Freshwater Mussel Survey Report

In Monticello Reservoir
Parr Hydroelectric Project
(FERC No. 1894)

Fairfield and Newberry Counties, South Carolina

Monticello Reservoir Shoreline Habitat

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1.0 INTRODUCTION

The Parr Hydro Project (FERC No. 1894) consists of the Parr Shoals Development and the Fairfield Pumped Storage Development; both are located along the Broad River in Fairfield and Newberry Counties, South Carolina. The Parr Shoals Development forms the lower reservoir, Parr Reservoir, along the Broad River. The Fairfield Pumped Storage Development is located directly off of the Broad River and forms the 6,800-acre upper reservoir, Monticello Reservoir, with four earthen dams. The Fairfield Development has a licensed capacity of 511.2 MW and is used for peaking operations, reserve generation, and power usage.

As part of the Federal Energy Regulatory Commission (FERC) re-licensing coordination, the Rare, Threatened and Endangered Species (RT&E) Technical Working Group made up of stakeholders including state and federal resource agencies requested information describing the status of freshwater mussels in Parr and Monticello reservoirs, as well as in the downstream reach of the Broad River influenced by Project operations. Review of existing freshwater mussel data for the Project vicinity determined that recent survey data existed and were adequate for characterizing the mussel fauna of Parr Reservoir and the downstream reach of the Broad River; thus, new survey information was only needed within Monticello Reservoir, and the Monticello Subimpoundment (herein referred to as the recreational lake) adjacent to the reservoir.

Three Oaks Engineering, Inc. (3Oaks) was retained to develop and implement a mussel survey plan for the Monticello Reservoir portion of the project area.

2.0 TARGET FEDERALLY PROTECTED SPECIES DESCRIPTION: Carolina Heelsplitter (*Lasmigona decorata*)

*2.1 Species Characteristic*s

The Carolina Heelsplitter, originally described as *Unio decoratus* by (Lea 1852), synonymized with *Lasmigona subviridis* (Conrad 1835, Johnson 1970), and later separated as a distinct species (Clarke 1985), is a federally Endangered freshwater mussel, historically known from several locations within the Catawba and Pee Dee River systems in North Carolina and the Pee Dee, Savannah, and possibly the Saluda River systems in South Carolina.

The Carolina Heelsplitter can reach a length of 118 mm, with a height of 68 mm and a width of 39 mm. Based on specimens collected by Keferl and Shelley (1988) from three different streams and rivers, the mean length is 78 mm, the mean height is 43 mm and the mean width is 27 mm. The shell is an ovate trapezoid. The dorsal margin is straight and may end with a slight wing. The umbo is flattened. The beaks are depressed and project a little above the hinge line. The beak sculpture is double looped. The unsculptured shell can have a yellowish, greenish or brownish periostracum. The Carolina Heelsplitter can have greenish or blackish rays. The lateral teeth may or may not be well developed; in most cases they are thin. The pseudo-cardinal teeth are lamellar and parallel to the dorsal margin, and there is a slight interdentum. The nacre varies from an iridescent white to a mottled pale orange. The shell's nacre is often pearly white

to bluish white, grading to orange in the area of the umbo (Keferl 1991). The hinge teeth are well developed and heavy and the beak sculpture is double looped (Keferl and Shelly 1988). Morphologically, the shell of the Carolina Heelsplitter is very similar to the shell of the Green Floater (Clarke 1985), with the exception of a much larger size and thickness in the Carolina Heelsplitter (Keferl and Shelly 1988).

Prior to collections in 1987 and 1990 by Keferl (1991), the Carolina Heelsplitter had not been collected in the 20th century and was known only from shell characteristics. Because of its rarity, very little information of this species' biology, life history, and habitat requirements was known until very recently. Feeding strategy and reproductive cycle of the Carolina Heelsplitter have not been fully documented, but are likely similar to other native freshwater mussels (USFWS 1996).

The feeding processes of freshwater mussels are specialized for the removal (filtering) of suspended microscopic food particles from the water column (Pennak 1989). Documented food sources for freshwater mussels include detritus, diatoms, phytoplankton, and zooplankton (USFWS 1996).

Freshwater mussels have complex reproductive cycles, which include a larval stage (glochidium) that is an obligatory parasite on a fish. The glochidia develop into juvenile mussels and detach from the "fish host" and sink to the stream bottom where they continue to develop, provided suitable substrate and water conditions are available (USFWS 1996). For more details regarding general freshwater mussel reproductive biology, McMahon and Bogan (2001) and Pennak (1989) should be consulted.

At the time of listing, nothing was known about the host species(s) for the Carolina Heelsplitter (USFWS 1996, Bogan 2002). Starnes and Hogue (2005) identified the most likely fish host candidates (15 species) based on fish community surveys in occupied streams throughout the range of the Carolina Heelsplitter. Captive propagation efforts for this species had not been attempted in the past; however, due to the critical level of imperilment of the North Carolina populations, acting on recommendations from the NC Scientific Council on Mollusks, the NC Wildlife Resources Commission (NCWRC) funded a life history/captive propagation study, which allowed for salvage of individuals from the Goose/Duck and Sixmile Creek populations to be used in the study. A total of nine minnow species (Cyprinidae) were identified as suitable, and two sunfish species (*Lepomis* spp.) were identified as marginally suitable host species (Eads and Levine 2008, Eads et al. 2010). All of these species may occur in habitat types known to be occupied by the Carolina Heelsplitter; however, "it is always possible that it may use a combination of fish host species and some may not be native to all streams inhabited by this mussel" (Starnes and Hogue 2005). Another member of the genus *Lasmigona*, the Green Floater (*L. subviridis*), perhaps a close relative to the Carolina Heelsplitter, has been documented to be capable of in situ early development with glochidia developing within the marsupium of the female (Barfield and Watters 1998), thus it is possible that the Carolina Heelsplitter may also be able to propagate by direct transformation.

2.2 Distribution and Habitat Requirements

Currently, the Carolina Heelsplitter has a very fragmented, relict distribution. Until recently, it was known to be surviving in only six streams and one small river (USFWS 1996); however, recent discoveries have increased the number of known populations to eleven:

Pee Dee River Basin:
1. Duck Creek/Goose Creek - Mecklenburg/Union counties, NC
2. Flat Creek/Lynches River - Lancaster/Chesterfield/Kershaw counties, SC
Catawba River Basin:
3. Sixmile Creek (Twelvemile Creek Subbasin) - Lancaster County, SC
4. Waxhaw Creek - Union County, NC and Lancaster County, SC
5. Cane Creek/Gills Creek - Lancaster County, SC
6. Fishing Creek Subbasin - Chester County, SC
7. Rocky Creek Subbasin (Bull Run Creek/UT Bull Run Creek/Beaverdam Creek - Chester County, SC
Saluda River Basin:
8. Redbank Creek - Saluda County, SC
9. Halfway Swamp Creek- Greenwood/Saluda County, SC
Savannah River Basin:
10. Little Stevens Creek/Mountain Creek/Sleepy Creek /Turkey Creek (Stevens Creek Subbasin) - Edgefield/McCormick counties, SC.
11. Cuffytown Creek (Stevens Creek Subbasin) - Greenwood/McCormick counties, SC

All of these populations occur in stream reaches within the Piedmont Physiographic Province, particularly within two northeast trending lithostratigraphic belts of the Carolina Terrane, the Carolina Slate Belt and the Charlotte Belt. The Carolina Slate Belt is a band of greenschist faces metavolcanic rock formations positioned in the central and lower Piedmont province extending from south-central Virginia to extreme eastern Georgia (Howell 2005, Butler and Secor 1991). The Charlotte Belt extends from north central North Carolina to eastern Georgia and is comprised of amphibolite faces metavolcanic and metaplutonic rock (Howell 2005, Butler and Secor 1991). These hard formations strongly dictate the channel morphology and character of stream substrates where they intersect. Starnes and Hogue (2005) describe such reaches as "generally characterized by dark, often tilted, bedrock stream bottom with associated large and small rock rubble interspersed with pockets of sand, silt, and gravel." Habitat for this species has been reported from small to large streams and rivers as well as ponds. The ponds are believed to be millponds on some of the smaller streams within the species' historic range (Keferl 1991). Keferl and Shelly (1988) and Keferl (1991) reported that most individuals have been found along well-shaded streambanks with mud, muddy sand, or muddy gravel substrates; however, numerous individuals in several of the populations have been found in cobble and gravel dominated substrate in stream reaches intersecting the hard rock formations described above (T. W. Savidge personal observations). The stability of stream banks appears to be very important to this species (Keferl 1991).

2.3 Threats to Species

The cumulative effects of several factors, including sedimentation, point and non-point discharge, and stream modification (impoundments, channelization, etc.) have contributed to low numbers and restricted range of surviving populations; therefore, they are extremely vulnerable to extirpation from a single catastrophic event or activity (USFWS 1996).

Siltation resulting from improper sedimentation control of various land usage practices, including agriculture, forestry, and development activities, has been recognized as a major contributing factor to the degradation of mussel populations (USFWS 1996). Siltation has been documented to be extremely detrimental to mussel populations by degrading substrate and water quality, increasing potential exposure to other pollutants, and by direct smothering of mussels (Ellis 1936, Markings and Bills 1979). Sediment accumulations of less than one inch have been shown to cause high mortality in most mussel species (Ellis 1936). Feral hog (*Sus scrofa*) activity has been observed to be another source of siltation in a number of Carolina Heelsplitter populations (Tim Savidge, personal observations).

Loss of riparian buffers can lead to degradation of adjacent aquatic habitats. The role of forested riparian buffers in protecting aquatic habitats is well documented (NCWRC 2002). The Recovery Plan for the Carolina Heelsplitter (USFWS 1996) identifies the establishment of stream buffer zones as a major Recovery Objective (Task 1.4). Riparian buffers provide many functions including pollutant reduction and filtration, a primary source of carbon for aquatic food web, stream channel stability, and maintenance of water and air temperatures. Numerous studies have recommended a range of buffer widths needed to maintain these functions. Recommended widths vary greatly depending on the parameter or function evaluated. Wide contiguous buffers of 100-300 feet (30-91 meters) are recommended to adequately perform all functions (NCWRC 2002). The NCWRC recommends a minimum of 200 foot (61 meter) native, forested buffer on perennial streams and a 100 foot (30 meter) forested buffer on intermittent streams in watersheds that support federally endangered and threatened aquatic species (NCWRC 2002). Although not officially adopted, the USFWS uses the NCWRC recommendations as guidance when addressing federally protected aquatic species in North Carolina and South Carolina.

Other factors threatening mussel species include sewage treatment effluent (Goudreau et al. 1988), dams, and other impoundments (USFWS 1992a, Neves 1993, USFWS 1996, USFWS 1992b), and the introduction of exotic species such as the Asian Clam (*Corbicula fluminea*) and Zebra Mussel (*Dreissena polymorpha*) (Fuller and Powell 1973, USFWS 1996, Neves and Widlack 1987, Alderman 1995).

2.4 Designated Critical Habitat

In accordance of Section 4 of the ESA, Critical Habitat for listed species consists of:

(1) The specific areas within the geographical area occupied by the species at the time it is listed in which are found those physical or biological features (constituent elements) that are:

a. essential to the conservation of the species, and
b. which may require special management considerations or protection

(2) Specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of Section 4 of the Act, upon a determination by the Secretary that such areas are "essential for the conservation of the species."

When designating Critical Habitat, the USFWS identifies physical and biological features (primary constituent elements) that are essential to the conservation of the species and that may require special management considerations or protection. The primary constituent elements essential for the conservation of the Carolina Heelsplitter (USFWS 2002) include:

1. permanent flowing, cool, clean water
2. geomorphically stable stream and river channels and banks
3. pool, riffle, and run sequences within the channel
4. stable substrates with no more than low amounts of fine sediment
5. moderate stream gradient
6. periodic natural flooding
7. fish hosts, with adequate living, foraging, and spawning areas for them.

Critical habitat for the Carolina Heelsplitter was designated in 2002 (USFWS 2002). The designated area totals approximately 92 miles (148 kilometers) of nine creeks and one river in North and South Carolina. These areas are considered essential to the conservation of the Carolina Heelsplitter. Six areas (Units) have been designated as critical habitat and a description of each follows.

Unit 1: Goose Creek and Duck Creek (Pee Dee River System), Union County, NC

Unit 1 encompasses approximately 4.5 miles (7.2 km) of the main stem of Goose Creek, Union County, NC, from the N.C. Highway 218 Bridge, downstream to its confluence with the Rocky River, and approximately 6.4 mi (10.3 km) of the main stem of Duck Creek, Union County, NC, from the Mecklenburg/Union County line downstream to its confluence with Goose Creek. The Carolina heelsplitter was first discovered in Goose Creek in 1987 (Keferl 1991) and in Duck Creek in 2000 (NCWRC Database). Between 1993 and 1999, a total of 15 live individuals had been recorded in Goose Creek. NCWRC surveys in early 2002, found 16 live individuals in Duck Creek (NCWRC Database); however, following extreme drought conditions in late 2002, where much of the streambed in both creeks was dry, status surveys in Duck Creek yielded only four live and more than 40 fresh dead. One fresh-dead shell was also found in Goose Creek during the 2002 drought surveys just below US 601. Pools and wet streambeds were much more common in lower Goose Creek, apparently providing refuge from desiccation during the drought. Between 2004 and 2005, four live individuals were found at two locations within Goose Creek, and 12 live individuals were found at six locations within Duck Creek. Prolonged severe drought conditions persisted in the Goose Creek watershed in 2006 through 2007. A total of nine individuals have been found in Duck Creek between 2006 and 2009. Three of the individuals were found on more than one occasion. Four of these individuals were taken into captivity, as much of the stream channel was dry when they were found. A survey conducted in

2011 of the critical habitat portion of Goose Creek, from the Rocky River confluence to the NC 218 crossing, located a total of 12 live individuals and one fresh dead shell (Catena 2012a). All of the live individuals were taken into captivity for a joint propagation effort between North Carolina State University and the North Carolina Wildlife Resources Commission. The majority of the individuals were estimated to be <5 years of age based on shell condition and growth rests, indicating relatively recent reproduction. Repeated survey efforts in Duck Creek in 2011 and 2012 have not located any live individuals post drought.

Unit 2: Waxhaw Creek (Catawba River System), Union County, NC

Unit 2 encompasses approximately 12.2 mi (19.6 km) of the main stem of Waxhaw Creek, Union County, NC, from the N.C. Highway 200 Bridge, downstream to the North Carolina/South Carolina state line. Very few Carolina Heelsplitter individuals have been found in Waxhaw Creek since they were first discovered in 1987. Keferl (1991) found one live individual in 1987 and two in 1990. Subsequent surveys failed to find any individuals until one weathered shell was found in 1996, followed by one live individual in 1998, one weathered shell in 2005, and three live individuals at three separate sites in 2006 (NCWRC Database). Surveys of Waxhaw Creek in South Carolina, conducted in 2004, documented only two live individuals at a single site – one of only a couple of sites in the stream below the North Carolina/South Carolina state line that appeared to provide suitable substrate for the Heelsplitter (USFWS 2007). On-going surveys conducted in 2015 have yielded ten individuals to date (Tim Savidge, personal observations).

Unit 3: Gills Creek (Catawba River System), Lancaster County, SC

Unit 3 encompasses approximately 6.0 mi (9.6 km) of the main stem of Gills Creek, Lancaster County, SC, from the County Route S-29-875, downstream to the SC Route 51 Bridge, east of the City of Lancaster. One 88.0 mm fresh shell and one 67.0 mm live individual discovered in 1998, represent this population (Alderman 1998). No additional surveys have been completed in this section of Gills Creek since 1998. In 2006, Catena discovered the species (two live and one shell) at three sites in Cane Creek, a tributary to Gills Creek (USFWS 2007). One weathered shell was found in 2015 (Tim Savidge, personal observations). While Cane Creek is not within the boundaries of Unit 3, Gills Creek and Cane Creek are considered a single population from a management perspective, as there are no physical barriers that would isolate the two areas. The discovery of the Carolina Heelsplitter in Cane Creek demonstrates that this population has been reduced to small pockets of habitat in the watershed.

Unit 4: Flat Creek (Pee Dee River System), Lancaster County, SC, and the Lynches River (Pee Dee River System), Lancaster, Chesterfield, and Kershaw Counties, SC

Unit 4 encompasses approximately 11.4 mi (18.4 km) of the main stem of Flat Creek, Lancaster County, SC, from the SC Route 204 Bridge, downstream to its confluence with the Lynches River, and approximately 14.6 mi (23.6 km) of the main stem of the Lynches River, Lancaster and Chesterfield Counties, SC, from the confluence of Belk Branch, Lancaster County, northeast (upstream) of the U.S. Highway 601 Bridge, downstream to the SC Highway 903 Bridge in Kershaw County, SC. Within this unit, the Lynches River local population is represented most

recently (2005 to 2007) by 14 live and two fresh dead shells (54-87mm) found above SC 265 Chesterfield/Lancaster Co. SC in 2007 (USFWS 2007, USFWS 2012). Between 1994 and 1997, the Flat Creek local population was represented by 28 live individuals ranging in length from 54.15 to 94.1 mm and by four shells ranging in length from 41.0 to 86.1 mm (Alderman 1998). In 2007, Alderman conducted surveys of two reaches of Flat Creek, one in upper Flat Creek and one in middle-lower Flat Creek, and documented 16 live Carolina Heelsplitter individuals, including several age classes, some likely less than five years of age based on shell measurements (USFWS 2007). In 2010, Alderman found 42 live and one weathered shell in Flat Creek, with a large number of size classes represented (Alderman 2010, pers. comm.).

Multiple survey efforts have been conducted in 2014 and 2015 in this unit and numerous individuals were found in both Flat Creek and the Lynches River. This data is not readily available at the time of writing this report (Tim Savidge, John Fridell, personal communication).

Unit 5: Mountain and Beaverdam Creeks (Savannah River System), Edgefield County, SC, and Turkey Creek (Savannah River System), Edgefield and McCormick Counties, SC

Unit 5 encompasses approximately 7.0 mi (11.2 km) of the main stem of Mountain Creek, Edgefield County, SC, from the SC Route 36 Bridge, downstream to its confluence with Turkey Creek; approximately 6.7 mi (10.8 km) of Beaverdam Creek, Edgefield County, from the SC Route 51 Bridge, downstream to its confluence with Turkey Creek; and approximately 11.4 mi (18.4 km) of Turkey Creek, from the SC. Route 36 Bridge, Edgefield County, downstream to the SC Route 68 Bridge, Edgefield and McCormick Counties, SC.

The Mountain Creek local population is represented by 15 live individuals ranging in length from 38.7 to 84.9 mm and by 15 shells ranging in length from 53.0 to 98.0 mm (Alderman 1998, 2002). During 2002, two additional local populations of Carolina Heelsplitter were discovered within the Turkey Creek Subbasin, one in Little Stevens Creek represented by a shell fragment, and one in Sleepy Creek represented by seven live individuals ranging in length from 51.1 to 73.0 mm and by three shells ranging in length from 61.4 to 71.0 mm (Alderman 2002). Seven live and one moribund individuals were documented in Little Stevens Creek in 2007 (USFWS 2007).

The Turkey Creek local population is represented by a few shells discovered in 1995, and by one live individual discovered in 1997 (Mcdougal 1997). Ten 10 individuals were found at eight locations in 2012-2013 (Catena 2013), and one individual was found just above the SC 68 bridge in December 2015 (Tim Savidge, personal observation). Within this unit, only a single shell of the Carolina Heelsplitter has been found in Beaverdam Creek (Alderman 1995) and additional surveys of the stream have failed to locate any individuals (USFWS 2007). This portion of the population may be extirpated or exist only in very low numbers (USFWS 2007).

A single shell of the Carolina Heelsplitter was found in Beaverdam Creek (Alderman 1995) and additional surveys of the stream failed to locate any individuals, and it was suggested that this portion of the population may have extirpated or exist only in very low numbers (USFWS 2007). However, two live individuals and three fresh shells were found in 2015 (Three Oaks 2015).

Unit 6: Cuffytown Creek (Savannah River System), Greenwood and McCormick Counties, SC

Unit 6 encompasses approximately 12.9 mi (20.8 km) of the main stem of Cuffytown Creek, from the confluence of Horsepen Creek, northeast (upstream) of the SC Route 62 Bridge in Greenwood County, SC, downstream to the U.S. Highway 378 Bridge in McCormick County. Within this unit, the population is represented by five live individuals (three discovered in 1998 and two discovered in 2001) with lengths ranging from 53.5 to 71.5 mm and by one shell discovered in 1998 with a length of 63.0 mm (Alderman 1998, 2002).

Five of the eleven Carolina Heelsplitter populations listed in Section 2.2: Sixmile Creek, Fishing Creek, Rocky Creek, Redbank Creek, and Halfway Swamp Creek, were discovered after Critical Habitat was designated. Like most of the other Carolina Heelsplitter populations, these populations are also limited in size and distribution. Live individuals have been found in 2015 in the Sixmile Creek (Tom Dickinson, personal observations), Fishing Creek and Rocky Creek populations (Tim Savidge, personal observations).

3.0 TARGET PETITIONED FEDERALLY PROTECTED SPECIES DESCRIPTION: Savannah Lilliput (*Toxolasma pullus*)

3.1 Species Characteristics

Savannah Lilliput was described by Conrad (1838) from the Wateree River in South Carolina, this species ranges from the Altamaha River basin in Georgia north to the Neuse River basin in North Carolina (Johnson 1970). The Savannah Lilliput is a small mussel with an oval or elliptical shell. The color of the shell is usually blackish but can also be brownish, greenish or olive with fine, green rays. A large individual's metrics would range from 30-35 mm long with a height of 19-20 mm and a width of 15-16 mm. Shells are usually inflated with a broadly rounded to angular double posterior ridge. Shells are sexually dimorphic. Periostracum is coarse due to numerous closely spaced growth lines and is blackish to brown-greenish with fine rays that are usually not visible. Nacre is bluish white with a pink to purplish iridescence towards the posterior. Individuals from the lower Savannah River have a slight different morphology and were once thought to be a different species (Bates 1966).

3.2 Distribution and Habitat Requirements

The historical range of the Savannah Lilliput included the Neuse River basin in North Carolina to the Altamaha basin in Georgia (Bogan and Alderman 2004). After rapid decline the range has been narrowed to select areas. In South Carolina, it has been recently found in the Pee-Dee, Santee, and Savannah River basins.

The species is found in creeks, rivers, and impounded habitats; it is rarely found in deeper lake waters. It is typically located in sand, silty-sand or mud substrates and appears to prefer near shore, still or low velocity shallow water habitats. The fish host species for the Savannah Lilliput is unknown (Bogan and Alderman 2004).

3.3 Threats to Species

Due to its distribution in shallow water, the Savannah Lilliput is susceptible to droughts, water drawdowns and off-road vehicle traffic. One particular event in January 2005, during a draw down in Lake Marion, SC, which is occupied by this species, resulted in numerous mussels stranded on near the shoreline attempting to move to lower water; many had dried up on the banks. The small size and limited distribution of many of this species populations make it vulnerable to events such as these.

4.0 SURVEY EFFORTS

In order to provide current data on the freshwater mussel fauna with regards to species composition, distribution, and relative abundance within the FERC project boundary, qualitative surveys were conducted in both the recreational and main lake of Monticello Reservoir (Figure 1).

4.1 Mussel Surveys for this Project

Surveys were conducted by 3Oaks personnel Tom Dickinson, Tim Savidge, and Evan Morgan on September 16-17, 2015, and by Tim Savidge and Nathan Howell on November 06, 2015. Nicole Riddle of SCDOT provided support for survey efforts on November 06. Weather conditions were sunny and warm during the September 16-17 surveys, and cloudy/rainy and cool during the November 06 surveys. The water was very clear during all surveys.

4.2 Methodology

Visual surveys were conducted using SCUBA and mask/snorkel techniques. Personnel using mask and snorkel covered a depth range of 0-3 feet (ft), while personnel using SCUBA covered a depth range of 3-18 ft. Surveys began at a distinct point along the shoreline and the surveyors evaluated the substrate for mussels from the shoreline out to a point where mussels were no longer present. Generally, mussels were present at depths of 2-4 ft down to 15-18 ft. The depth at which mussels were found varied from site to site, but were more related to water levels at the time than distance from the shoreline, as there is a wide daily fluctuation in water levels within the reservoir. Surveys began at approximately 9:00 am on all three days and ended at 7:00 pm on September 16-17 and at 6:00 pm on November 06. Water levels, measured as pool elevation dropped steadily from the beginning to the end of the surveys on all three days:

a) 09-16: 423.7204895 ft. to 422.7026062 ft.

b) 09-17: 423.8225098 ft. to 422.1596985 ft.

c) 11-06: 423.3981934 ft. to 422.5299988 ft.

Survey sites are denoted by the last two digits of the year (15 for 2015), followed by the two-digit month (09 for September, etc.) and two-digit day followed by a period and the survey number for that date (i.e.1,2,3….) and the initials for the survey lead (tws for Tim Savidge, or ted for Tom Dickinson). For instance, the first survey conducted on September 16 by Tom Dickinson corresponds to site 150916.1ted.

Ten survey locations were larger in area than the others in terms of a starting and endpoint and overlapped. These sites were combined as appropriate due to proximity into five sites (150916.4ted, 150917.8ted, 151106.3tws, 151106.6tws and 151106.7tws).

All freshwater bivalves were recorded and returned to the substrate. Representative photographs of each species were taken. Timed survey efforts provided Catch per Unit Effort (CPUE) data for each species found. Relative abundance estimates for freshwater snails and freshwater clam species were developed using the following criteria:

- (VA) Very abundant > 30 per square meter
- (A) Abundant 16-30 per square meter
- (C) Common 6-15 per square meter
- (U) Uncommon 3-5 per square meter
- (R) Rare 1-2 per square meter
- (P-) Ancillary adjective "Patchy" indicates an uneven distribution of the species within the sampled site.

5.0 RESULTS

Six species of freshwater mussels were found in Monticello Reservoir, only one of which was found within the recreational lake (relict shell evidence only). The survey results for each site are presented below.

5.1 Site 150916.1ted

This site was located at the mouth of a cove on the southeast side of the recreational lake, and was surveyed to a depth of 10 ft. The substrate along the shoreline consisted of mud and gradually transitioned to a sandy mud in the deeper areas. Large mats of Water Willow (*Justicia americana*) occurred along the shoreline. Surveys were conducted for 1.0 person hour, and one relict shell of the Paper Pondshell (*Utterbackia imbecillis*) was found. Other mollusk species found include the Japanese Mysterysnail (*Cipangopaludina japonica*) and the Asian Clam (*Corbicula fluminea*), which were uncommon (Table 1). Although live individuals of the Asian Clam were uncommon, relict shells were fairly common suggesting a large die off in recent years.

Table 1. Results in Monticello Reservoir Recreational Lake, Site 150916.1ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Utterbackia imbecillis	Paper Pondshell	1 shell	~

Freshwater Snails and Clams			Relative Abundance
Cipangopaludina japonica	Japanese Mysterysnail	~	U
Corbicula fluminea	Asian Clam	~	U

5.2 Site 150916.2ted

This site was located at the upper portion of the cove where Site # 150916.1ted is located. Habitat conditions were similar to the site at the mouth of the cove; with the exception of maximum depth, which was 6 ft. Surveys were conducted for 1.17 person hours. Relict shells of the Japanese Mysterysnail and Asian Clam were found in low numbers (Table 2).

Table 2. Results in Monticello Reservoir Recreational Lake, Site 150916.2ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	Shell only
Corbicula fluminea	Asian Clam	~	Shell Only

5.3 Site 150916.3ted

This site was located along a large point in the northeast portion of the recreational lake. The substrate consisted of large accumulations of silt over gravel. Surveys were conducted from the shoreline down to a depth of 12 ft for 1.0 person hour. Relict shells of the Asain Clam were uncommon (Table 3).

Table 3. Results in Monticello Reservoir Recreational Lake, Site 150916.3ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	Shell Only

5.4 Site 150916.4ted

This combined site was located on both sides of the northern most cove within the recreational lake; surveys were conducted along both shorelines as well as in the middle of the cove, which had a maximum depth of 15 ft. The substrate consisted of mud and sand. Surveys were conducted for 2.0 person hours, and live individuals of the Asian Clam were rare; however, relict shells were fairly common (Table 4).

Table 4. Results in Monticello Reservoir Recreational Lake, Site 150916.4ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	R

5.5 Site 150916.5ted

This site was located along a wide point in the northwest portion of the recreational lake. Several old pilings were present in this area. The substrate consisted of sand with submerged and emergent vegetation. Surveys were conducted to a depth of 6.5 ft for 1.0 person hour. The Asian Clam was found in low numbers (Table 5).

Table 5. Results in Monticello Reservoir Recreational Lake, Site 150916.5ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	R

5.6 Site 150916.6ted

This site was located within the vicinity of the swimming area of the recreational lake. Substrate consisted of sand and clay. Surveys were conducted to a maximum depth of 8 ft for 1.50 person hours. The Asian Clam was rare (Table 6).

Table 6. Results in Monticello Reservoir Recreational Lake, Site 150916.6ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Corbicula fluminea	Asian Clam	~	R

5.7 Site 150916.7ted

This site was located within the recreational lake along the causeway that separates the lake from Monticello Reservoir. The substrate consisted of rock rip/rap with sand and silt in-between. Surveys were conducted to a depth of 8 ft for 0.67 person hour. Asian Clam shells were uncommon as were live Japanese Mystersnail individuals (Table 7).

Table 7. Results in Monticello Reservoir Recreational Lake, Site 150916.7ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
None	~	~	~
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	Uncommon
Corbicula fluminea	Asian Clam	~	Shell Only

5.8 Site 150916.8ted

This site was located off a point in the northeast portion of Monticello Reservoir. The substrate consisted of sand overlain with silt. Surveys were conducted from the shoreline to a maximum depth of 14 ft; however, the majority of mussels were found between 4 and 10 ft. Three native

freshwater mussel species, the Carolina Lance (*Elliptio angustata*), Eastern Floater (*Pyganadon cataracta*) and Eastern Creekshell (*Villosa delumbis*) were found, along with the Asian Clam, Japanese Mysterysnail and the Banded Mysterysnail (*Viviparus georgianus*) in 1.5 person hours (Table 8).

Table 8. Results in Monticello Reservoir, Site 150916.8ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	12	8.0/hr
Pyganadon cataracta	Eastern Floater	39	26.0/hr
Villosa delumbis	Eastern Creekshell	5	3.3/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	R

5.9 Site 150916.9ted

This site was located in the vicinity of a small island in the northeast portion of Monticello Reservoir. Surveys were conducted on both sides of the island from the shoreline to a maximum depth of 14 ft. The substrate consisted of a mixture of sand and gravel. Three mussel species, the Carolina Lance, Eastern Floater and Florida Pondhorn (*Uniomerus carolinianus*) were found in 1.75 person hours (Table 9.

Table 9. Results in Monticello Reservoir, Site 150916.9ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	18	10.29/hr
Pyganadon cataracta	Eastern Floater	41	23.43/hr
Uniomerus carolinianus	Florida Pondhorn	1	0.57/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	R

5.10 Site 150917.1ted

This site was located along a broad point on the western shore in the central portion of Monticello Reservoir. Surveys were conducted from the shoreline to a maximum depth of 15 feet; however, the majority of mussels were found between 5 and 10 ft deep. The substrate consisted of sand overlain with silt. Five mussel species were found in 1.5 person hours (Table 10).

Table 10. Results in Monticello Reservoir, Site 150917.1ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	53	29.3/hr
Pyganadon cataracta	Eastern Floater	47	5.3/hr
Uniomerus carolinianus	Florida Pondhorn	2	8.0/hr
Utterbackia imbecillis	Paper Pondshell	3	7.3/hr
Villosa delumbis	Eastern Creekshell	3	
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	PC

5.11 Site 150917.2ted

This site was located along the west shoreline on the north side of a large peninsula in the central portion of Monticello Reservoir. Surveys were conducted to a maximum depth of 14 ft; however, the majority of effort was located between 6 to 8 ft. The substrate consisted of a mixture of sand and mud. Five mussel species were found in 1.0 person hours (Table 11).

Table 11. Results in Monticello Reservoir, Site 150917.2ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	123	123.0/hr
Pyganadon cataracta	Eastern Floater	76	76.0/hr
Unimoerus carolinianus	Florida Pondhorn	2	2.0/hr
Utterbackia imbecillis	Paper Pondshell	5	5.0/hr
Villosa delumbis	Eastern Creekshell	10	10.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	VA
Viviparus georgianus	Banded Mysterysnail	~	U

5.12 Site 150917.3ted

This site was located along the west shore within a small cove in the north-central portion of Monticello Reservoir. Surveys were conducted to a maximum depth of 14 ft; however, the majority of effort occurred between 6 to 8 ft. The substrate consisted of a mixture of sand and cobble. Four mussel species were found in 1.67 person hours (Table 12).

Table 12. Results in Monticello Reservoir, Site 150917.3ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	24	14.4/hr
Pyganadon cataracta	Eastern Floater	34	20.4/hr
Utterbackia imbecillis	Paper Pondshell	3	1.84/hr
Villosa delumbis	Eastern Creekshell	6	3.6/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	C

5.13 Site 150917.4ted

This site was located along the west shoreline in the south central portion of Monticello Reservoir. The shoreline has been armored with rip rap to stabilize the adjacent roadbed. Surveys were conducted to a maximum depth of 18 ft; however, the majority of effort occurred between 6 and 8 ft. The substrate consisted of a mixture of sand and gravel beyond the rip rap. All six mussel species found during this survey effort were found in 1.23 person hours (Table 13).

Table 13. Results in Monticello Reservoir, Site 150917.4ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	69	56.1/hr
Pyganadon cataracta	Eastern Floater	50	40.7/hr
Uniomerus carolinianus	Florida Pondhorn	10	8.1/hr
Utterbackia imbecillis	Paper Pondshell	4	3.7/hr
Villosa delumbis	Eastern Creekshell	12	9.8/hr
Villosa vaughaniana	Carolina Creekshell	3	2.4/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	C

5.14 Site 150917.5ted

This site was located adjacent to an island in the west central portion of Monticello Reservoir. Surveys were conducted from the western shoreline of the island to a maximum depth of 12 ft; however, the majority of effort occurred between 3 and 8 ft. The substrate consisted of sand overlain with silt. Five mussel species were found in 1.0 person hours (Table 14).

Table 14. Results in Monticello Reservoir, Site 150917.5ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	112	112.0/hr
Pyganadon cataracta	Eastern Floater	58	58.0/hr
Uniomerus carolinianus	Florida Pondhorn	4	4.0/hr
Utterbackia imbecillis	Paper Pondshell	1	1.0/hr
Villosa delumbis	Eastern Creekshell	3	3.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	C

5.15 Site 150917.6ted

This site was located along the east shoreline in the north-central portion of Monticello Reservoir. Surveys were conducted from the sandy beach along the shore to a maximum depth of 12 ft; however, the majority of effort occurred between 3 and 5 ft. The substrate consisted of sand with some silt. Four mussel species were found in 1.1 person hours (Table 15).

Table 15. Results in Monticello Reservoir, Site 150917.6ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	20	18.2/hr
Pyganadon cataracta	Eastern Floater	21	19.1/hr
Utterbackia imbecillis	Paper Pondshell	3	2.7/hr
Villosa delumbis	Eastern Creekshell	1	0.9/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	C
Viviparus georgianus	Banded Mysterysnail	~	C

5.16 Site 150917.7ted

This site was located adjacent to a narrow peninsula along the east shoreline in the central portion of Monticello Reservoir. A bedrock outcropping extends from the point of the peninsula, with the remainder of the shoreline consisting of a sandy beach. Surveys were conducted to a maximum depth of 14 ft, with the majority of mussels found between 3 and 8 ft. Six mussel species were found in 1.7 person hours (Table 16).

Table 16. Results in Monticello Reservoir, Site 150917.7ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	60	35.3/hr
Pyganadon cataracta	Eastern Floater	48	28.2/hr
Uniomerus carolinianus	Florida Pondhorn	2	1.2/hr
Utterbackia imbecillis	Paper Pondshell	3	1.8/hr
Villosa delumbis	Eastern Creekshell	4	2.4/hr
Villosa vaughaniana	Carolina Creekshell	1	0.6/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	U
Viviparus georgianus	Banded Mysterysnail	~	C

5.17 Site 150917.8ted

This combined site was located in the vicinity of a small island off the eastern shoreline in the central portion of Monticello Reservoir. The shoreline of the island is rocky. All sides of the island were surveyed to a depth of 14 ft. Pockets of sand covered the rocks along the bottom. Five mussel species were found in 2.01 person hours (Table 17).

Table 17. Results in Monticello Reservoir, Site 150917.8ted

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	26	12.9/hr
Pyganadon cataracta	Eastern Floater	29	14.4/hr
Uniomerus carolinianus	Florida Pondhorn	6	3.0/hr
Utterbackia imbecillis	Paper Pondshell	7	3.5/hr
Villosa delumbis	Eastern Creekshell	7	3.5/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.18 Site 151106.1tws

This site was located adjacent to the boat landing along the eastern shore off of SC 215 in the southern portion of Monticello Reservoir. The shoreline has been armored with rip rap to stabilize the parking area. Surveys were conducted from the shoreline to a maximum depth of 20 ft. The substrate graded from the rip rap along the shoreline to sand. Most of the mussels were found between 4 and 10 ft. Four mussel species were found in 1.5 person hours (Table 18).

Table 18. Results in Monticello Reservoir, Site 151106.1tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	44	29.3/hr
Pyganadon cataracta	Eastern Floater	8	5.3/hr
Utterbackia imbecillis	Paper Pondshell	12	8.0/hr
Villosa delumbis	Eastern Creekshell	11	7.3/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.19 Site 151106.2tws

This site was located just south of the SC 215 boat landing and extended from the sandy beach on the shoreline to a depth of 18 ft, with the majority of mussels found between 6 and 12 ft. The substrate consisted of a mixture of sand and gravel. Five mussel species were found in 1.0 person hours (Table 19).

Table 19. Results in Monticello Reservoir, Site 151106.2tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	24	24.0/hr
Pyganadon cataracta	Eastern Floater	2	2.0/hr
Uniomerus carolinianus	Florida Pondhorn	1 shell	~
Utterbackia imbecillis	Paper Pondshell	6	6.0/hr
Villosa delumbis	Eastern Creekshell	18	18.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.20 Site 151106.3tws

This combined site was located adjacent to Monticello Park off SC 215 along the eastern shore of Monticello Reservoir. The surveyed reaches extend along the shoreline of long peninsula around the point. Surveys were conducted to a depth of 18 ft; however, most mussels were found between 6 and 12 ft. The substrate consisted of sand and cobble. Five mussel species were found in 2.0 person hours (Table 20).

Table 20. Results in Monticello, Site 151106.3tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	71	35.5/hr
Pyganadon cataracta	Eastern Floater	9	4.5/hr
Uniomerus carolinianus	Florida Pondhorn	3	1.5/hr
Utterbackia imbecillis	Paper Pondshell	9	4.5/hr
Villosa delumbis	Eastern Creekshell	13	6.5/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.21 Site 151106.4tws

This site was located south of the Monticello Park off of SC 215, and was accessed from a pull off on SC 215. Surveys were conducted from the shoreline to a maximum depth of 18 ft. The substrate graded from clay along the banks to sand downslope. The majority of mussels were found in 3 to 8 ft of water in sandy clay substrate. Five mussel species were found in 1.0 person hours (Table 21).

Table 21. Results in Monticello Reservoir, Site 151106.4tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	48	48.0/hr
Pyganadon cataracta	Eastern Floater	14	14.0/hr
Uniomerus carolinianus	Florida Pondhorn	2	2.0/hr
Utterbackia imbecillis	Paper Pondshell	5	5.0/hr
Villosa delumbis	Eastern Creekshell	14	14.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.22 Site 151106.5tws

This site was located adjacent to the southern edge of Monticello Park. Surveys were conducted from the shoreline to a maximum depth of 20 ft. Although a few mussels were found at the maximum depth, most were found between 6 and 10 ft. The substrate consisted of sand and cobble. Five mussel species were found in 1.2 person hours (Table 22).

Table 22. Results in Monticello Reservoir, Site 151106.5tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	48	40.0/hr
Pyganadon cataracta	Eastern Floater	23	11.6/hr
Uniomerus carolinianus	Florida Pondhorn	1 shell	~
Utterbackia imbecillis	Paper Pondshell	1	0.8/hr
Villosa delumbis	Eastern Creekshell	12	10.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.23 Site 151106.6tws

This combined site was located adjacent to the boat landing off of Ladds Road in the northern portion of Monticello Reservoir and extended into the cove northwest of the parking area. The maximum depth surveyed was 21 ft, although most mussels were found between 4 and 10 ft. Substrate consisted of sand and cobble. Six mussel species were found in 1.95 person hours (Table 23).

Table 23. Results in Monticello Reservoir, Site 151106.6tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	6	3.1/hr
Pyganadon cataracta	Eastern Floater	89	45.6/hr
Uniomerus carolinianus	Florida Pondhorn	7	3.6/hr
Utterbackia imbecillis	Paper Pondshell	33	16.9/hr
Villosa delumbis	Eastern Creekshell	5	2.6/hr
Villosa vaughaniana	Carolina Creekshell	2	1.0/hr
Freshwater Snails and Clams			**Relative Abundance**
Campeloma deisum	Pointed Campeloma	~	PU
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.24 Site 151106.7tws

This combined site extended along a cove northwest of the Ladds Road boat landing and was accessed via a foot trail through the woods originating next to the parking area. Multiple transects were surveyed along the cove extending from the shoreline to a depth of 18 ft. The substrate graded from mud along the shoreline to sand at greater depths. Six freshwater mussel species were found in 1.9 person hours (Table 24).

Table 24. Results in Monticello Reservoir, Site 151106.7tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	5	2.63/hr

Pyganadon cataracta	Eastern Floater	58	30.52/hr
Uniomerus carolinianus	Florida Pondhorn	2	1.1/hr
Utterbackia imbecillis	Paper Pondshell	40	21.1/hr
Villosa delumbis	Eastern Creekshell	8	4.2/hr
Villosa vaughaniana	Carolina Creekshell	1	0.5/hr
Freshwater Snails and Clams			**Relative Abundance**
Campeloma deisum	Pointed Campeloma	~	PU
Cipangopaludina japonica	Japanese Mysterysnail	~	A
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

5.25 Site 151106.8tws

This site was located just east of the Ladds Road boat landing, and extended from the shoreline to a maximum depth of 18 ft. A small area along the shoreline was armored with rip rap. The substrate was dominated by a mixture of sand and cobble. Five mussel species were found in 1.3 person hours (Table 25).

Table 25. Results in Monticello Reservoir, Site 151106.8tws

Scientific Name	Common Name	Number	CPUE (#/hr)
Freshwater Mussels			
Elliptio angustata	Carolina Lance	13	10.0/hr
Pyganadon cataracta	Eastern Floater	22	16.9/hr
Uniomerus carolinianus	Florida Pondhorn	2	1.5/hr
Utterbackia imbecillis	Paper Pondshell	9	6.9/hr
Villosa delumbis	Eastern Creekshell	5	3.8/hr
Freshwater Snails and Clams			**Relative Abundance**
Cipangopaludina japonica	Japanese Mysterysnail	~	C
Corbicula fluminea	Asian Clam	~	A
Viviparus georgianus	Banded Mysterysnail	~	PU

6.0 MUSSEL SPECIES FOUND

The survey results indicate that at least six freshwater mussel species occur in Monticello Reservoir; however, only one species of freshwater mussel (Paper Pondshell), represented by a single relict shell was observed in the adjacent, and hydrologically connected recreational lake. Brief descriptions of the six freshwater mussel species found are provided below.

6.1 Carolina Lance (Elliptio angustata)

This species was described from the Cooper River, South Carolina (Lea 1831). The shell is more than twice as long as high coming to a posterior point, below the midline between the dorsal and ventral margins. The dorsal margin is straight and essentially parallel to the ventral margin. Umbos are slightly elevated with beak sculpture consisting of strong ridges. Johnson (1970) synominized this species and over 20 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). The Carolina Lance ranges from the Ogeechee, Georgia north to the Potomac River in Maryland and Virginia. The species is usually found in large steams or rivers in thalweg habitat and is associated with coarse substrates. It is not typically found in reservoir habitats (personal observations). This species was found at every site sampled within Monticello Reservoir and was the most abundant species encountered (776 total live individuals). Williams et al. (1993) list this species as special concern.

6.2 Eastern Floater *(Pyganadon cataracta)*

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, the pond form, the creek/small river form and the big river form, that were related to environmental conditions. 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. It often occurs in reservoirs, and was found at every site sampled in Monticello Reservoir and was second in total numbers (668 individuals. This species is considered common and currently stable throughout its range (Williams et al. 1993).

6.3 Florida Pondhorn *(Uniomerus carolinianus)*

Described by (Bosc 1801-1804) from "the Carolinas," this species ranges from Ocmulgee River in Georgia north to the Chowan River in Virginia. Shells are usually inflated rhomboid, to long rhomboid and reach lengths to 114 mm. The species generally exhibits a dark brown to black periostracum with a slightly roughened, satiny sheen. Teeth of the left valve contain two subequal pseudocardinals, often with a vestigal tooth above them, and one lateral tooth. It was found at eleven sites within Monticello Reservoir in fairly low numbers (41 total). This species is considered common and currently stable throughout its range (Williams et al. 1993).

6.4 **Paper Pondshell *(Utterbackia imbecillis)***

Described from the Wabash River in Indiana, this mussel occurs throughout the Mississippi River and Great Lakes drainages, as well as sporadically along the Atlantic slope (Say 1829). 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. It was found at all but two of the sites sampled in Monticello Reservoir, and was the third most abundant species encountered (144 individuals). With the exception of two sites in the northern portion of the reservoir (151106.7tws and 151106.6tws) it was generally found in low numbers; however, a total of 40 and 33 individuals were recorded respectively at these sites. It was the only freshwater mussel species observed in the recreational lake; however, it was represented by only one relict shell. This species is considered common throughout its range (Williams et al. 1993).

6.5 **Eastern Creekshell *(Villosa delumbis)***

This species, described by Conrad (1834) from small streams near the Cooper River South Carolina, ranges from Ocmulgee River, Georgia north to the Cape Fear River in North Carolina. Johnson (1970) synonomized three other species described from the greater CSB with *V. delumbis*. One of these, *V. vaughaniana*, is currently recognized as a valid species (Bogan and Alderman 2008), and was found during this study (see description below). The Eastern Creekshell has a generally thin shell that is ovate in outline. 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 and swollen, particularly in the posterior margin. The periostracum is yellow with numerous green rays that are broken along the prominent growth lines. It was found at all but one of the sites sampled in Monticello Reservoir (150916.9ted). It was the fourth most abundant species encountered (137 individuals). Williams et al. (1993) consider this species to be stable; however, Bogan and Alderman (2008) propose it a conservation status of special concern in South Carolina.

6.6 **Carolina Creekshell (*Villosa vaughaniana*)**

This species was described from Sawney's Creek near Camden, South Carolina (Lea 1838). As discussed above under the description for *V. delumbis*, Johnson (1970) synonomized this species under *V. delumbis*; however, it is currently recognized as a valid species (Bogan and Alderman 2004). The previously reported range extends from the Wateree River Basin portion of the Greater Cooper Santee Basin in South Carolina north to the Cape Fear River Basin in North Carolina (Bogan and Alderman 2008). Like other members of this genus, this species is sexually dimorphic, with the shells of the male being more elongate, and the females more inflated and rounded in the posterior

margin. The periostracum is usually dark yellow brown with many green, unbroken rays. The shell of this species is generally thicker, with more prominent pseudocardinal teeth than the similar (in shell characteristics) Eastern Creekshell. A total of seven individuals were found at 4 sites in Monticello Reservoir. The species is usually restricted to small, or medium size streams and is rarely found in large bodies of water, and has not previously been reported from reservoirs (John Alderman and Art Bogan, personal communication). Given that it is uncommon to find this species outside of stream habitats, it is possible that these individuals are simply unusual specimens of the Eastern Creekshell. However, the seven individuals identified as Carolina Creekshell were done so based on conchological (shell), and soft part anatomy characteristics, and should be considered as such until further study proves otherwise. Two voucher specimens were preserved in 95% ethanol and will be deposited in an appropriate museum collection to allow for genetic evaluation to be performed. Williams et al. (1993) lists this species as special concern. It is proposed as Endangered in South Carolina (Bogan and Alderman 2008).

7.0 CONCLUSIONS

The survey results indicate that Monticello Reservoir supports a mussel fauna of at least six species. Mussels were found at every site sampled and most likely occur throughout the reservoir in areas that are not exposed during the daily water fluctuations, down to depths of 16-20 ft. With the exception of the Carolina Creekshell, multiple size (= age) classes of all species were observed, suggesting that the daily water level fluctuation regime is not limiting population sustainability of these species. Three of these species, Carolina Creekshell, Carolina Lance, and Eastern Creekshell have some reported level of conservation concern (see Sections 6.6, 6.1 and 6.5 respectively).

The two most common species encountered, the Carolina Lance and the Eastern Floater, were found at every site sampled; however, the Eastern Floater was definitely more common than the Carolina Lance at the sites sampled in the northern portion of the lake. Likewise, the Paper Pondshell which typically occupies similar habitats (ponded conditions, soft substrate) as the Eastern Floater, was more common in the northern portion of the reservoir than anywhere else. It is unclear however, if this is due to location within the reservoir, or simply related to site specific habitat conditions.

Considering the level of coverage within the reservoir and the relative consistent species distribution between sites, it is unlikely that other freshwater mussel species occur within the reservoir. The two target species, the Carolina Heelsplitter and the Savannah Liliput described in Section 2.0 and 3.0 respectively, are not known from the Broad River Basin and are very unlikely to occur in the reservoir. The Carolina Heelsplitter is known to occur only within lotic habitats. While historically it was reported from mill ponds, it is now believed that these were likely occurrences just below mill ponds as site locality data were often not very specific (i.e. lat/long coordinates) and a mill pond is a recognizable landmark. The Savannah Liliput is known to occur within reservoirs; however, it usually occupies very shallow habitats along the shoreline. The daily fluctuations of water levels in Monticello Reservoir would likely preclude this species from ever becoming established.

The recreational lake does not currently appear to support a viable mussel fauna. The reasons for this are unclear; however, physical habitat conditions (substrate, water depth) do not appear to be limiting factors.

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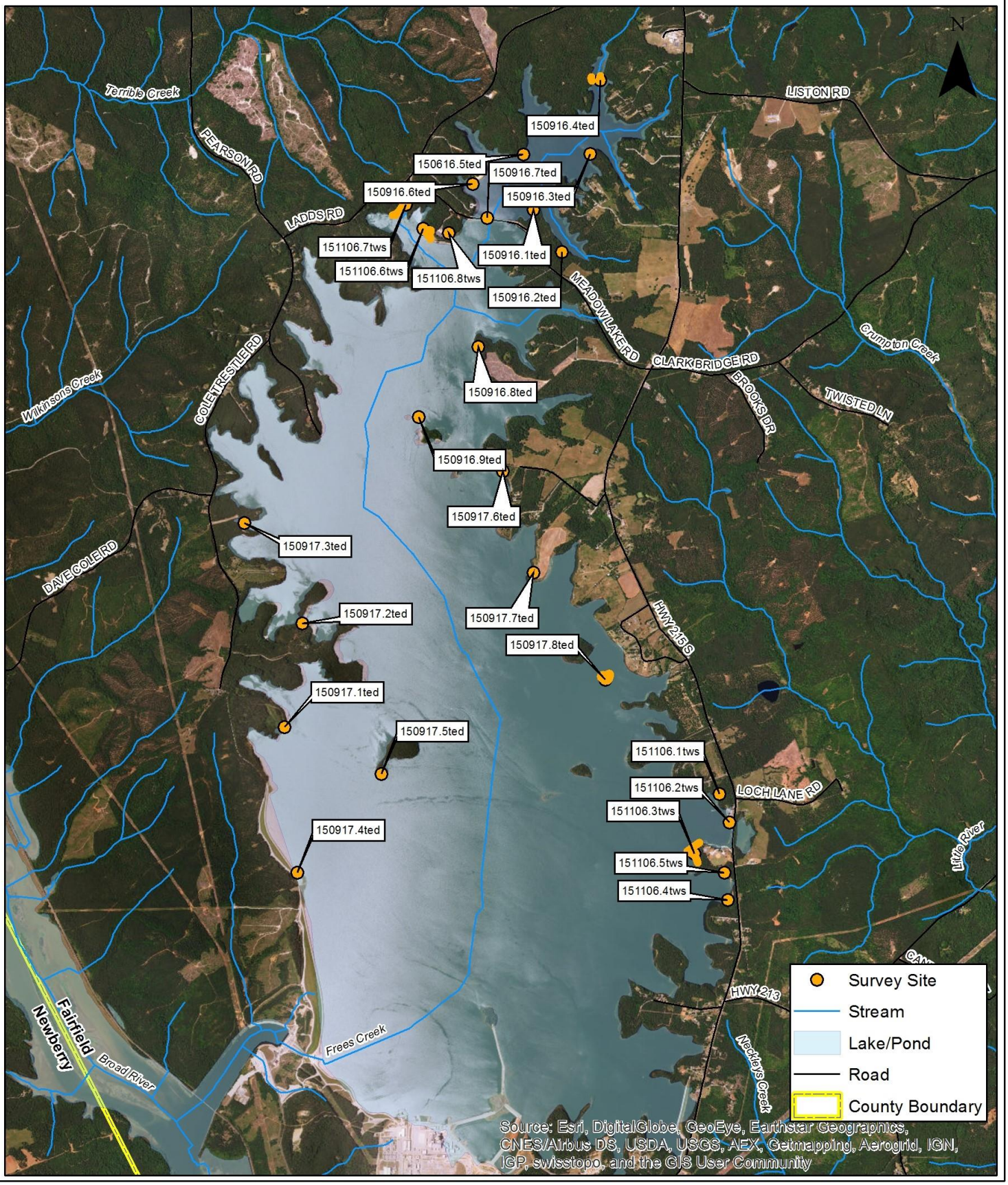
APPENDIX A: Figure 1



THREE OAKS ENGINEERING

Prepared For:

Kleinschmidt

Freshwater Mussel Survey
Monticello Reservoir

Date: December 2015

Scale 0 1,000 2,000 Feet

Job No.:

Figure

1

APPENDIX B: Select Photographs