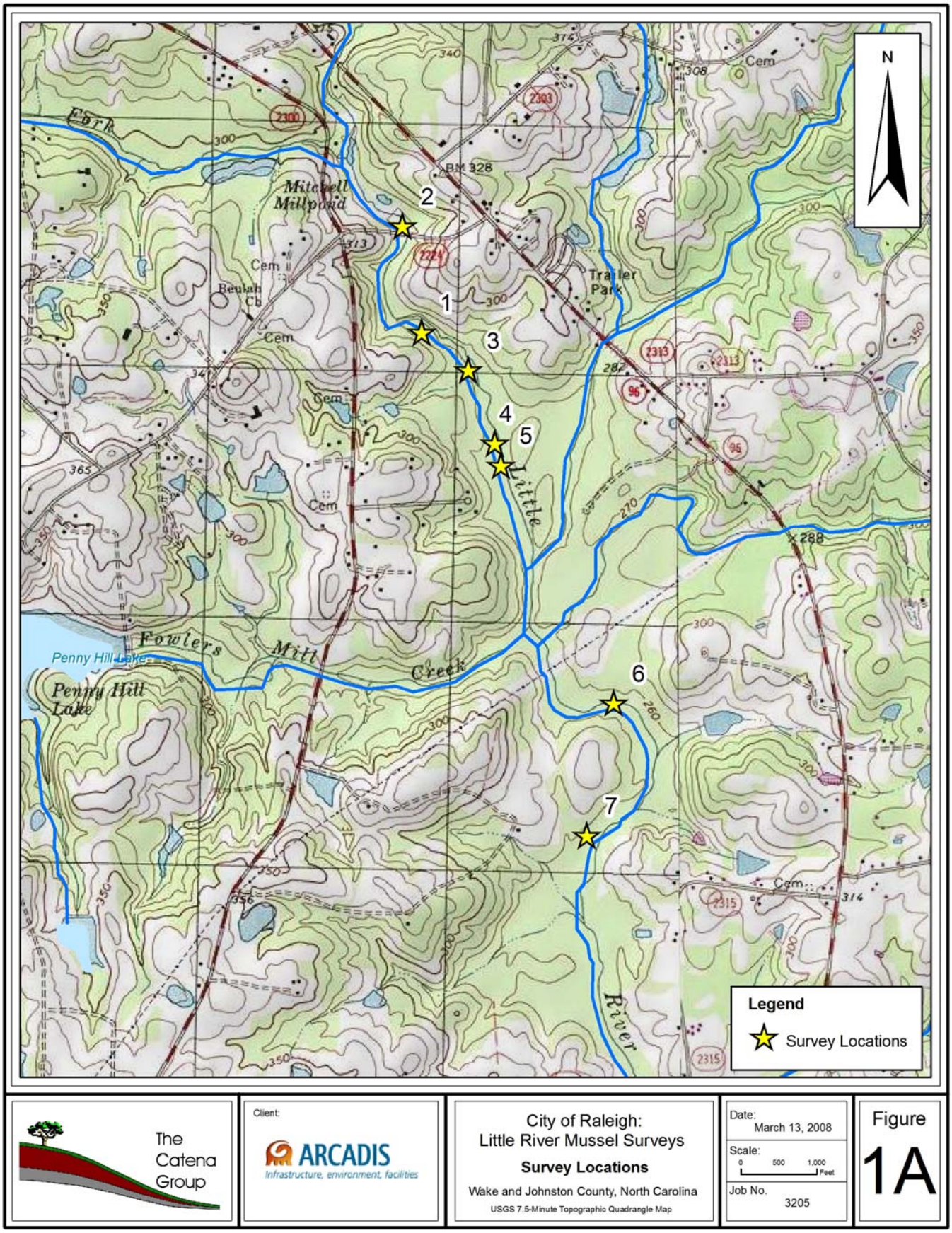
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Mitchell Millpond
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Little
River
Fowlers Mill Creek
Penny Hill Lake
Penny Hill Lake
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Legend
Survey Locations
The Catena Group
Client:
ARCADIS
Infrastructure, environment, facilities
City of Raleigh:
Little River Mussel Surveys
Survey Locations
Wake and Johnston County, North Carolina
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Figure
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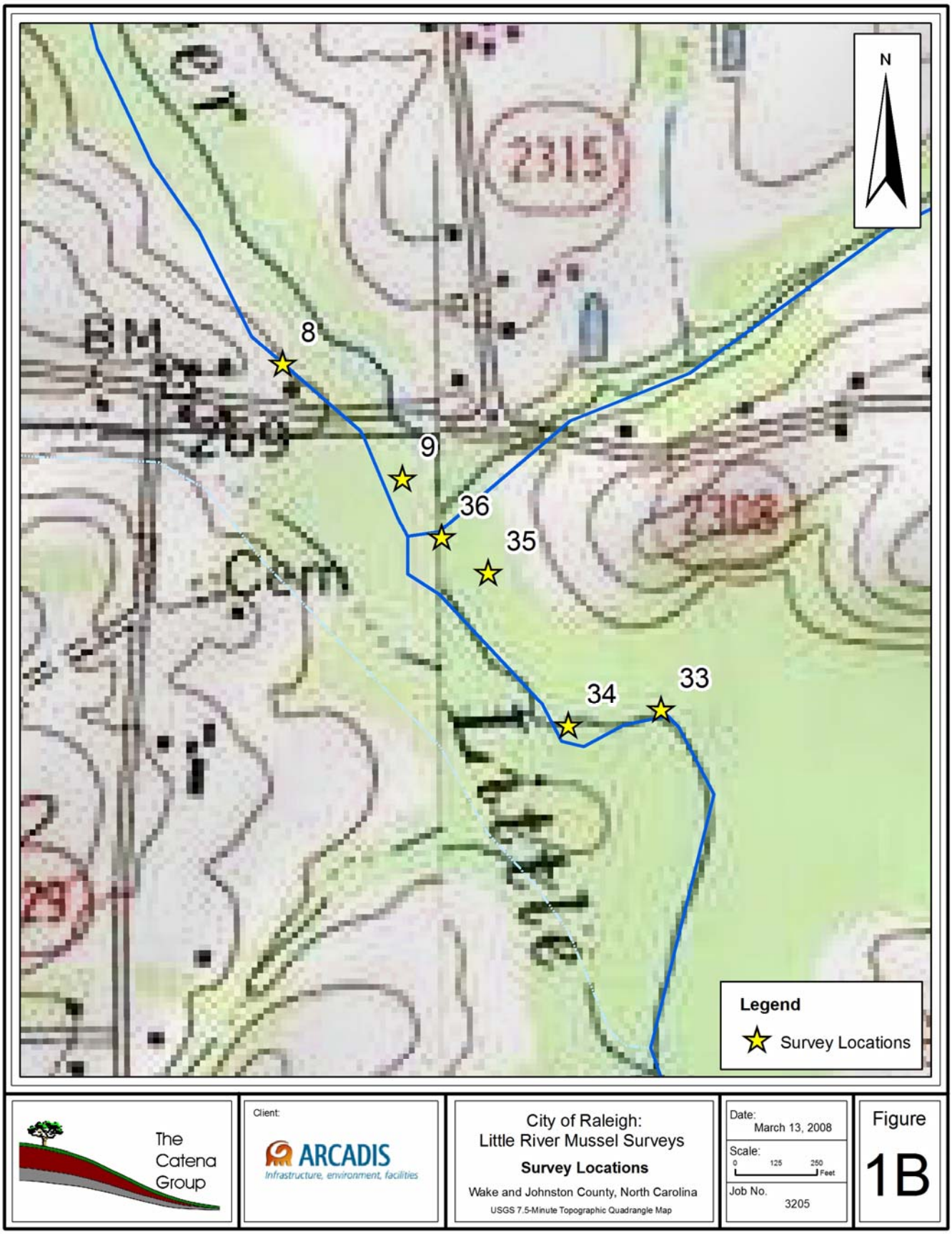
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The Catena Group
Client:
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Infrastructure, environment, facilities
City of Raleigh:
Little River Mussel Surveys
Survey Locations
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March 13, 2008
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Figure
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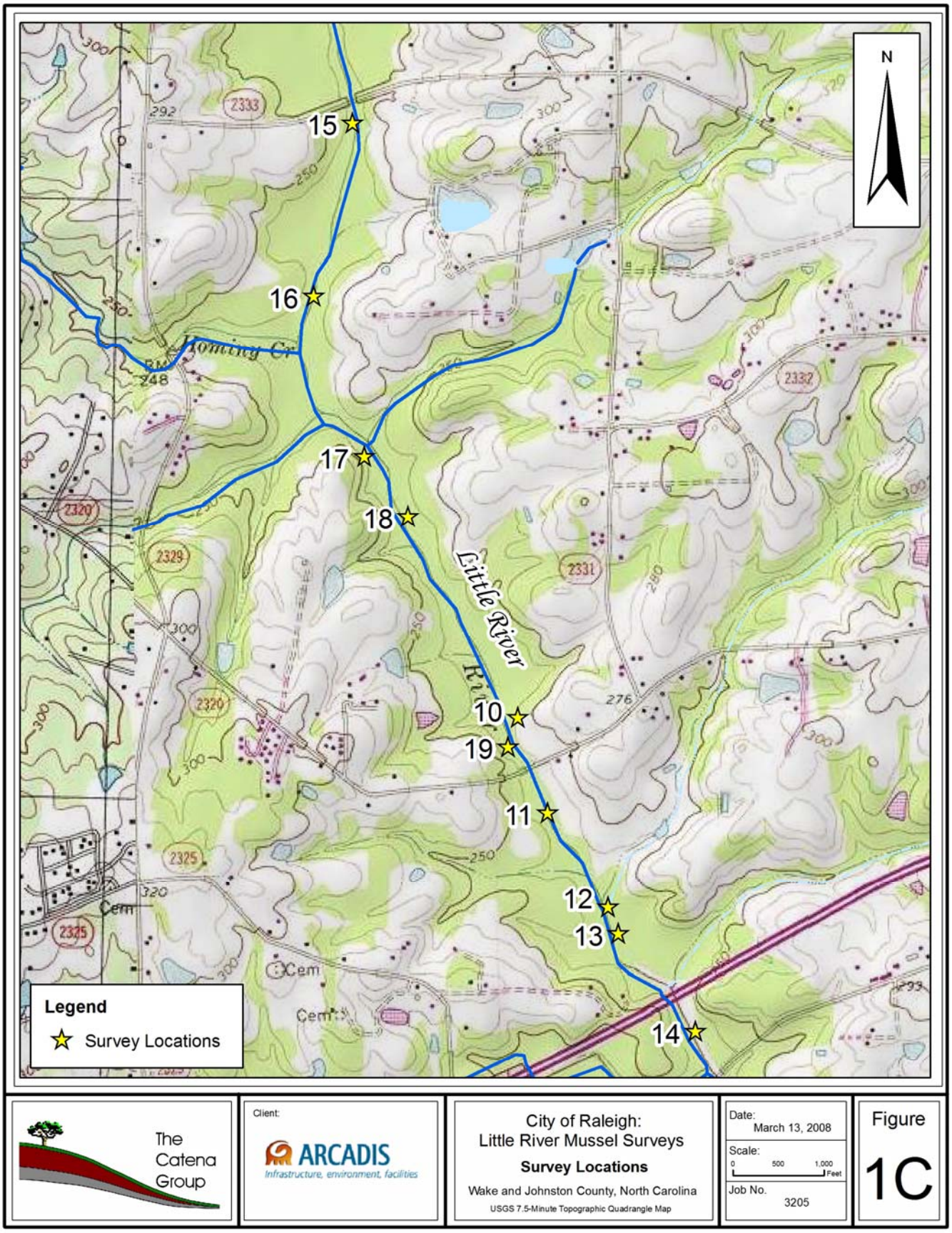
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Survey Locations
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Client:
ARCADIS
Infrastructure, environment, facilities
City of Raleigh:
Little River Mussel Surveys
Survey Locations
Wake and Johnston County, North Carolina
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March 13, 2008
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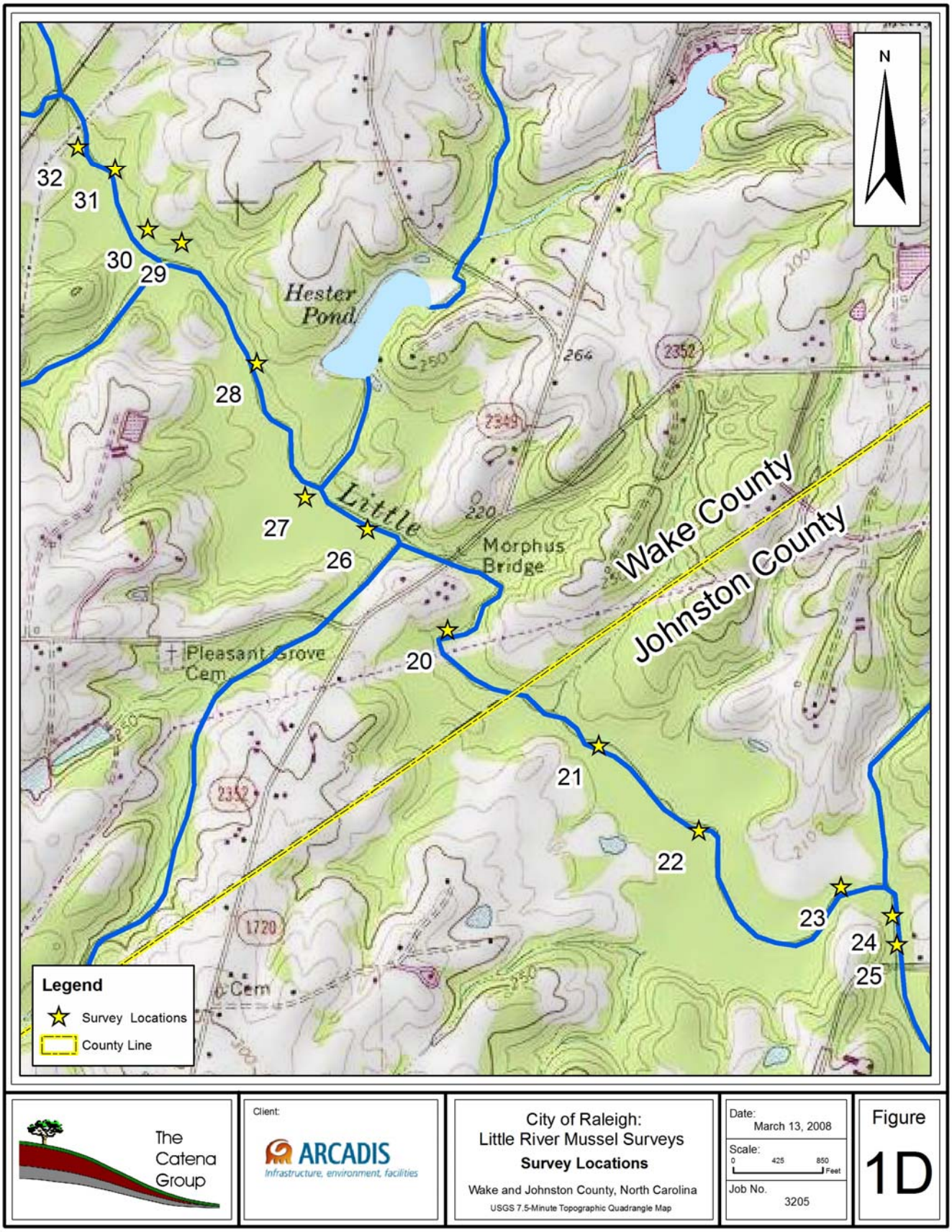
N
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Hester Pond
Little
Morphus Bridge
Pleasant Grove Cem
Cem
Wake County
Johnston County
Legend
Survey Locations
County Line
The Catena Group
Client:
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Survey Locations
Wake and Johnston County, North Carolina
USGS 7.5-Minute Topographic Quadrangle Map
Date:
March 13, 2008
Scale:
0 425 850 Feet
Job No.
3205
Figure
1D

Table 2. Little River Survey Sites

#	Date	Person Hours	Location	People
1	4-20-07	2	35.91051°N, -78.38607°W	TS,CS,JLo,RN
2	4-20-07	11.73	35.91435°N, -78.38688°W	TS,CS,JLo,RN
3	4-24-07	1	35.90912°N, -78.38399°W	TS,CS,JLo,JL
4	4-24-07	2.17	35.90678°N, -78.36289°W	TS,CS,JLo,JL
5	4-24-07	1	35.90601°N, -78.38278°W	TS,CS,JLo,JL
6	4-24-07	2.17	35.89702°N, -78.37760°W	TS,CS,JLo,JL
7	4-24-07	1.5	35.89223°N, -78.37885°W	TS,CS,JLo,JL
8	4-24-07	1.5	35.88238°N, -78.37632°W	TS,CS,JLo,JL
9	4-24-07	0.33	35.88141°N, -78.37509°W	TS,CS
10	4-25-07	3.75	35.83909°N, -78.36050°W	TS,CS,JLo,JL
11	4-25-07	2.3	35.83622°N, -78.35941°W	TS,CS,JLo,JL
12	4-25-07	1.6	35.83336°N, -78.35720°W	TS,CS,JLo,JL
13	4-25-07	1.33	35.83256°N, -78.35682°W	TS,CS,JLo,JL
14	4-25-07	1	35.82961°N, -78.35398°W	TS,CS,JLo,JL
15	5-15-07	5	35.85706°N, -78.36649°W	TD,ME,GK,JJ,JT
16	5-15-07	2.08	35.85184°N, -78.36797°W	TD,ME,GK,JJ,JT
17	5-15-07	2.92	35.84700°N, -78.36613°W	TD,ME,GK,JJ,JT
18	5-15-07	6.67	35.84518°N, -78.36452°W	TD,ME,GK,JJ,JT
19	5-15-07	5.42	35.83821°N, -78.36086°W	TD,ME,GK,JJ,JT
20	5-16-07	3.5	35.78062°N, -78.32644°W	TD,ME,GK,JJ,JT
21	5-16-07	1.67	35.77757°N, -78.32162°W	TD,ME,GK,JJ,JT
22	5-16-07	1.25	35.77534°N, -78.31844°W	TD,ME,GK,JJ,JT
23	5-16-07	1.67	35.77384°N, -78.31390°W	TD,ME,GK,JJ,JT
24	5-16-07	5	35.77308°N, -78.31225°W	TD,ME,GK,JJ,JT
25	5-16-07	5	35.77232°N, -78.31211°W	TD,ME,GK,JJ,JT
26	9-28-07	2.33	35.78326°N, -78.32898°W	TS,CS,SG,JL
27	9-28-07	2.43	35.78411°N, -78.33098°W	TS,CS,SG,JL
28	9-28-07	1.15	35.78761°N, -78.33249°W	TS,CS,SG,JL
29	9-28-07	2.38	35.79077°N, -78.33487°W	TS,CS,SG,JL
30	9-28-07	2.65	35.79113°N, -78.33595°W	TS,CS,SG,JL
31	9-28-07	0.58	35.79270°N, -78.33699°W	TS,CS
32	9-28-07	1.12	35.79329°N, -78.33818°W	TS,CS
33	10-12-07	3	35.87945°N, -78.37243°W	TS,CS,SG,JLo,JL,ME
34	10-12-07	4.3	35.87932°N, -78.37339°W	TS,CS,SG,JLo,JL,ME
35	10-12-07	3.25	35.88061°N, -78.37421°W	TS,CS,SG,JLo,JL,ME
36	10-12-07	4.8	35.88091°N, -78.37469°W	TS,CS,SG,JLo,JL,ME
	Total:	**101.55**	~	~

4.0 RESULTS

A total of 9,389 live native freshwater mussels comprising at least eight species were collected during the survey efforts. The total number of individuals, number of sites where located, highest recorded CPUE for the species, and the site number where the highest CPUE was recorded for each species is listed in Table 3. Species numbers and CPUE for each site are provided in Appendix B.

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Species	# of Individuals Found	# of Sites Where Found	Site of Highest # Individuals	Site # of Highest CPUE
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The Asian clam (*Corbicula fluminea*) occurred at all of the sites and was the most abundant mollusk. Three species of aquatic snails were found sporadically throughout the Study Area, these include, in order of frequency of encounter, the pointed campeloma (*Campeloma decisum*), two ridge ram's horn (*Helisoma anceps*), and a physid (*Physa* sp.).

4.1 Habitat Conditions and Mussel Distribution

Mussels were very unevenly distributed throughout the study area as well as within a particular site, which is reflective of the distribution and quality of microhabitats, particularly the substrate. In general, mussels were most abundant in compact sand and clay, which existed in small patches throughout the braided channel system. Although not investigated as part of this study, the size, number and age of beaver dams at a particular site is likely the most important factor determining mussel distribution and abundances. Many of the river sections that were free flowing in the mid 1990's are now inundated by multiple beaver dams, with no discernable channel (Tim Savidge, personal observations). Large concentrations of relict shells, with very few live individuals were observed in many of these areas, suggesting a localized decline in habitat suitability. However, high numbers of mussels were occasionally found in close proximity to beaver dams, in the main channel as well as secondary channels. Although not quantified, mussel abundances appeared to be negatively affected by increasing amount of fine sediments and woody debris.

5.0 DISCUSSION

These surveys provide new and updated mussel distribution for the section of the Little River that will be impacted by the proposed action. Much of the survey effort took place during extreme drought conditions in the region; however, the Little River did not appear to be as significantly impacted with regards to water levels as other streams in the area as

the beaver dam complexes appeared to retain water (Tim Savidge, personal observations).

5.1 The Mussel Fauna of the Little River

Historically, at least 20 species of freshwater mussels have been reported to occur in the Little River subbasin. This study confirms the high species diversity (for Atlantic Slope drainages) of this stream, as at least 16 species were collected. It is very possible that the *E. complanata* and *E. icterina* complexes are represented by several species, which would further raise the number of species in the subbasin. The only two species reported to occur in Swift Creek that were not found in this study are the green floater (*Lasmigona subviridis*) and the Carolina lance (*Elliptio angustata*). The green floater was reported as occurring in Swift Creek by Walter (1956) and one specimen was found by Alderman (1991); however, it has not been found in Swift Creek in subsequent surveys. Taxonomic uncertainties with lanceolate elliptios exist; thus, specimens reported as the Carolina lance in previous surveys may in fact be the same species as what is reported in this study as the Atlantic spike or the northern lance, two other lanceolate elliptio species.

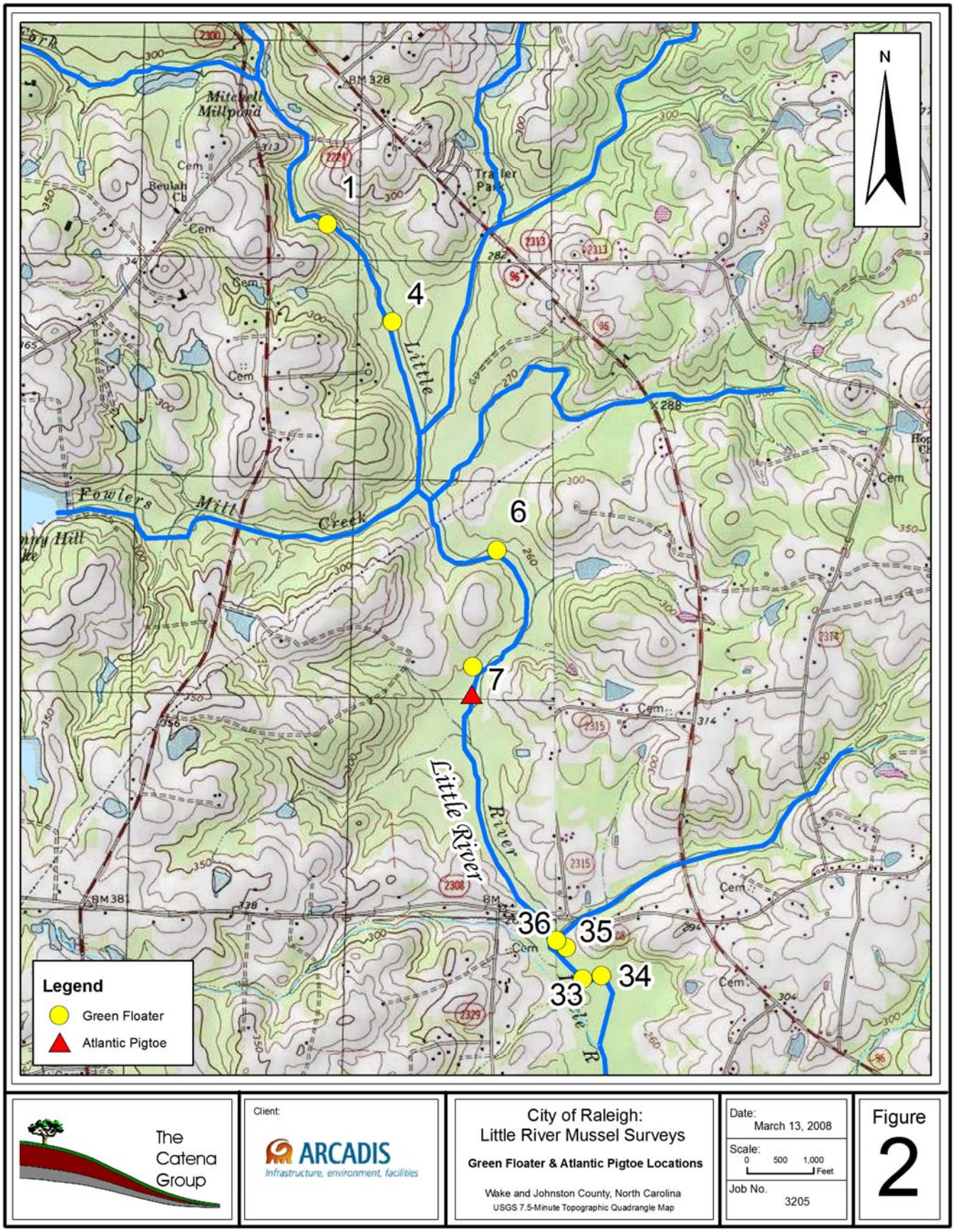
5.1.1 Mussel species found during the surveys

Brief descriptions of each of the mussel species found in the Little River are provided below. The original species descriptions along with Bogan (2002) and Johnson (1970) should be consulted for more detailed descriptions. Distribution within the study area for each species is shown in Figures 2-8.

5.1.1.1 *Alasmidonta undulata* (triangle floater)
This species was described from the Schuylkill River near Philadelphia (Say 1817). Its range extends from the Savannah River in South Carolina/Georgia north to the lower St. Lawrence River. The shell shape is subtriangular to ovate and inflated. The anterior and ventral shell margins are rounded. The periostracum is dull yellowish green with distinct green rays of varying width and length. This species is considered special concern throughout its range (Williams et al. 1993), and is listed as Threatened in North Carolina.

This species can occur in a variety of habitats in small streams to large rivers, usually in quiet waters with some current in a variety of substrates. Based on previous collections, this species ranges throughout most of the Little River from its headwaters to the confluence with the Neuse River; however, it was not detected within the proposed reservoir pool during this study. It was found at only three sites (four individuals) with a maximum of three individuals at a particular site (Site 30). One of the sites was represented by relict shell only. The four live individuals ranged in size from 63 mm to 74 mm Total Length (TL).

5.1.1.2 *Elliptio complanata* (eastern elliptio)
This species was described as *Mya complanata* from the Potomac River in Maryland (Lightfoot 1786). Shell characteristics are highly variable. Shell shape is typically trapezoidal to rhomboid, and compressed to inflated. The usually straight ventral margin is mostly parallel with the dorsal margin and the posterior margin is broadly rounded.



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Little River Mussel Surveys

Green Floater & Atlantic Pigtoe Locations

Wake and Johnston County, North Carolina
USGS 7.5-Minute Topographic Quadrangle Map

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Job No. 3205

Figure 2

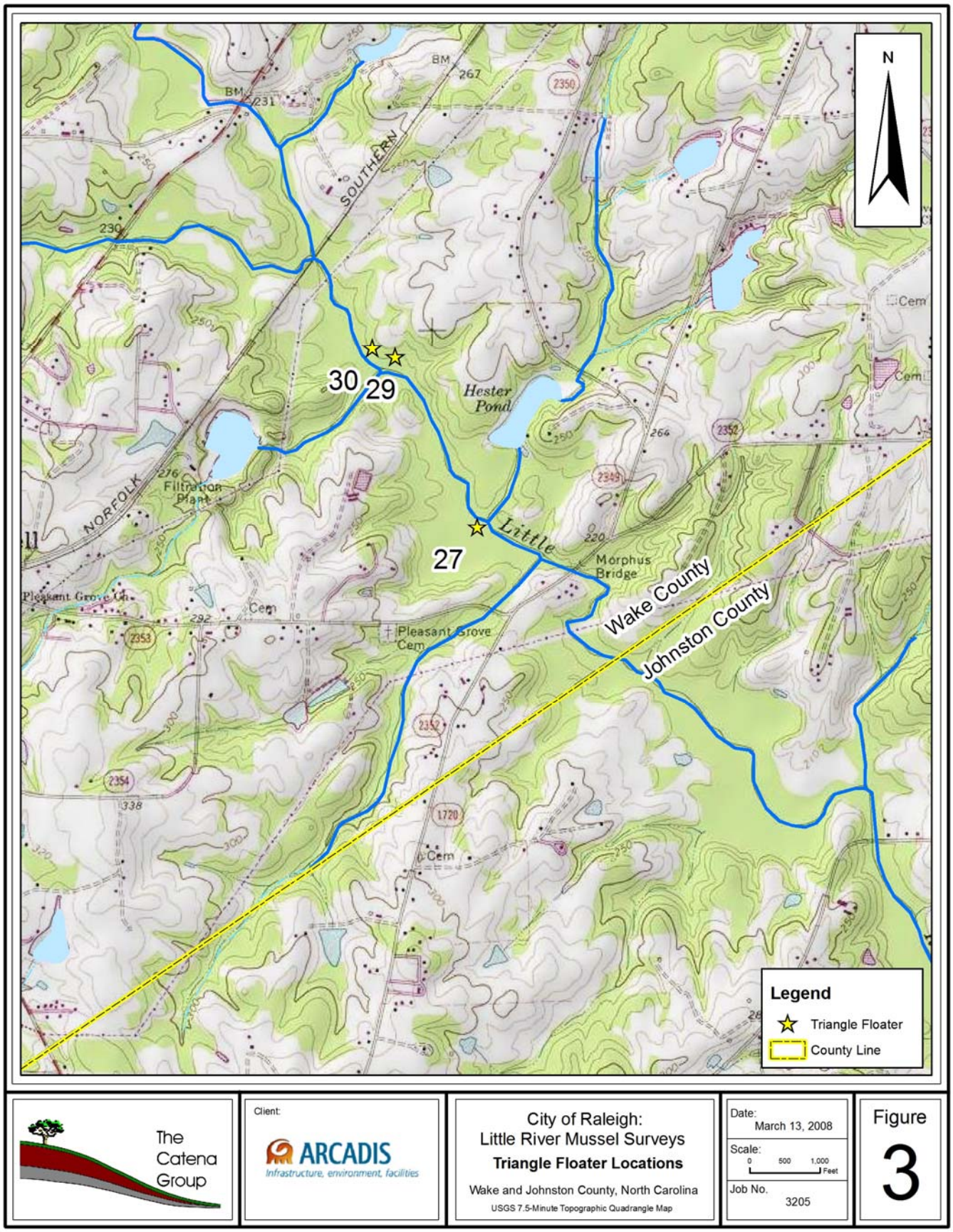
Shell thickness varies from thin to solid. Johnson (1970) synonomized the following species described from the Neuse River Basin with *E. complanata*: Unio (= *Elliptio*) *macer*, *U. neusensis*, *U. exactus*, *U. raleighensis*, *U. aberrans*, *U. quadrilatterus*, *U. idefinitus*, *U. cisteliformis*, *U. protensus*, and *U. ratus*. This species is widely distributed along the Atlantic Slope from the Altamaha River Basin in Georgia north to the St. Lawrence River Basin, and west to Lake Superior and parts of the Hudson Bay Basin. It can be found in a variety of habitats from large rivers and lakes to small headwater streams. The species is widespread and common throughout its range and considered "Stable" (Williams, Warren et al. 1993).

This species occurred at all of the sites sampled (except Site 9) and was the most abundant. Multiple age classes were observed ranging in size from 23 mm to 100 mm TL. Several forms occurred throughout the study area, often within a particular site. This species generally occupied multiple habitat types within a particular site. However, due to time constraints and not being the focus of this study, efforts to correlate different forms with different habitat types were not attempted. It is unclear whether the variations in shell morphology within the study area, as well as within particular sites, represent ecophenotypic or genotypic variability.

5.1.1.3 *Elliptio fisheriana* (northern lance)
This species was described from the Chester River in Maryland (Lea 1838). The shell is more than twice as long as high coming to a posterior point, usually at or above the midline between the dorsal and ventral margins. The dorsal ridge is angled. The smooth periostracum of the northern lance is usually yellowish-green with darker green rays, becoming black with age. Johnson (1970) synonymized this species and 25 other named species of lance-shaped elliptio mussels into *Elliptio lanceolata*. Recent genotypic and phenotypic analysis suggests that some of these formally described species are valid, including "true" *Elliptio lanceolata* (type locality, Tar River). Northern populations are thinner and more elongate than those from the south. The nacre may be purple or white. The northern lance likely encompasses several lanceolate elliptios, with similar characteristics that were described from a number of river basins along the Atlantic Slope. Included in this is *Elliptio viridula* from the Neuse River Basin. The name *E. fisheriana* is used for these forms as it is the oldest one. Because of taxonomic uncertainty, the status of this species is undetermined.

The northern lance was found at 32 of the 36 sites and was the second most common species encountered. It was typically found in shallow, bank habitats with soft substrates.

5.1.1.4 *Elliptio icterina* (variable spike)
Described from the Savannah River near Augusta Georgia (Conrad 1834), this highly variable species represents a complex of nearly 50 species (Johnson 1970). The shell shape is oblong, subelliptical, or subrhomboid, with a prominent posterior ridge, and moderately elevated beaks. The periostracum is usually smooth and greenish yellow to tawny-brown. This species is considered common and currently stable throughout its range (Williams et al. 1993).


N
30
29
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Hester Pond
Little
Morphus Bridge
Wake County
Johnston County
SOUTHERN
NORFOLK
Filtration Plant
Pleasant Grove Cem
Legend
Triangle Floater
County Line
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Wake and Johnston County, North Carolina
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March 13, 2008
Scale:
0 500 1,000 Feet
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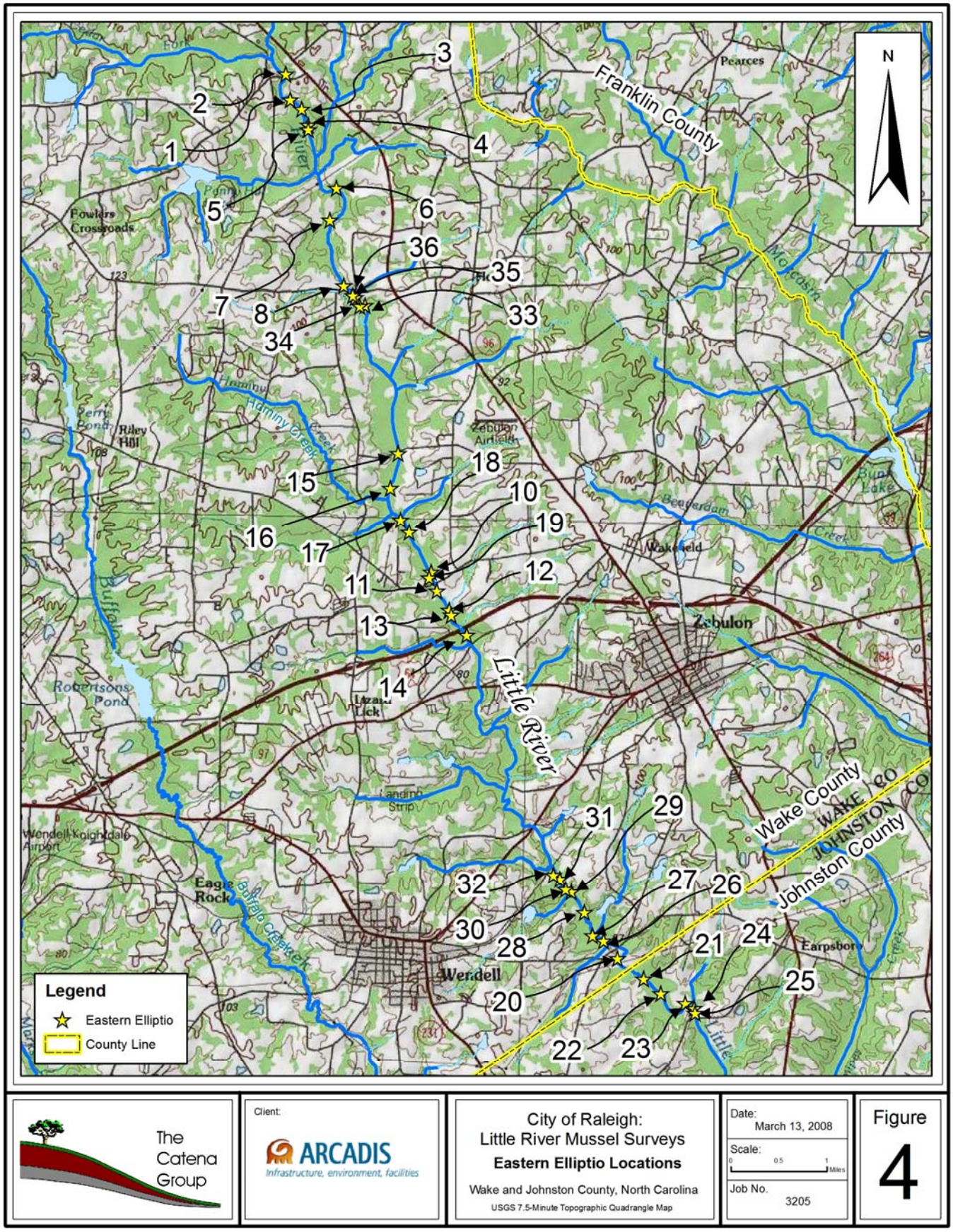
3205
Figure
3

The variable spike was found at 31 of the 36 sites. This was the third most abundant species encountered, and like the eastern elliptio, multiple age classes were observed (20-87 mm TL). This species was found in multiple habitat types within the study area; however, it appeared to be most prevalent in habitats containing coarse sand and gravel substrates. Due to time constraints and not being the focus of this study, efforts to correlate different forms with different habitat types were not attempted. It is unclear whether the variations in shell morphology within the study area, as well as within particular sites, represent ecophenotypic or genotypic variability.

5.1.1.5 *Elliptio* spp. (*E. complanata* and *E. icterina* complexes)
Mussels in the genus *Elliptio* were the most common species found throughout the study area. Based on shell morphologies, Johnson (1970) synonymized nearly 150 named species into two complexes: *E. complanata* and *E. icterina* respectively (102 and 47). Many of these species were described in the Carolinas. Preliminary genetic research suggests that some of these may be valid species. In some of the streams surveyed for this project, there appeared to be several forms of *Elliptio*, with gradation between each form, making separation difficult and subjective. A number of distinct "forms" of *E. complanata* and *E. icterina* were consistently noted during this study. Unfortunately time constraints and the scope of this study did not allow for the separation of each form at each site and assignment of a former species name to the elliptio fauna found. In many instances, separation into the two species complexes was determined to be too time consuming thus causing excessive exposure (time out of the water) of individual mussels; thus, they were lumped into one group (*Elliptio* spp.). A total of 2,226 elliptio mussels were lumped into the *E*. spp. When separation to species complex was made, the ratio of *E. complanata* to *E. icterina* was estimated at 9.7 to 1. Thus, it is estimated that the *E*. spp. consisted of approximately 2,157 *E. complanata* and 69 *E. icterina*.

5.1.1.6 *Fusconaia masoni* (Atlantic pigtoe)
The Atlantic pigtoe was described by Conrad (1834) from the Savannah River in Augusta, Georgia. Its range extends from the Ogeechee River Basin in Georgia north to the James River Basin in Virginia (Johnson 1970). The Atlantic pigtoe occurs in medium size streams to large rivers, but has experienced major declines throughout its entire range. The preferred habitat is a substrate composed of gravel and coarse sand, usually at the base of riffles; however, it can be found in a variety of other substrates and habitat conditions (personal observations). Shells of the Atlantic pigtoe are subrhomboidal in outline, with a parchment, or cloth-like yellow to dark brown periostracum. The posterior ridge is very distinct, and the umbos extend well above the dorsal margin. The dorsal margin is also marked by a short, thick hinge ligament. Williams et al. (1993) list this species as endangered. It is considered Endangered in North Carolina and is a Federal Species of Concern.

Only one individual of this species was found (Site 7) during the entire study. Although it has been recorded within the study area during previous surveys, the species appears to be more prevalent in the river further downstream in Johnston County. Its apparent rarity



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Little River Mussel Surveys
Eastern Elliptio Locations
Wake and Johnston County, North Carolina
USGS 7.5-Minute Topographic Quadrangle Map

Date: March 13, 2008
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Figure 4

in within the study area is likely a reflection of a rarity of suitable habitat due to the beaver dams.

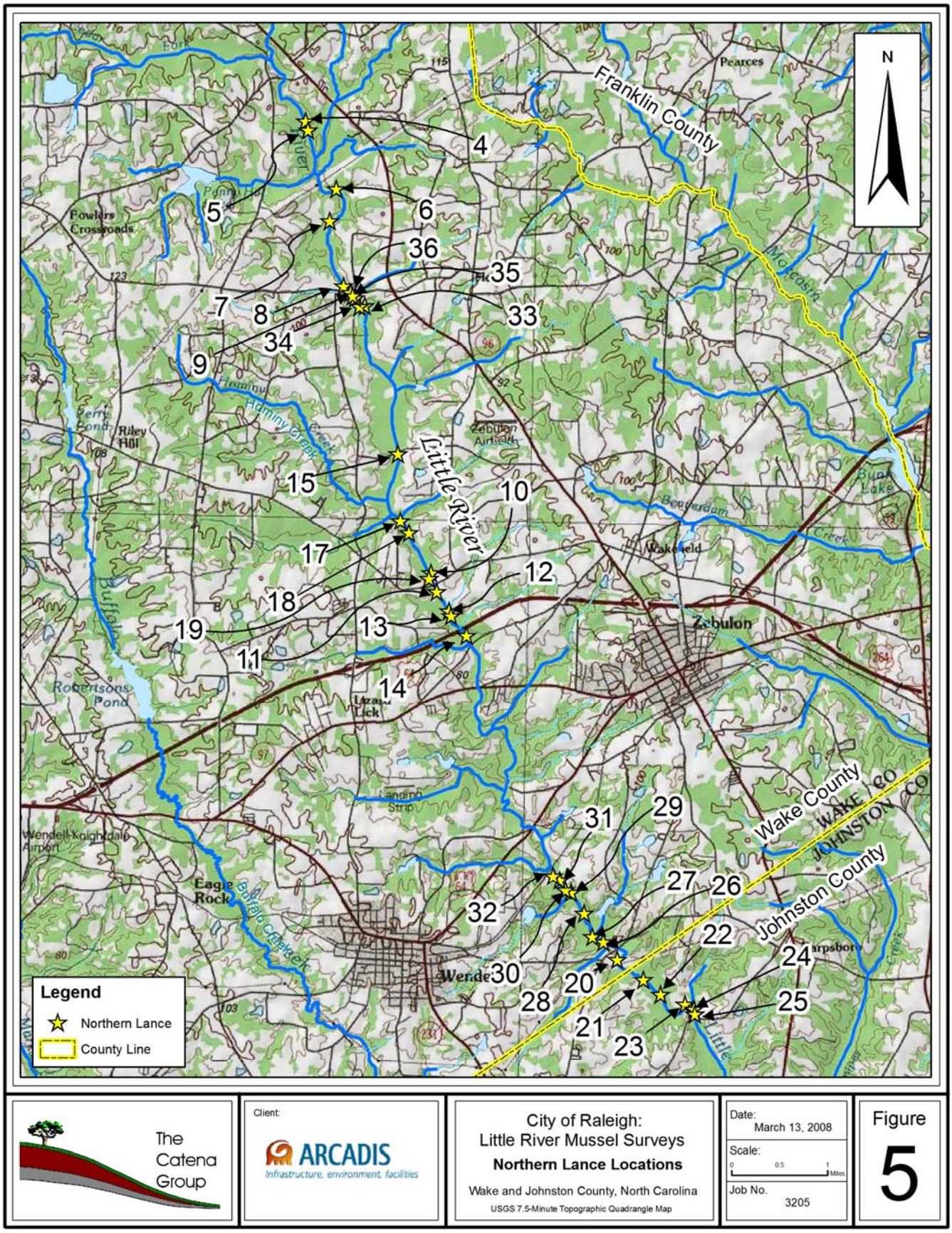
5.1.1.7 *Lasmigona subviridis* (green floater)
The green floater, described by Conrad (1835) from the Schuylkill River in Lancaster County, Pennsylvania, is relatively small with a thin slightly inflated subovate shell that is narrower in front and broader behind. The dorsal margin forms a blunt angle with the posterior margin. The shell is dull yellow or tan to brownish green, usually with concentrations of dark green rays. The green floater occurs along the Atlantic slope from the Savannah River in Georgia north to the Hudson River in New York, as well as in the "interior" river basins, the New, Kanawah, and Wataugua (of the Tennessee River). It occurs in small size streams to large rivers, in quiet waters of pools, or eddies, with gravel and sand substrates. It has experienced major declines throughout its entire range.

This species is a Federal Species of Concern and is listed as endangered in North Carolina. Williams et al. (1993) list this species as Threatened. Efforts are being made by the USFWS to gather information to elevate this species to Candidate status.

Based on preliminary genetics research, the southern populations of the green floater (Tar Pamlico, Neuse, and Yadkin/Pee Dee River Basins) appear to be genetically distinct from populations from the Roanoke River to the north and west (Railey and Bogan 2007 personal communication). Further research is needed to determine if these differences warrant classification of the southern populations as a distinct species.

This species occurred in low numbers (total nine individuals) at eight sites, all within the proposed reservoir pool. Size range of individuals found was from 42 to 61 mm TL with three size (age) classes observed. Gravid (females holding young) were observed during the surveys in October. Based on previous surveys, this species distribution within the Little River is primarily confined to the upper portion of the basin, with most occurrences located within the proposed reservoir pool. Although it is difficult to make population based conclusions from qualitative survey efforts, this species was locally common in a number of sites in the Little River (Alderman 2007, personal communication, Tim Savidge, personal observations). Its apparent rarity in this and other recent surveys (NCWRC 2008) indicate a declining trend in population numbers and possibly distribution.

5.1.1.8 *Pyganadon cataracta* (eastern floater)
Described by Say (1817) in the deep part of a milldam presumably near Philadelphia, this species is wide ranging in the Atlantic drainages from the lower St. Lawrence River Basin south to the Altamaha River Basin, Georgia, and in the Alabama-Coosa River drainage, and the Apalachicola and Coctawhatchee River Basins, Florida. The shells of this species are uniformly thin, and lack hinge teeth. The shell shape is ovate, subelliptical and elongate, with an evenly rounded anterior margin and a broadly rounded ventral margin. The periostracum is light to dark green with broad green rays on the posterior slope. Ortman (1919) recognized three generalized shell forms that were related to environmental conditions: the pond form, the creek/small river form, and the



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Northern Lance Locations
Wake and Johnston County, North Carolina
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Figure 5

big river form. The pond form occurs in small ponds with muddy substrates and is characterized by very thin elongate inflated shells. The creek form occurs in riffle-pool habitats in gravel substrates and is much thicker and more compressed. The big river form is generally short and inflated and occurs in soft substrates. This species is considered common and currently stable throughout its range (Williams et al. 1993).

This species was found at only two sites in the upper portion of the study area (total four individuals). Its apparent rarity is not understood, as it typically prefers slack water habitats, which are prevalent in the study area.

5.1.1.9 *Utterbackia imbecillis* (paper pondshell)
Described from the Wabash River in Indiana (Say 1829), this mussel occurs throughout the Mississippi River and Great Lakes drainages, as well as sporadically along the Atlantic slope. It has an extremely thin shell that is oblong and inflated. The dorsal and ventral margins are nearly straight and parallel. The periostracum is greenish yellow with fine green rays. This species is considered common throughout its range (Williams et al. 1993).

This species was found at seven sites throughout the study area in low numbers (total 13 individuals). Like with the eastern floater, its apparent rarity is not understood, as it typically prefers slack water habitats, which are prevalent in the study area.

5.1.2 Targeted Mussel species not found during the surveys

The federally endangered dwarf wedgemussel and Tar spinymussel, as well as the state endangered yellow lampmussel, yellow lance and the state threatened creeper, eastern lampmussel, and Roanoke slabshell and the state special concern notched rainbow are all known to occur within the Little River. Brief descriptions of each of these species, along with possible explanations for their absence in this study, are provided below.

5.1.2.1 *Alasmidonta heterodon* (dwarf wedgemussel)
Originally described as *Unio heterodon* (Lea 1829), the dwarf-wedge mussel was listed as federally endangered on March 14, 1990. The specific epithet *heterodon*, refers to the chief distinguishing characteristic of this species, which is the only North American freshwater mussel that consistently has two lateral teeth on the right valve and only one on the left (Fuller 1977). All other laterally dentate freshwater mussels in North America normally have two lateral teeth on the left valve and one on the right. The dwarf wedgemussel is generally small, with a shell length ranging between 25 mm and 38 mm TL. The largest specimen ever recorded was 56.5 mm TL taken from the Ashuelot River in New Hampshire (Clarke 1981). The periostracum is generally olive green to dark brown and the nacre bluish to silvery white, turning to cream or salmon colored towards the umbonal cavities. Sexual dimorphism occurs, with the females having a swollen region on the posterior slope, and the males are generally flattened. Clarke (1981) provides a detailed description of the species.

The historic range of the dwarf-wedge mussel was confined to Atlantic slope drainages from the Peticodiac River in New Brunswick, Canada, south to the Neuse River, North

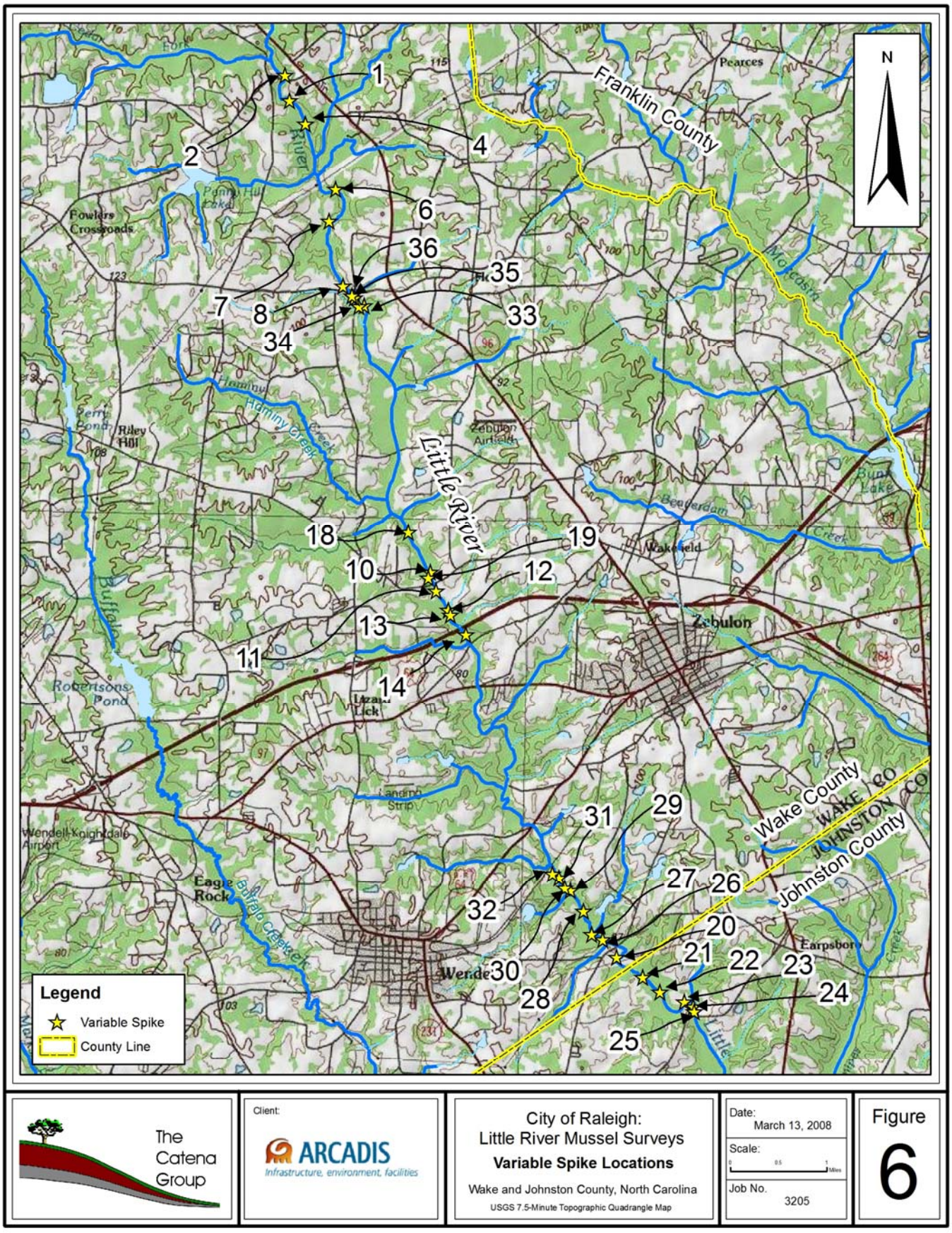

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Figure 6

Carolina. Occurrence records exist from at least 70 locations, encompassing 15 major drainages, in 11 states and 1 Canadian Province (USFWS 1993). It is currently believed to have been extirpated from all but 36 localities, 14 of them in North Carolina (USFWS 1993). The dwarf-wedge mussel inhabits creeks and rivers of varying sizes (down to approximately 6.6 feet wide), with slow to moderate flow. A variety of preferred substrates have been described that range from coarse sand, to firm muddy sand to gravel (USFWS 1993). In North Carolina, the dwarf-wedge mussel often occurs within submerged root mats along stable streambanks. The wide range of substrate types used by this species suggests that the stability of the substrate is likely as important as the composition.

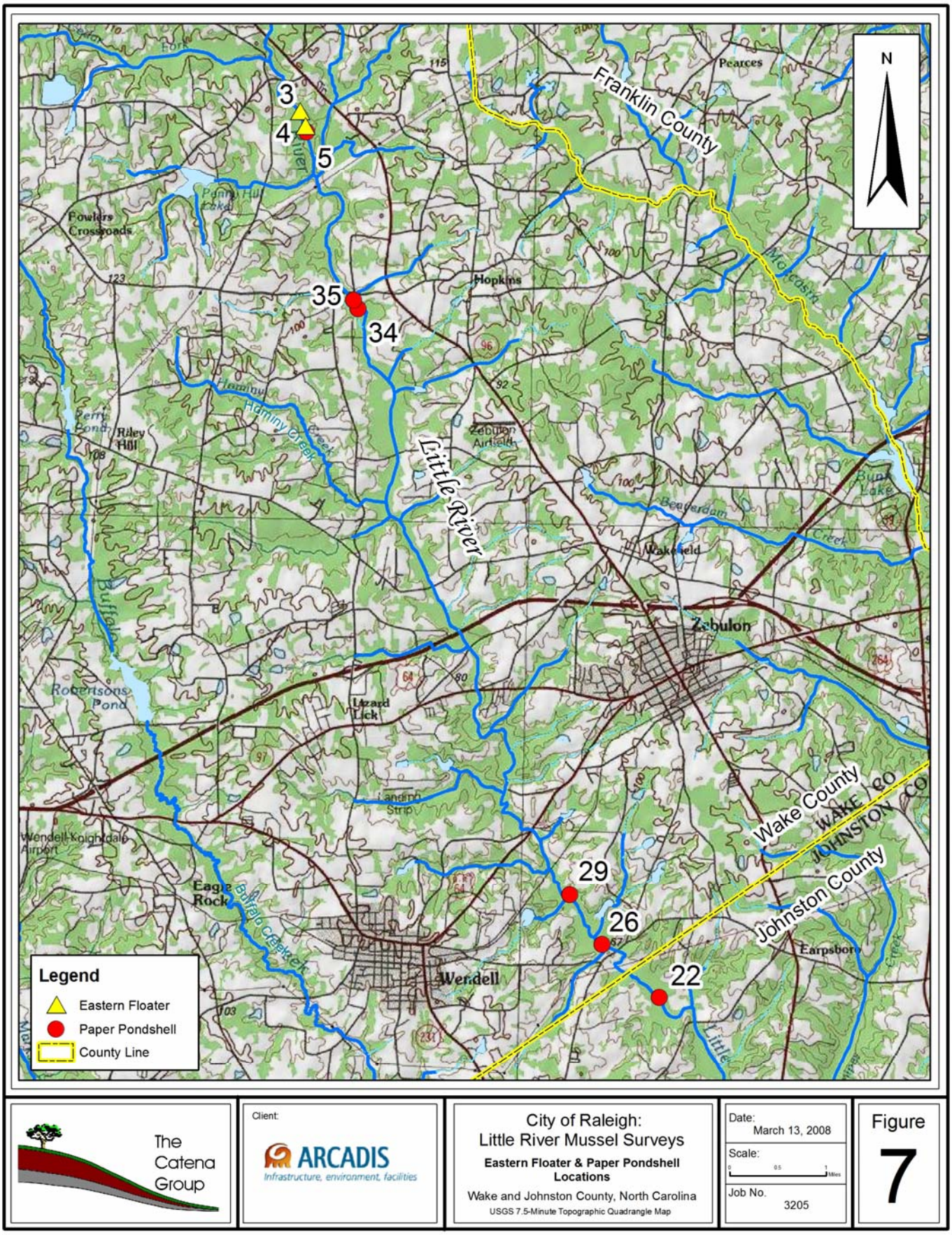
Suitable habitat for this species does occur sporadically throughout the study area. However, its absence during this study and other recent surveys suggest the species is extremely rare, or absent, from this stretch of the Little River.

5.1.2.2 *Elliptio lanceolata* (yellow lance)
Described from the Tar River at Tarboro, North Carolina by Lea (1828), this species differs from other lance-shaped elliptios by having a "waxy" bright yellow periostracum that lacks rays. The posterior ridge is distinctly rounded and curves dorsally towards the posterior end. This species is distributed from the Neuse River Basin north to the Rappahannock, but is in considerable decline throughout its range. Extant populations occur in the Neuse, Tar/Pamlico, Chowan and York River basins. This species is a Federal Species of Concern and is listed as Endangered in North Carolina. Williams et al. (1993) list this species as Endangered range wide.

This species is typically found in sandy/gravel substrates associated with riffle habitats, which are lacking in the study area. Based on survey data, it appears to have declined dramatically in the Little River, a phenomena that is occurring with nearly all of the known yellow lance populations.

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

The Roanoke slabshell is believed to use an anadromous fish species as its host species, because it is usually not found above the first barrier on a water body. Anecdotal evidence suggested that the removal of the Raines Mill Dam in 1998, allowed the species to expand its range in the Little River up to the next barrier the Lowell Mill Dam (The Catena Group 2005), which was removed in 2006. Additional monitoring of the river



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Wake and Johnston County, North Carolina

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Scale: 0 0.5 1 Miles

Job No. 3205

Figure 7

will be conducted to determine if the species will continue to expand its range in the river.

5.1.2.4 *Elliptio steinstansana* (Tar spinymussel)
The Tar spinymussel was described from the Tar River (Johnson and Clarke1983). It grows to a maximum length of 60 millimeters. Short spines are arranged in a radial row anterior to the posterior ridge on one valve and symmetrical to the other valve. The shell is generally smooth in texture with as many as 12 spines that project perpendicularly from the surface and curve slightly ventrally. However, adult specimens tend to lose their spines as they mature (USFWS 1992). It is distinguished by its shiny periostracum, parallel pseudocardinal teeth, and the linear ridges on the inside surface of the shell.

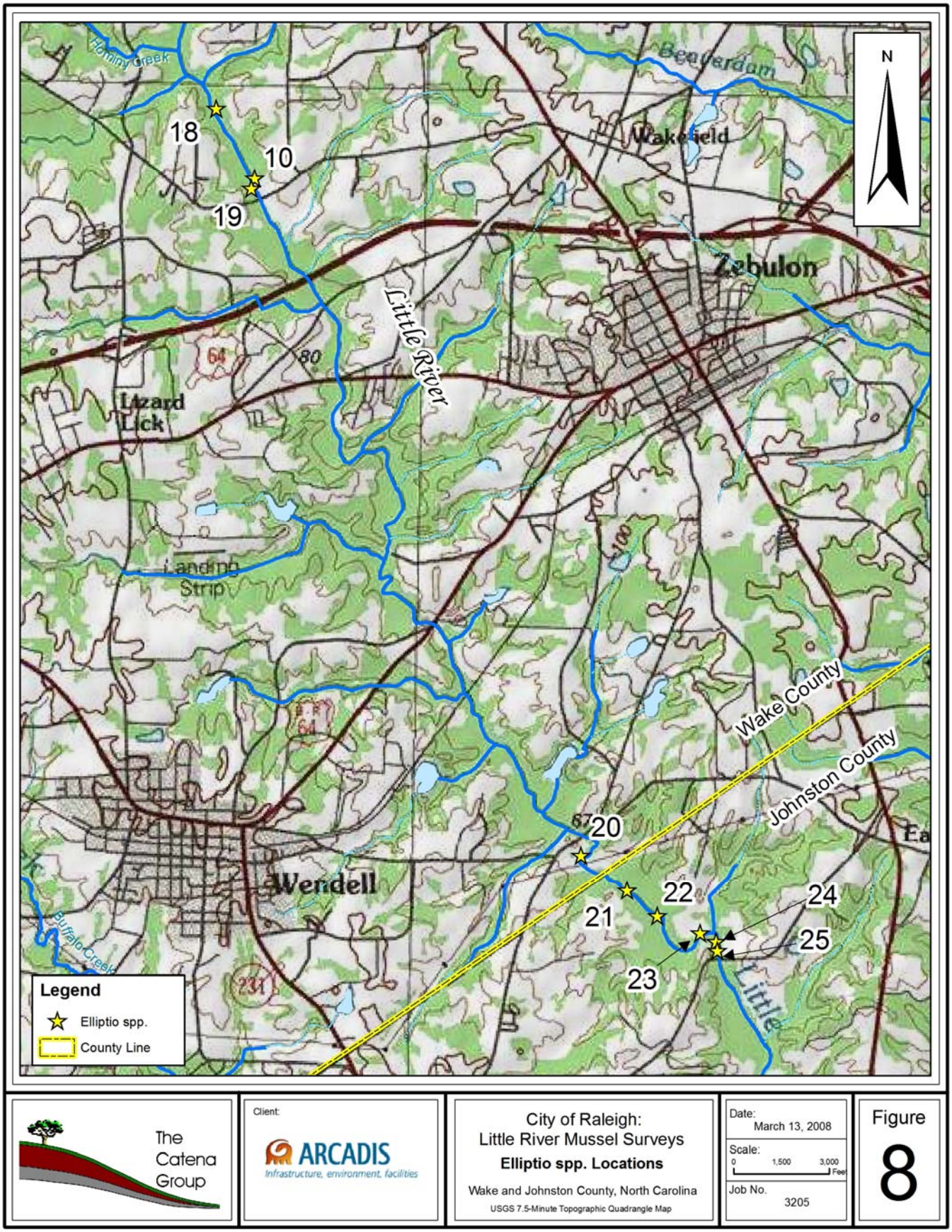
This species is known from relatively short stretches of the Tar River and three creeks (Shocco, Sandy/Swift and Fishing/Little Fishing) within in the Tar River drainage, and in the Johnston County portion of the Little River of the Neuse River Basin.

As mentioned previously, this species is represented in the Little River, by only three individuals. Clarke (1983) concluded that the Little River was too "slow moving" to support this species. Typical sandbar habitats with relatively fast flow are lacking from the study area.

5.1.2.5 *Lampsilis cariosa* (yellow lampmussel)
This species was described from the Schuykill River near Philidelphia (Say 1817). Its range extends from the Ogeechee River in Georgia north to Novia Scotia. The waxy-yellow shell is obovate in outline, with a rounded anterior margin and slightly curved posterior margin and is rarely rayed. Like other members of this genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more rounded, particularly in the posterior margin. This species is a Federal Species of Concern and is listed as Endangered in North Carolina. Williams et al. (1993) list this species as endangered.

This species typically occurs in coarse sand substrates in riffle and glide habitats, which are largely absent from the study area as a result of beaver dams.

5.1.2.6 *Lampsilis radiata radiata* (eastern lampmussel) and *Lampsilis radiata conspicua* (Carolina fatmucket)
The eastern lampmussel was described from Saratoga Lake in New York by Lamarck (1819). Carolina fatmucket was described from the Yadkin/Pee Dee River Basin in North Carolina as *Unio conspicuus* by Lea (1874). Simpson (1914) considered it to be a variety of *L. radiata radiata* (eastern lampmussel). The Carolina fatmucket was synonomized with *L. radiata radiata* by Johnson (1970). The taxonomic status of the *Lampsilis radiata* complex is still uncertain. Both the eastern lampmussel and the Carolina fatmucket forms are known to occur in the Neuse River basin. This large mussel is subelliptical to subovate in outline. Shells are generally thick and solid, with rounded anterior and posterior margins. The periostracum is usually yellowish or brownish green with dark green rays over the entire surface. Like other members of this



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Elliptio spp. Locations
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Job No. 3205

Figure 8

genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more rounded and swollen, particularly in the posterior margin. Williams et al. (1993) consider this species to be Stable; however, both the eastern lampmussel and the Carolina fatmucket are considered Threatened in North Carolina.

The absence of this species from the study area, and its apparent rarity in throughout much of the Little River (based on previous surveys), is not understood. This species occurs in a variety of habitat conditions, and has been found in other water bodies that have multiple beaver impoundments like the Little River (Tim Savidge personal observations).

5.1.2.7 *Strophitus undulatus* (creeper)
This species was described from the Schuylkill River near Philadelphia (Say 1817). Its range extends throughout much of the Interior River Basin and Atlantic Slope regions. The shell is elliptical to rhomboid in outline and somewhat inflated. The anterior end is rounded, and the posterior end is bluntly pointed. The periostracum is yellowish green to brown, with dark green rays. This species occupies a variety of habitats, from high-gradient small streams, to larger rivers. Williams et al. (1993), considers it Special Concern and it is listed as Threatened in North Carolina.

Like with the eastern lampmussel, the absence of the creeper from this study is not understood, as it also can be found in a variety of habitats, including those associated with beaver impoundments (Tim Savidge personal observations). This species can be found in low numbers with relative ease in the Little River in Johnston County (Tim Savidge personal observations).

5.1.2.8 *Villosa constricta* (notched rainbow)
Described by Conrad (1838) from the North River in Rockbridge County, Virginia, it is reported to occur from the James River Basin in Virginia south to the Catawba River Basin in North Carolina (Johnson 1970). The shell is fairly small and short, and subelliptical in outline. The beaks are generally not elevated. The periostracum is shiny yellowish green to black occasionally having dark green rays. Like other members of the genus, the notched rainbow is sexually dimorphic; however, the marsupial swelling of the females is generally small compared to other species. Williams et al. (1993) lists this species as Special Concern. It is listed as Special Concern in North Carolina.

This species, like the Tar spinymussel, is typically found in riffle/glide habitats with gravel substrate, which are largely absent from the study area. It can be found in low numbers with relative ease in the Little River in Johnston County (Tim Savidge personal observations), but based on recent surveys (NCWRC 2008), it appears to be declining in range, as it has not been found in the study area in recent years.

6.0 CONCLUSIONS

Based on the survey results, it is apparent that a fairly diverse mussel fauna is present within the potential impact area. However, the study also indicates that there may be trend in reduction of numbers and species diversity within the study area of the Little

River. Neither the dwarf wedgemussel, nor the notched rainbow, were found during this study, despite being present in the study area in previous years. Additionally, based on CPUE, some of the rare mussel species like the green floater and Atlantic pigtoe, may be declining within the study area. This apparent trend may be the result of habitat modifications caused by beaver impoundments and may be temporary, unless other anthropogenic or natural factors impact the Little River.

These and previous survey results also indicate that the Little River population of the green floater is largely confined to the area that occurs within the proposed reservoir pool. Inundation of this reach of river may result in further reduction of numbers or the ultimate extirpation of the population.

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APPENDIX A

DEFINITIONS OF FEDERAL AND STATE LISTING CATEGORIES

(From LeGrand et al. 2006)

United States Status. This status is designated by the U.S. Fish and Wildlife Service. Federally listed Endangered and Threatened species are protected under the provisions of the Endangered Species Act of 1973, as amended through the 100th Congress. Unless otherwise noted, definitions are taken from the Federal Register, Vol. 56, No. 225, November 21, 1991 (50 CFR Part 17).

STATUS CODE	STATUS	STATUS DEFINITION
E	Endangered	A taxon "which is in danger of extinction throughout all or a significant portion of its range" (Endangered Species Act, Section 3).
T	Threatened	A taxon "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (Endangered Species Act, Section 3).
FSC	(Federal) Species of Concern [also known as Species at Risk]	"... the Service is discontinuing the designation of Category 2 species as candidates in this notice. The Service remains concerned about these species, but further biological research and field study are needed to resolve the conservation status of these taxa. Many species of concern will be found not to warrant listing, either because they are not threatened or endangered or because they do not qualify as species under the definition in the [Endangered Species] Act. Others may be found to be in greater danger of extinction than some present candidate taxa. The Service is working with the States and other private and public interests to assess their need for protection under the Act. Such species are the pool from which future candidates for listing will be drawn." (Federal Register, February 28, 1996). The Service suggests that such taxa be considered as "Species of Concern" or "Species at Risk", neither of which has official status. The N.C. Natural Heritage Program uses "(Federal) Species of Concern" in this document for those taxa formerly considered as Category 2.
P	Proposed	Species proposed in the Federal Register as a status different from its current Federal status.

T (S/A)	Threatened due to Similarity of Appearance	"Section 4 (e) of the [Endangered Species] Act authorizes the treatment of a species (subspecies or population segment) as endangered or threatened even though it is not otherwise listed as endangered or threatened if -- (a) the species so closely resembles in appearance an endangered or threatened species that enforcement personnel would have substantial difficulty in differentiating between the listed and unlisted species; (b) the effect of this substantial difficulty is an additional threat to an endangered or threatened species; and (c) such treatment of an unlisted species will substantially facilitate the enforcement and further the policy of the Act." (Federal Register, November 4, 1997). [The American Alligator is listed as T (S/A) due to Similarity of Appearance with other rare crocodilians, and the southern population of the Bog Turtle is listed as T (S/A) due to Similarity of Appearance with the northern population of the Bog Turtle (which is federally listed as Threatened and which does not occur in North Carolina).]
XN	Nonessential Experimental Population	"Section 10 (j) of the Endangered Species Act of 1973, as amended, provides for the designation of introduced populations of federally listed species as nonessential experimental. This designation allows for greater flexibility in the management of these populations by local, state, and Federal agencies. Specifically, the requirement for Federal agencies to avoid jeopardizing these populations by their actions is eliminated and allowances for taking the species are broadened." (U.S. Fish and Wildlife Service, 1995).
D	De-listed	Species has been proposed by the U.S. Fish and Wildlife Service for de-listing from the List of Endangered and Threatened Wildlife. However, at the present time, the species is still on the List of Endangered and Threatened Wildlife and is thus protected under the Endangered Species Act. Because such species still have legal Federal protection, the NHP will maintain existing records on the species, though new records might not necessarily be added. If the status becomes law prior to the next publication of the NHP Rare Animal List, the Program will remove the Federal designation from its database (and thus the species will no longer appear on printouts of Federally listed species). NHP may or may not continue to track the species, depending on its legal State status and other factors such as overall abundance and range in the state.

North Carolina Status. Endangered, Threatened, and Special Concern species of mammals, birds, reptiles, amphibians, freshwater fishes, freshwater and terrestrial mollusks, and crustaceans have legal protection status in North Carolina (Wildlife Resources Commission). In addition to the above categories, the Natural Heritage Program maintains computer and map files on Significantly Rare species, as well as species considered Extirpated. Paper files only are maintained for a few of the above species; these species are indicated by the phrase "not tracking."

STATUS CODE	STATUS	STATUS DEFINITION
E	Endangered	"Any native or once-native species of wild animal whose continued existence as a viable component of the State's fauna is determined by the Wildlife Resources Commission to be in jeopardy or any species of wild animal determined to be an 'endangered species' pursuant to the Endangered Species Act." (Article 25 of Chapter 113 of the General Statutes; 1987).
T	Threatened	"Any native or once-native species of wild animal which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, or one that is designated as a threatened species pursuant to the Endangered Species Act." (Article 25 of Chapter 113 of the General Statutes; 1987).
SC	Special Concern	"Any species of wild animal native or once-native to North Carolina which is determined by the Wildlife Resources Commission to require monitoring but which may be taken under regulations adopted under the provisions of this Article." (Article 25 of Chapter 113 of the General Statutes; 1987).
P	Proposed	Species has been proposed by a Scientific Council as a status (Endangered, Threatened, Special Concern, Watch List, or for Delisting) that is different from the current status, but the status has not yet been adopted by the General Assembly as law. In the lists of rare species in this book, these proposed statuses are listed in parentheses below the current status. Only those proposed statuses that are different from the current statuses are listed.

SR	Significantly Rare	Any species which has not been listed by the N.C. Wildlife Resources Commission as an Endangered, Threatened, or Special Concern species, but which exists in the state in small numbers and has been determined by the N.C. Natural Heritage Program to need monitoring. (This is a N.C. Natural Heritage Program designation.) Significantly Rare species include "peripheral" species, whereby North Carolina lies at the periphery of the species' range (such as Hermit Thrush).
EX	Extirpated	A species which is no longer believed to occur in the state. (This is a N.C. Natural Heritage Program designation, though WRC also uses this status; the NHP list includes those on the WRC list.)
W	Watch List	Any other species believed to be of conservation concern in the state because of scarcity, declining populations, threats to populations, or inadequacy of information to assess its rarity (see page 59 for a more complete discussion). (This is a N.C. Natural Heritage Program designation.)
G		Species is a game animal, and therefore (by law) cannot be listed for State protection as E, T, or SC.

APPENDIX B

MUSSEL SPECIES PER SITE

SITE	DATE	COORDINATES	SCIENTIFIC NAME	#	CPUE (#/ph)
1	4/20/2007	35.91051°N, -78.38607°W	*Elliptio complanata*	325	27.70
			Elliptio icterina	13	1.11
			Lasmigona subvirdis	1	0.08
2	4/20/2007	35.91435°N, -78.38688°W	*Elliptio complanata*	27	9.0
			Elliptio icterina	3	1.0
3	4/24/2007	35.90912°N, -78.38399°W	*Elliptio complanata*	34	34.0
			Elliptio icterina	5	5.0
			Pyganodon cataracta	1	1.0
4	4/24/2007	35.90678°N, -78.38289°W	*Elliptio complanata*	383	176.50
			Elliptio fisheriana	4	1.84
			Elliptio icterina	7	3.23
			Lasmigona subvirdis	3 shells	~
			Pyganodon cataracta	3	1.38
			Utterbackia imbecillis	1	0.46
5	4/24/2007	35.90601°N, -78.38278°W	*Elliptio complanata*	58	58.0
			Elliptio fisheriana	4	4.0
			Utterbackia imbecillis	5	5.0
6	4/24/2007	35.89702°N, -78.37760°W	*Elliptio complanata*	124	57.14
			Elliptio fisheriana	22	10.14
			Elliptio icterina	4	1.84
			Lasmigona subvirdis	2	0.92
7	4/24/2007	35.89223°N, -78.37885°W	*Elliptio complanata*	162	108.0
			Elliptio fisheriana	13	8.67
			Elliptio icterina	12	8.0
			Fusconaia masoni	1	0.67
			Lasmigona subvirdis	2	1.33
8	4/24/2007	35.88238°N, -78.37632°W	*Elliptio complanata*	31	20.67
			Elliptio fisheriana	3	2.0
			Elliptio icterina	1	0.67
9	4/24/2007	35.88141°N, -78.37509°W	*Elliptio fisheriana*	1 shell	~
10	4/25/2007	35.83909°N, -78.36050°W	*Elliptio fisheriana*	32	8.53
			Elliptio spp.	674	179.73
11	4/25/2007	35.83622°N, -78.35941°W	*Elliptio complanata*	192	83.48
			Elliptio fisheriana	4	1.74
			Elliptio icterina	5	2.17
12	4/25/2007	35.83336°N, -78.35720°W	*Elliptio complanata*	96	60.0
			Elliptio fisheriana	3	1.88
			Elliptio icterina	1	0.63
13	4/25/2007	35.83256°N, -78.35682°W	*Elliptio complanata*	163	122.56
			Elliptio fisheriana	1	0.75
			Elliptio icterina	2	1.50
14	4/25/2007	35.82961°N, -78.35398°W	*Elliptio complanata*	17	17.0
			Elliptio fisheriana	12	12.0
			Elliptio icterina	1	1.0
15	5/15/2007	35.85706°N, -78.36649°W	*Elliptio complanata*	98	19.6
			Elliptio fisheriana	5	1.0
16	5/15/2007	35.85184°N, -78.36797°W	*Elliptio complanata*	5 shells	~

SITE	DATE	COORDINATES	SCIENTIFIC NAME	#	CPUE (#/ph)
17	5/15/2007	35.84700°N, -78.36613°W	*Elliptio complanata*	34	11.64
			Elliptio fisheriana	2	0.68
18	5/15/2007	35.84518°N, -78.36452°W	*Elliptio fisheriana*	23	3.45
			Elliptio spp.	11	1.65
19	5/15/2007	35.83821°N, -78.36086°W	*Elliptio fisheriana*	9	1.66
			Elliptio spp.	440	81.18
20	5/16/2007	35.78062°N, -78.32644°W	*Elliptio fisheriana*	2	0.57
			Elliptio spp.	278	79.43
21	5/16/2007	35.77757°N, -78.32162°W	*Elliptio fisheriana*	94	56.29
			Elliptio spp.	4	2.39
22	5/16/2007	35.77534°N, -78.31844°W	*Elliptio fisheriana*	2	1.60
			Elliptio spp.	13	10.40
			Utterbackia imbecillis	2	1.60
23	5/16/2007	35.77384°N, -7831390°W	*Elliptio fisheriana*	1	0.60
			Elliptio spp.	42	25.15
24	5/16/2007	35.77308°N, -78.31225°W	*Elliptio fisheriana*	6	1.20
			Elliptio spp.	236	47.20
25	5/16/2007	35.77232°N, -78.31211°W	*Elliptio fisheriana*	7	1.40
			Elliptio spp.	528	105.6
26	9/28/2007	35.78326°N, -78.32898°W	*Elliptio complanata*	29	12.45
			Elliptio fisheriana	7	3.0
			Elliptio icterina	6	2.58
			Utterbackia imbecillis	1	0.43
27	9/28/2007	35.78411°N, -78.33098°W	*Alasmidonta undulata*	1	0.41
			Elliptio complanata	236	97.12
			Elliptio fisheriana	6	2.47
			Elliptio icterina	28	11.52
28	9/28/2007	35.78761°N, -78.33249°W	*Elliptio complanata*	78	67.83
			Elliptio fisheriana	3	2.61
			Elliptio icterina	4	3.48
29	9/28/2007	35.79077°N, -78.33487°W	*Alasmidonta undulata*	1 shell	~
			Elliptio complanata	686	288.24
			Elliptio fisheriana	5	2.10
			Elliptio icterina	25	10.50
			Utterbackia imbecillis	1	0.42
30	9/28/2007	35.79113°N, -78.33595°W	*Alasmidonta undulata*	3	1.13
			Elliptio complanata	1005	379.25
			Elliptio fisheriana	3	1.13
			Elliptio icterina	17	6.42
31	9/28/2007	35.79270°N, -78.33699°W	*Elliptio complanata*	298	513.79
			Elliptio fisheriana	1	1.72
			Elliptio icterina	1	1.72
32	9/28/2007	35.79329°N, -78.33818°W	*Elliptio complanata*	706	630.36
			Elliptio fisheriana	1 shell	~
			Elliptio icterina	13	11.61

SITE	DATE	COORDINATES	SCIENTIFIC NAME	#	CPUE (#/ph)
33	10/12/2007	35.87945°N, -78.37243°W	*Elliptio complanata*	641	213.67
			Elliptio fisheriana	33	11.0
			Elliptio icterina	25	8.33
			Lasmigona subvirdis	1	0.33
34	10/12/2007	35.87932°N, -78.37339°W	*Elliptio complanata*	482	112.09
			Elliptio fisheriana	33	7.67
			Elliptio icterina	17	3.95
			Lasmigona subvirdis	2	0.47
			Utterbackia imbecillis	2	0.47
35	10/12/2007	35.88061°N, -78.37421°W	*Elliptio complanata*	203	62.46
			Elliptio fisheriana	56	17.23
			Elliptio icterina	8	2.46
			Lasmigona subvirdis	1	0.31
			Utterbackia imbecillis	1	0.31
36	10/12/2007	35.88091°N, -78.37469°W	*Elliptio complanata*	408	85.0
			Elliptio fisheriana	11	2.29
			Elliptio icterina	11	2.29
			Lasmigona subvirdis	2 shells	~