Prepared for

SCE&G, VC Summer Station
Highway 215 and Bradham Blvd
Jenkinsville, South Carolina 29065

SOURCE WATER BASELINE BIOLOGICAL CHARACTERIZATION DATA

V.C. SUMMER NUCLEAR STATION UNIT 1

40 CFR §122.21(r)(4)

SOUTH CAROLINA ELECTRIC & GAS COMPANY
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LIST OF ACRONYMS

CFR	Code of Federal Regulations
CWA	Clean Water Act
CWIS	cooling water intake structure
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FPSF	Fairfield Pumped Storage Facility
Geosyntec	Geosyntec Consultants, Inc.
gpm	gallons per minute
MGD	million gallons per day
mm	millimeters
MSL	Mean sea level
MW	megawatt
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
Normandeau	Normandeau Associates, Inc.
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SCE&G	South Carolina Electric and Gas
UCL	upper confidence limit
USFWS	U.S. Fish and Wildlife Service
VCSNS	Virgil C. Summer Nuclear Station

1. INTRODUCTION

This report provides source water baseline biological characterization data for South Carolina Electric & Gas Company's (SCE&G's) Virgil C. Summer Nuclear Station (VCSNS) Unit 1. VCSNS Unit 1 is an existing nuclear-powered generating facility located on Monticello Reservoir in the Broad River system near Jenkinsville, Fairfield County, South Carolina. SCE&G operates VCSNS Unit 1 under National Pollutant Discharge Elimination System (NPDES) Permit Number SC0030856. The information provided in this report supports the facility's compliance with section 316(b) of the Clean Water Act (CWA).

The U.S. Environmental Protection Agency's (EPA's) 316(b) regulations for cooling water intake structures (CWISs) at existing power generating and manufacturing facilities became effective October 14, 2014 (40 CFR Parts 122 and 125). The final 316(b) rule requires the submittal of applicable CWIS information under 40 CFR § 122.21(r) to the South Carolina Department of Health and Environmental Control (SCDHEC), the NPDES permitting agency in South Carolina.

As provided in the regulations at 40 CFR § 122.21(r)(4), the source water baseline biological characterization data submitted must include:

(i) *A list of the data in paragraphs (r)(4)(ii) through (vi) of this section that are not available and efforts made to identify sources of the data;*

(ii) *A list of species (or relevant taxa) for all life stages and their relative abundance in the vicinity of the cooling water intake structure;*

(iii) *Identification of the species and life stages that would be most susceptible to impingement and entrainment. Species evaluated must include the forage base as well as those most important in terms of significance to commercial and recreational fisheries;*

(iv) *Identification and evaluation of the primary period of reproduction, larval recruitment, and period of peak abundance for relevant taxa;*

(v) *Data representative of the seasonal and daily activities (e.g., feeding and water column migration) of biological organisms in the vicinity of the cooling water intake structure;*

(vi) *Identification of all threatened, endangered, and other protected species that might be susceptible to impingement and entrainment at your cooling water intake structures;*

(vii) *Documentation of any public participation or consultation with Federal or State agencies undertaken in development of the plan; and*

(viii) *If you supplement the information requested in paragraph (r)(4)(i) of this section with data collected using field studies, supporting documentation for the Source Water Baseline Biological Characterization must include a description of all methods and quality assurance procedures for sampling, and data analysis including a description of the study area; taxonomic identification of sampled and evaluated biological assemblages (including all life stages of fish and shellfish); and sampling and data analysis methods. The sampling and/or data analysis methods you use must be appropriate for a quantitative survey and based on consideration of methods used in other biological studies performed within the same source water body. The study area should include, at a minimum, the area of influence of the cooling water intake structure.*

(ix) *In the case of the owner or operator of an existing facility or new unit at an existing facility, the Source Water Baseline Biological Characterization Data is the information in paragraphs (r)(4)(i) through (xii) of this section.*

(x) *For the owner or operator of an existing facility, identification of protective measures and stabilization activities that have been implemented, and a description of how these measures and activities affected the baseline water condition in the vicinity of the intake.*

(xi) *For the owner or operator of an existing facility, a list of fragile species, as defined at 40 CFR 125.92(m), at the facility. The applicant need only identify those species not already identified as fragile at 40 CFR 125.92(m). New units at an existing facility are not required to resubmit this information if the cooling water withdrawals for the operation of the new unit are from an existing intake.*

(xii) *For the owner or operator of an existing facility that has obtained incidental take exemption or authorization for its cooling water intake structure(s) from the U.S. Fish and Wildlife Service or the National Marine Fisheries Service, any information submitted in order to obtain that exemption or authorization may be used to satisfy the permit application information requirement of paragraph 40 CFR 125.95(f) if included in the application.*

The following sections present source water baseline biological characterization data for Monticello Reservoir in the vicinity of the VCSNS Unit 1 CWIS.

2. BACKGROUND AND ENVIRONMENTAL SETTING

VCSNS Unit 1 is located at the southern end of Monticello Reservoir (Figure 1). The facility is situated in a rural area of the Piedmont physiographic province within the Broad River system of the larger Santee-Cooper River basin. VCSNS Unit 1 operates using a single CWIS located along the shoreline of Monticello Reservoir (Figure 2). Although the cooling system operates in a "once-through" mode, Monticello Reservoir was constructed for the purpose of serving as part of the cooling water system (U.S. Nuclear Regulatory Commission [NRC], 2004). Thus, the use of Monticello Reservoir as a cooling impoundment for VCSNS Unit 1 has been determined by SCDHEC and EPA to be a "closed-cycle recirculating system" under 40 CFR, Part 125, Subpart J, § 125.92(c)(2).

2.1 Monticello Reservoir

Monticello Reservoir is a 6,500-acre freshwater impoundment with 51 miles of shoreline. It was built (completed in 1978) to serve as the cooling water source for VCSNS Unit 1 and the upper pool for the Fairfield Pumped Storage Facility (FPSF) (NRC, 2004). Monticello Reservoir has an average depth of 59 feet (ft), a maximum depth of 125 ft, and a watershed area of 17.4 square miles in the Frees Creek valley, a tributary to the Broad River.

Monticello Reservoir and Parr Reservoir serve as the upper and lower reservoirs, respectively, for the FPSF. FPSF is part of the Parr Hydroelectric Project operated by SCE&G and licensed by the Federal Energy Regulatory Commission (FERC) as Project Number 1894. FPSF generates hydroelectricity by releasing water from Monticello Reservoir into Parr Reservoir, a 4,398-acre freshwater impoundment on the main-stem Broad River (Figure 1). During off-peak power demand periods, FPSF turbines reverse flow and pump water from Parr Reservoir into Monticello Reservoir. The full-pool elevation of Monticello Reservoir is 425 ft mean sea level (MSL, NGVD29). Monticello Reservoir experiences daily fluctuations in surface elevation of up to 4.5 ft due to pumped storage operations (Kleinschmidt, 2015). Under the FERC license for the Parr Hydroelectric Project, SCE&G operates Monticello Reservoir within an elevation range of 420.5 to 425.0 ft MSL.

At the northern end of Monticello Reservoir is a 300-acre impoundment known as the Monticello Sub-impoundment (Figure 1). Although hydraulically connected to the main

reservoir by a conduit that passes under South Carolina Highway 99, the water level in this sub-impoundment is minimally influenced by pumped storage operations on Monticello Reservoir proper. The sub-impoundment is managed for fishing and recreation by SCE&G and SCDNR.

A survey to delineate the area of hydraulic influence attributable to the VCSNS Unit 1 CWIS was performed in April 2005 using acoustic Doppler current profiling technology (Geosyntec Consultants, Inc. [Geosyntec], 2005). The area of influence survey remains relevant and representative of conditions at the facility because the cooling water system operations have not changed appreciably. The survey was conducted over a 24-hour period to represent daily changes in reservoir elevations that occur as a result of FPSF operations. Boundaries of the area of influence were conservatively estimated based on the detection of any flow vector oriented towards the CWIS regardless of the velocity (ichthyoplankton may be susceptible to entrainment even at low velocities directed toward the CWIS). The maximum area of influence, delineated to encompass the areas measured for three different reservoir elevations, covered 2.92 surface acres and extended from the intake approximately 550 ft out into the reservoir with a width of about 250 ft (Figure 3).

2.2 VCSNS Unit 1

VCSNS Unit 1 is a 972.7-megawatt, nuclear-fueled, base-load generating facility. Unit 1 uses a cooling water system with a design intake capacity of approximately 533,122 gallons per minute or 768 million gallons per day (MGD). The actual intake flow of the CWIS is greater than 125 MGD.

The VCSNS Unit 1 CWIS consists of an inlet bay about 550 ft wide (east to west) and about 200 ft in length (north to south) (Figure 2). Water depth in the inlet bay ranges from 30 to 40 ft.

The circulating pump house structure located within the inlet bay is 93 ft wide with six intake bays each approximately 13-ft wide. Parallel concrete retainer walls extend out into the inlet bay approximately 30 ft. Trash racks comprised of steel bars with 10-inch spacing are located along the upstream face of the pump house structure to prevent large debris from entering the intake bays. The trash racks are mounted to the bottom of a skimmer wall that extends from the water surface to a depth of 9.5 ft (415.5 ft MSL) at normal high water (425 ft MSL). The skimmer wall is designed to exclude floating debris

from entering the cooling water system and, combined with the intake retainer walls, to optimize withdrawal of the coolest water from mid depth of the water column at the pump house. Vertical traveling water screens are located 25 ft behind the trash racks to strain out smaller debris. A bar grid structure is located between the traveling screens and the circulating pumps. Three circulating water pumps convey screened flow to the condensers. At normal high water, the CWIS is designed to withdraw water from the water column between the 415.5 ft and 390 ft MSL; or from a depth of 9.5 ft to 35 ft.

Fish and shellfish are potentially subject to impingement and entrainment at the CWIS's six vertical traveling screens. Under normal operations, the traveling screens are activated by timer approximately every 12 hours, or more frequently if differential pressure across the screens becomes excessive. High-pressure screen-wash water is used to clean the screens of debris and impinged organisms and conveys removed items to a trash sump where they are accumulated in a collection basket. The screen wash water is then returned to the intake pumps downstream of the traveling screens. As the collection basket reaches capacity, its contents are discarded (about every two weeks depending on debris load), thus resulting in 100-percent mortality of impinged fish and shellfish.

Entrained organisms pass through the cooling water system. After leaving the condensers, the heated cooling water discharges to Monticello Reservoir via a discharge basin and 1,000-foot-long discharge canal located east of the CWIS beyond the service water pond and jetty (Figure 2).

3. STUDY METHODS

The existing aquatic biological community in the vicinity of the VCSNS Unit 1 CWIS was characterized based on review of existing information sources. Efforts made to identify sources of existing data included review of fisheries studies previously conducted in Monticello Reservoir for species, life-stage, and relative abundance information; online searches of protected species databases and relevant technical reports; and review of the scientific literature for life history information on species occurring in the vicinity of the CWIS, including data representative of seasonal and daily activities. Key sources of information identified included:

- The CWA section 316(b) demonstration study conducted for VCSNS Unit 1 in 1983-1984 by Dames & Moore (1985), which included fish community and ichthyoplankton surveys in Monticello Reservoir, and impingement sampling at the CWIS;
- Fisheries surveys and creel surveys conducted on Monticello Reservoir by the South Carolina Department of Natural Resources (SCDNR) between 1987 and 1996 (Nash et al., 1990; Christie and Stroud, 1996, 1997, 1998, 1999);
- The generic environmental impact statement for VCSNS license renewal (NRC, 2004), which characterized changes in the fish community composition of the reservoir based on the previous fisheries studies conducted since 1983;
- The 1-year impingement mortality characterization study conducted at the VCSNS Unit 1 CWIS in 2005-2006 by Geosyntec (2007);
- Seasonal fisheries surveys of the reservoir conducted between fall 2006 and winter 2009 by Normandeau Associates, Inc. (Normandeau, 2007, 2008, 2009a);
- Ichthyoplankton surveys of Monticello Reservoir conducted over 1 year in 2008-2009 by Normandeau (2009b) to support SCE&G's combined license application for new VCSNS Units 2 and 3;
- Ichthyoplankton surveys of Monticello Reservoir conducted over 6 months in 2016 by Normandeau (2017) to support SCE&G's Entrainment Chartization Study for VCSNS Unit 1

- The final environmental impact statement for combined licenses for VCSNS Units 2 and 3 (NRC, 2011), which characterizes the aquatic biological community of Monticello Reservoir based on existing data;

- The baseline fisheries resources report for SCE&G's Parr Hydroelectric Project by Kleinschmidt (2013), which describes the fish community in Monticello Reservoir and summarizes the Normandeau fisheries surveys from 2006-2009;

- Life history information for fishes occurring in Monticello Reservoir from Rohde et al. (2009), Jenkins and Burkhead (1993), Boschung and Mayden (2004), and in other scientific sources;

- Scientific literature on the temporal distribution, species, composition, and chronology of appearance of larval fishes in streams and rivers; and

- Information on rare, threatened, and endangered aquatic species in the Broad River from online databases and information maintained by the SCDNR Heritage Trust Program, U.S. Fish and Wildlife Service (USFWS), and from scientific literature.

In response to 40 CFR § 122.21(r)(4)(i), based on the efforts made above to identify sources of relevant data, the following types of data were not readily available for characterizing certain aspects of the aquatic biological community in the vicinity of the VCSNS Unit 1 CWIS:

- Data on habitat use by larval and juvenile life stages were available for some fish species but were generally lacking in the scientific literature; and

- Data describing the daily activity patterns of fishes were available for several fish species but were lacking for other species in the scientific literature.

4. SPECIES FOR ALL LIFE STAGES AND THEIR RELATIVE ABUNDANCE IN THE VICINITY OF THE CWIS

This section describes the aquatic resources of Monticello Reservoir, the source water body for the VCSNS Unit 1 CWIS. This information is characterized with respect to fish and shellfish species composition and relative abundance.

4.1 Fish

Monticello Reservoir supports a warmwater fish community characteristic of a southeastern Piedmont reservoir. It shares many of the same fish species with Parr Reservoir on the Broad River (Normandeau 2007, 2008, 2009a; Kleinschmidt, 2013), with which it exchanges water daily through FPSF operations. Fisheries surveys, impingement sampling, and ichthyoplankton surveys conducted between 1983 and 2017 have documented the occurrence of 42 species of freshwater fish from 10 families in Monticello Reservoir (Table 1). The families represented by the most species were sunfishes (11), suckers (8), catfishes (7), and minnows (6). The principal sport fishes inhabiting the reservoir include blue catfish, channel catfish, white catfish, largemouth bass, black crappie, white bass, yellow perch, and a variety of sunfishes. Other recreationally important species include bluegill and white perch. Forage fish for predators include gizzard shad, threadfin shad, and juvenile white perch.

Since 1984, the Monticello Reservoir fish community has shifted in species composition and abundance as a result of the introduction of white perch and blue catfish (NRC, 2004 and SCDNR studies cited therein). The fish standing crop from 1984 to 1988 was dominated by bluegill, gizzard shad, channel catfish, and white catfish. Blue catfish and white perch were collected from Monticello Reservoir for the first time in 1989 and 1995, respectively. By 1996, blue catfish had become the dominant species, increasing dramatically in SCDNR standing stock estimates from 7 pounds per acre in 1995 to 110 pounds per acre in 1996 (Christie and Stroud, 1997). White perch was the sixth most dominant species in 1996. Like previous years, other dominant species in 1996 included gizzard shad, channel catfish, bluegill, and white catfish (NRC, 2004).

SCDNR roving creel surveys conducted in 1997-1999 found that fishing effort had increased substantially since the late 1980s and that the most harvested species by numbers were blue catfish, channel catfish, white catfish, white perch, and bluegill

(Christie and Stroud, 1998, 1999). Harvest by weight was dominated by channel catfish, blue catfish, and white catfish.

Normandeau (2007, 2008, 2009a) conducted seasonal surveys of the Monticello Reservoir fish community in fall 2006, spring 2007, summer 2008, and winter 2009. The primary sampling methods used in all seasons were boat electrofishing and gillnetting. Limited hoopnetting was also used in fall 2006 and spring 2007 but the method yielded few fish. Electrofishing transects and netting stations were located in the southern end of the reservoir and included the shoreline in the vicinity of the VCSNS Unit 1 CWIS. A total of 2,063 fish representing 25 species was collected during the study period using all gear types (Table 2). Bluegill, gizzard shad, blue catfish, white perch, and largemouth bass numerically dominated the catch (in descending order of abundance), comprising 82.7 percent of the total catch. Electrofishing in shallow, shoreline habitats yielded bluegill as the numerically most abundant species, comprising 51.2 percent of the total catch (Table 3). The next most abundant species in electrofishing samples were gizzard shad, largemouth bass, white perch, whitefin shiner, pumpkinseed, channel catfish, and white catfish (in descending order of abundance), comprising 37.4 percent of the total catch.

In response to 40 CFR § 122.21(r)(4)(xi) (see Section 1), two fragile species are identified as commonly occurring in the vicinity of the VCSNS Unit 1 CWIS: gizzard shad and threadfin shad. Gizzard shad, specifically identified as fragile at 40 CFR § 125.92(m), is one of the most abundant species collected in historical and recent fisheries surveys of Monticello Reservoir (Table 2). Threadfin shad is another highly abundant, fecund forage species closely related to gizzard shad (same genus), and like gizzard shad is especially susceptible to naturally occurring mortality resulting from cold shock in winter months. During the coldest periods, cold-shocked threadfin shad and gizzard shad often arrive in large numbers at power plant CWISs in a naturally moribund condition resulting from diminished swimming performance and a loss of equilibrium (Loar et al., 1978; McLean et al., 1985; Frost, 2006). As described in the 316(b) regulations, EPA (2014) does not intend for such naturally occurring mortality to be counted against a facility's performance in reducing impingement mortality, rather to allow the permitting director to establish site-specific measures addressing fragile species under 40 CFR § 125.94(c)(9).

4.2 Shellfish

Only three taxa of shellfish have been documented from Monticello Reservoir, including the introduced, invasive species Asian clam, freshwater grass shrimp, and unidentified crayfish (Table 1). None of these taxa are known to be of recreational or commercial significance in Monticello Lake.

5. SPECIES AND LIFE STAGES THAT WOULD BE MOST SUSCEPTIBLE TO IMPINGEMENT AND ENTRAINMENT

This section identifies the species and life stages of fish and shellfish that would be most susceptible to impingement and entrainment at the VCSNS Unit 1 CWIS. Readily available information and data for the evaluation include the impingement and ichthyoplankton sampling conducted in 1983-1984 (Dames & Moore, 1985), the impingement mortality study conducted in 2005-2006 (Geosyntec, 2007), the ichthyoplankton sampling conducted in 2008-2009 (Normandeau, 2009b), and the ichthyplankton sampling conducted in 2016 (Normandeau, 2017). The evaluation also considers the location and configuration of the CWIS in Monticello Reservoir relative to the known life-stage habitat use of resident species.

5.1 Impingement

Impingement studies previously conducted at VCSNS Unit 1 indicate that the species most susceptible to impingement are threadfin shad and gizzard shad. Both are highly abundant, fecund forage species that school in open water and are especially susceptible to natural swimming impairment and mortality resulting from cold shock in winter months. Each species meets EPA's definition of a fragile species at 40 CFR § 125.92(m) because their impingement survival may be on the order of less than 30 percent. Shad impingement rates may vary substantially from year to year depending in part on the severity of cold winter conditions. The next most numerically abundant species impinged include catfishes (blue catfish, channel catfish, and white catfish), white perch, and yellow perch.

The life stages most susceptible to impingement are small fish, including juvenile and sub-adult life stages. Shellfish taxa impinged in low numbers include crayfish, grass shrimp, and Asian clam but none of these species is commercially or recreationally important in Monticello Reservoir or the Broad River. No federally or state listed protected species are known to be impinged at the facility.

Fish impingement at the VCSNS Unit 1 CWIS was documented in two, 1-year studies conducted in 1983-1984 (Dames & Moore, 1985) and in 2005-2006 (Geosyntec, 2007). The results from both studies remain relevant and representative of conditions at the facility for the following reasons. First, the operation of the CWIS has changed very little compared to historical operations. The 2005-2006 impingement study reflects the

composition of the fishery after the introductions of blue catfish and white perch. Although the 1983-1984 impingement study pre-dates these introductions, the data are relevant to characterizing the susceptibility to impingement of resident species that have remained abundant in the reservoir, including bluegill, gizzard shad, channel catfish, white catfish, largemouth bass, and other species. In addition, when evaluated along with the 2005-2006 impingement data, the historical data also contribute to understanding of potential annual variation in impingement mortality as may be related to shad cold-shock events and other conditions at the facility.

5.1.1 2005-2006 Impingement Study

Impingement sampling was conducted biweekly at the VCSNS Unit 1 intake from July 12 2005 through 27 June 2006 for a total of 26 sampling events (Geosyntec, 2007). Samples were collected using the existing collection basket, modified to incorporate 3/8-inch wire mesh openings matching the opening size of the traveling screens. Each impingement sampling event consisted of a 24-hour collection period split into approximately equal 12-hour samples, yielding a total of 52 individual impingement samples. Size distributions of impinged fish in each sample were determined by weighing (grams) and measuring in total length (millimeters [mm]) up to 100 representative individuals of each species. Fish impingement data were standardized to reflect density and mass of organisms per unit volume of cooling water pumped.

Annual impingement mortality was estimated using Monte Carlo simulation techniques (Geosyntec, 2007). The base density impingement rates were grouped by season and then randomly drawn to estimate impingement rates for unsampled days within the specified season. The base density impingement rates were multiplied by the volume of cooling water withdrawn for each day of the half-month period associated with the sampling event. Daily estimates were then summed to yield an annual estimate of impingement mortality. The process was repeated 10,000 times to incorporate all possible outcomes from the available dataset. A 95-percent upper confidence limit (UCL) was calculated for the annual estimate to account for uncertainties associated with expected diel, seasonal, and operational variability.

5.1.1.1 Species Composition and Relative Abundance

Impingement sampling in 2005-2006 yielded 574 organisms representing 12 species of fish, one hybrid sunfish, and two taxa of shellfish (crayfish and freshwater grass shrimp)

(Table 4). The forage species threadfin shad comprised 50.2 percent of the total number of organisms collected. The impinged threadfin shad were small, ranging in length from 35 to 119 mm (Table 5). The majority of the threadfin shad (84 percent) were collected in the coldest months December-March (Geosyntec, 2007). Blue catfish, channel catfish, white perch, yellow perch, and gizzard shad were the next most numerically abundant species impinged, together comprising 43.9 percent of the sample (Table 4). The impingement of blue catfish, channel catfish, and white perch was scattered throughout the year with no discernible seasonal peaks (Geosyntec, 2007). Yellow perch were collected in impingement samples almost exclusively in December-February. Impinged gizzard shad were collected only in late November and December. No other single species comprised more than 3 percent of total impingement (Table 4). Although relatively abundant in the fish community, bluegill were impinged in low numbers (1.0 percent) and largemouth bass and black crappie were absent from impingement samples in 2005-2006.

White perch dominated impingement biomass (36.6 percent) (Table 4). The next most dominant species by biomass (in descending order) were blue catfish, gizzard shad, channel catfish, white catfish, and threadfin shad. These six species totaled 92.4 percent of the impingement biomass. No other single species accounted for more than 4 percent of the impingement biomass.

No rare, threatened, or endangered species of fish or shellfish were collected during the impingement sampling.

5.1.1.2 Size Distribution

Impinged fish were small, consisting mainly of juveniles and sub-adult fish. The vast majority of impinged fish were less than 169 mm (6.7 inches) long. The mean total length by species ranged from 35 to 155 mm (Table 5). The length-frequency distribution of all impinged organisms exhibited modal peaks from 59 to 79 mm (Geosyntec, 2007). Length-frequency distributions of the most commonly impinged fish species indicated the following size characteristics (Geosyntec, 2007):

- Threadfin shad and yellow perch, which ranked first and fourth in numerical abundance in impingement samples, respectively, had mean lengths less than 100 mm (3.9 inches). The modal size class of impinged threadfin shad was 50 to 69 mm, while that for yellow perch was 90 to 109 mm.

- The majority of blue catfish and channel catfish impinged were juveniles and sub-adults less than 119 mm long but each species was represented by multiple life stages across the full size range of impinged fish (Table 5).

- Impinged white catfish represented modal size classes of 69 and 199 mm, and likely included multiple life stages across the impinged size range (Table 5).

- White perch ranged in length from 30 to 250 mm, were broadly represented in most size classes, and represented multiple life stages (juvenile to adult).

- Impinged gizzard shad ranged in length from 56 to 332 mm, with the modal size class occurring at 60 to 69 mm.

5.1.1.3 Seasonal Occurrence

Impingement rates were greatest during the winter, from late December through early March (Geosyntec, 2007). Impingement samples from December through March comprised 62 percent of total impingement; 67.5 percent of these impinged organisms were threadfin shad. Other species contributing to peak impingement rates in winter included yellow perch, blue catfish, gizzard shad, channel catfish, and white perch.

The number of taxa impinged on the traveling screens per sampling event ranged from one to seven (Geosyntec, 2007). The frequency of occurrence by species during the 26 sampling events varied from 1 to 19 events (3.8 to 73.1 percent, respectively). Channel catfish occurred in the highest frequency of sampling events (73.1 percent) but represented only 11.8 percent of the total impingement sample. Four fish species – threadfin shad, blue catfish, channel catfish, and white perch – were collected in at least 65 percent of the sampling events, each occurring in 10 months of the year. Yellow perch occurred in 23 percent of the sampling events (4 months), while gizzard shad occurred in 11.5 percent of the sampling events (2 months).

Shellfish taxa occurred in 15.4 percent of the sampling events (Geosyntec, 2007). Crayfish was collected in December-January, and grass shrimp was collected in May.

5.1.1.4 Diel Distribution

Fifty-six percent of the fish collected during the 2005-2006 impingement study were taken in the night samples, which were generally collected between 1800 and 0600 hours

(Geosyntec, 2007). Impingement rates were higher during the night in 19 of the 26 sampling events.

5.1.1.5 Annual Impingement Estimate

Annual impingement mortality was estimated using Monte Carlo simulation techniques (Geosyntec, 2007). After adjustments reflecting actual plant operations during the study, the 95-percent UCL of estimated annual impingement mortality was determined to be 9,154 organisms weighing 272 pounds (lb) (Table 6). This estimate was representative of the VCSNS Unit 1 cooling water system in the absence of any structural controls specifically intended to reduce impingement mortality.

The rate of impingement documented for VCSNS Unit 1 in 2005-2006 study is very low compared to once-through facilities located on regional freshwater reservoirs, as shown by Geosyntec (2007). The VCSNS Unit 1 impingement rate of 0.03 organisms per million gallons of cooling water pumped was the lowest impingement rate of seven facilities evaluated. Several factors may contribute to these low impingement rates at VCSNS Unit 1, such as (Geosyntec, 2007):

- Rapid attenuation of the hydraulic area of influence with increasing distance from the CWIS;
- Possible beneficial effects of the existing CWIS skimmer wall in restricting cooling water withdrawals to depths greater than 9.5 ft, thereby reducing impingement of surface-oriented fish species;
- Natural aging of Monticello Reservoir following trophic upsurge commonly associated with new reservoirs, leading to reduced biological productivity since construction (and the previous impingement study);
- Lack of significant allochthonous nutrient input to the reservoir due to limited natural inflow from the small upstream watershed (about 17.4 square miles); and
- Daily water level fluctuations of up to 4.5 ft, which may limit the reproductive success of littoral-zone spawning species in the vicinity of the CWIS.

5.1.2 1983-1984 Impingement Study

Impingement sampling was conducted at the VCSNS Unit 1 intake from October 1983 through September 1984 as part of the facility's original 316(b) demonstration study (Dames & Moore, 1985). Fish were collected from the traveling screens over a 1-day period twice per month for a total of 22 sampling events. The impingement sampling yielded 5,140 fish representing 17 species of fish in six families and two taxa of shellfish (Asian clam and grass shrimp) (Table 4).

5.1.2.1 Species Composition and Relative Abundance

The forage species gizzard shad comprised 82.6 percent of the total number of impinged fish collected (Table 4). Gizzard shad, a historically abundant species in Monticello Reservoir, is a pelagic, schooling species exhibiting high reproductive and growth rates. Nearly all of the impinged gizzard shad (99 percent) were collected during the coldest months December through March, implicating cold shock as likely contributing to an impaired swimming ability or moribund condition of shad arriving at the intake screens (Dames & Moore, 1985). During January 1984, 2,834 gizzard shad were impinged, representing 55 percent of total study impingement and at least 3.75 times the number of impinged gizzard shad collected in any other winter sampling month (December 1983-March 1984). The gizzard shad impinged were consistently small young-of-year and juvenile fish, which tend to be more susceptible to cold shock.

Yellow perch was the second most abundant species impinged, comprising 7.6 percent of the sample (Table 4). Ninety-six percent of impinged yellow perch were collected from the traveling screens in December through March (Dames & Moore, 1985). White catfish ranked third in numerical abundance, comprising 2.4 percent of the total sample. White catfish impingement was scattered throughout the year with no discernible seasonal peaks, and size data indicated no clear relationship between size class and impingement susceptibility. No other single species comprised more than 2 percent of total impingement. Although sunfish and bass (family Centrarchidae) were relatively abundant in the fish community, the eight species present in impingement samples accounted for only 4.9 percent of the total study impingement (Table 4).

Gizzard shad dominated impingement biomass in the 1983-1984 study, representing 51.8 percent of the total impingement sample, followed by white catfish (17.6 percent), yellow perch (8.0 percent), white bass (5.2 percent), and channel catfish (4.7 percent) (Table 4).

No other single species accounted for more than 4 percent of the impingement biomass. Centrarchid species comprised 11.9 percent of the biomass.

5.1.2.2 Size Distribution

Nearly all of the impinged fish were small, and analysis of their lengths showed them to be predominantly young-of-the-year or age-1 fish (Dames & Moore, 1985). The mean length of gizzard shad and yellow perch impinged by sampling event was typically less than 100 mm (3.9 inches).

5.1.2.3 Seasonal Occurrence

The greatest numbers of fish were impinged in January through March 1984, primarily reflecting the seasonal abundance of gizzard shad and yellow perch (Dames & Moore, 1985). The high numbers of gizzard shad collected during this period, especially in January, indicated the likely influence of cold shock in impairing the swimming performance of gizzard shad and increasing their susceptibility to impingement.

5.1.2.4 Annual Impingement Estimate

The total number of fish collected during the study was extrapolated to obtain an annual impingement estimate of about 85,000 fish weighing 1,133 lb. This estimate was over nine times higher than the 95-percent UCL reported for the 2005-2006 impingement study. The difference in the impingement rates between the two studies stemmed in part from the high impingement rates reported for young-of-year gizzard shad in January 1984 when cold-induced swimming impairment was implicated.

5.2 Entrainment

Planktonic fish larvae occurring in the southern end of Monticello Reservoir are the life stages most susceptible to entrainment at the VCSNS Unit 1 CWIS because of their potential to enter the CWIS area of influence and their small size and lack of swimming ability. Based on entrainment studies previously conducted at VCSNS and the known life-stage habitats of resident fish species (Table 7), the species most susceptible to entrainment are threadfin shad, gizzard shad, and white perch. Each of these species is relatively abundant in Monticello Reservoir and highly fecund. Although their eggs are demersal and removed from the CWIS area of influence, as the larvae grow and move into the water column of nearshore waters, they become susceptible to entrainment upon

drifting toward the inlet bay to the CWIS. Sunfishes and catfishes are relatively abundant in the reservoir fish community but are much less susceptible to entrainment because their larvae receive prolonged parental care and reside in sheltered littoral-zone habitats away from the generally deeper waters of the CWIS area of influence.

Entrainment performance studies previously conducted at VCSNS include two, 1-year ichthyoplankton surveys conducted in 1983-1984 (Dames & Moore, 1985) and in 2008-2009 (Normandeau, 2009b), and one 6-month ichthyplankton survey conducted in 2016 (Normandeau, 2017).

The results of these entrainment studies are relevant and representative of conditions at the facility for the following reasons. First, the operation of the Unit 1 CWIS has changed very little compared to historical operations. The 2008-2009 ichthyoplankton survey represents the current species composition of the reservoir as well as the overall physical characteristics and aquatic habitats available in the vicinity of the Unit 1 CWIS. Although the fish community has shifted in species composition since the 1983-1984 study, these historical data are still relevant to characterizing the seasonal and spatial distribution of the early life stages of fish species that have remained abundant in the reservoir, including gizzard shad and white bass. The historical data also contribute to an understanding of potential annual variation in entrainment.

5.2.1 2016 Entrainment Study

Normandeau (2017) conducted an ichthyplankton survey within the area of influence of the Unit 1 CWIS from March through August 2016. Ichthyoplankton samples were collected from transects orientated parallel to the shoreline within the area of influence of the Unit 1 CWIS at both the surface and mid-depth using paired 0.5 m-diameter, 0.300 mm-mesh nets. Day and night ichthyoplankton samples were collected twice per month. A total of 48 samples were collected during the study. Organisms were and enumerated as to life stage, either eggs, yolk-sac, post yolk-sac, larvae, young-of-year (YOY), or juvenile (age 1). In a few instances, larvae were identified as having an undetermined larval stage due to unambiguous size and the lack of distinguishing guts and/or yolk sac.

Ichthyoplankton were collected in all samples from March through August 2016, though numbers collected in March and August were the lowest observed during the sampling period (Appendix A, Table 4-1 and 4-7). A total of 1,311 organisms comprising seven fish families were collected with over half (50.8%) occurring during the month of June.

Larval fish dominated collections with only one egg (*Dorosoma* spp.) and five YOY catfish (blue and channel catfish) comprising other life stages. As expected, no federal or state protected species were identified in ichthyoplankton samples. Ichthyoplankton were dominated by members of the Clupeid family (*Dorosoma* genus), which comprised over 86% of all organisms collected (Appendix A, Table 4-6). Centrarchidae comprised 9.6%, Cyprinidae 1.6%, and the Catostomidae, Ictaluridae, Moronidae, and Percidae each comprised less than 1% of the total number collected.

No differences were found in larval density based on the sampling depth, however, density was typically higher during the day than the night. Ichthyoplankton densities were highest in June with *Dorosoma* genus dominating the numbers for April, May and June. Lepomid larval fish were the most abundant taxon in July and August, but with far few organisms.

5.2.2 2008-2009 Entrainment Study

Normandeau (2009b) conducted an ichthyoplankton survey along the southern shoreline of Monticello Reservoir from September 2008 through August 2009. Ichthyoplankton samples were collected from two transects oriented parallel to the shoreline near the proposed location for the Units 2/3 CWIS using paired (i.e., bongo) 0.5 m-diameter, 0.300 mm-mesh nets. Samples were collected at the surface along the nearshore transect and at mid-depth along the offshore transect. The transects were located west and in the vicinity of the Unit 1 CWIS. The nets were fitted with calibrated flow meters and each side filtered a minimum of 50 m^3 of water in a tow length of 250 m. Samples were collected once per month from August through February and twice per month from March through July. Day and night samples were collected during each event. A total of 68 samples were collected during the study. Organisms were identified to the lowest practical taxon and enumerated as to life stage, either eggs, yolk-sac larvae, post yolk-sac larvae, YOY, or juvenile (age 1).

Although sampling was conducted year-round, fish larvae were collected only in March through August (Table 8). No shellfish were collected. The primary species collected as larvae were threadfin shad, which comprised 70.6 percent of the mean monthly sample density, white perch, other unidentified shad, and gizzard shad (Table 9). No eggs were collected in any sample, probably because most of the resident fish species have demersal, adhesive eggs typically not found in the water column (Table 7). As a group, the clupeids (shads) comprised 84.7 percent of ichthyoplankton collected near the intake structure

(Table 9). White perch was the next most abundant taxon, comprising 12.6 percent of the total catch. The remaining 2.7 percent included sunfishes, minnows, suckers, darters, and yellow perch. Although abundant in the fish community, catfish were not collected in ichthyoplankton samples.

5.2.3 1983-1984 Entrainment Study

Dames & Moore (1985) collected ichthyoplankton samples at seven stations located throughout Monticello Reservoir from October 1983 through September 1984. One station (Station M) was located in the vicinity of the VSCNS Unit 1 CWIS. Samples were collected at the surface and at mid-depth using net tows. Specimens were identified to the lowest practical taxon and enumerated.

Larval fish were collected throughout the reservoir in 1983-1984 but no fish eggs or shellfish were collected. Larval fish were collected at Station M in the months February through August. The numerically dominant taxon collected at all stations in the reservoir (surface and mid-depth) was shad (Clupeidae), primarily gizzard shad. Gizzard shad dominated the samples at both depths, comprising 94 percent of the samples. White bass represented about 5 percent of the samples. Other taxa collected in low numbers were minnows, suckers, sunfish, and perch. Catfish eggs and larvae were not collected.

6. PRIMARY PERIOD OF REPRODUCTION, LARVAL RECRUITMENT, AND PERIOD OF PEAK ABUNDANCE

The primary periods of reproduction in Monticello Reservoir for 18 fish species considered to be representative of those species most susceptible to impingement and entrainment at the VCSNS Unit 1 CWIS are characterized in Figure 4. The spawning periods shown are based on the species and life history information compiled in Table 7. Early spring spawners include black crappie, gizzard shad, yellow perch, and eastern silvery minnow. Although striped bass begin spawning in March, successful reproduction is not expected to occur in Monticello Reservoir due to the absence of suitable spawning habitat. Mid-spring to early summer spawners include threadfin shad, spottail shiner, shorthead redhorse, catfishes, white perch, and tessellated darter. Sunfishes, catfishes, and gizzard shad spawn through the summer. While there is substantial temporal overlap of spawning periods, the greatest numbers of species tend to spawn during the period April-June (Figure 4). Table 8 shows the monthly larval occurrence and density by species in 2008-2009. Table 4-1 of Appendix A shows the numbers of ichythoplankton collected by month.

Larval recruitment and peak larval abundance likely follow the primary periods of reproduction by several days or weeks, as eggs of the numerically dominant species tend to hatch within periods of a few days to a week or more (Jenkins and Burkhead 1993; Boschung and Mayden, 2004; Pflieger, 1997). The appearance of various species in larval drift in rivers corresponds with when they spawned (Brown and Armstrong, 1985; Niles and Hartman, 2010). The 2008-2009 ichthyoplankton survey in Monticello Reservoir found larval fish recruitment beginning in March (Normandeau, 2009b). Larval abundance increased through April, peaked in May, and then declined steadily from June to August (Table 8). The 1983-1984 ichthyoplankton survey collected fish larvae from February through August (Dames & Moore, 1985). Larval abundance in the vicinity of VCSNS Unit 1 also peaked in May and steadily declined from June to August. The 2016 ichthyoplankton survey collected fish larvae from March through August, with larval abundance peaking in June and steadily declining from late June to August (Appendix A, Table 4-7).

7. SEASONAL AND DAILY ACTIVITIES OF BIOLOGICAL ORGANISMS IN THE VICINITY OF THE CWIS

The principal seasonal activities of organisms in Monticello Reservoir in the vicinity of the VCSNS Unit 1 CWIS that may influence their susceptibility to impingement and entrainment include their movements and habitat use associated with: spawning; larval recruitment and propensity for larval drift within the water column; juvenile rearing; downstream transport from tributary stream habitats; vulnerability to swimming impairment during cold winter periods; outmigration of juveniles and sub-adults; and related activities. Table 7 summarizes the known seasonal life-stage habitat use of many of the representative fishes in the vicinity of the VCSNS Unit 1 CWIS.

Impingement rates in 2005-2006 at VCSNS Unit 1 were low throughout the year with the exception of December-February when higher numbers of threadfin shad, yellow perch, and gizzard shad were impinged (Geosyntec, 2007). Impingement rates in 1983-1984 were highest in December-March, with a pronounced peak in January that may have been attributable to cold shock of gizzard shad (Dames & Moore, 1985).

The daily activities of fish and shellfish in the vicinity of the VCSNS Unit 1 CWIS may also influence their susceptibility to impingement and entrainment. Catfish adults may become more active at night, moving from beneath rocks, deep water, and other cover into pools and shallows to feed (Pflieger, 1997; Rohde, 2009). Sunfish species, including bluegill, and yellow perch tend to exhibit peaks of feeding activity at dawn and dusk, and bluegills move onshore after sunset and offshore after sunrise (Boschung and Mayden, 2004). Some species show peaks of spawning activity during daylight hours (e.g., gizzard shad and threadfin shad), and others spawn mostly in the evening or at night (e.g., yellow perch).

Egg and larval fish distribution within the water column may vary substantially over the course of a day. Larval fish drift in streams and rivers tends to exhibit a pronounced diel pattern, with peaks observed at night and densities of drifting larvae highest near the surface and channel margins (Brown and Armstrong, 1985). Spatial and diel distribution patterns of larval fish in reservoirs have been found to be similar to those in large rivers (Sammons and Bettoli, 2002). Surface densities of most species are typically higher at night, although diel shad distributions can vary among reservoir systems, species, and possibly years (Sammons and Bettoli, 2002). These daily distribution patterns of larval fish suggest that potential fish entrainment at the VCSNS Unit 1 CWIS may be greatest

at night. Ichthyoplankton densities in the 2008-2009 and 2016 study were higher at night (Normandeau, 2009b; Normandeau, 2017).

Another factor that may affect the diel and spatial distribution of fish and shellfish in the vicinity of the VCSNS Unit 1 CWIS is the daily operations of FPSF. Pump-back operations occur at night, transferring water and organisms from Parr Reservoir into Monticello Reservoir, steadily increasing reservoir elevation, and influencing the magnitude and direction of flow in the reservoir. Impingement rates in 2005-2006 were significantly higher at night and may have been influenced by fish movements caused by pump-back operations. Pump-back operations may also transport ichthyoplankton into the vicinity of the CWIS, and from the rising water level and general mixing, contribute to a more uniform vertical distribution of larvae in the water column at night.

8. THREATENED, ENDANGERED, AND OTHER PROTECTED SPECIES

Review of protected species lists for Fairfield County indicates that there are no known occurrences of federally protected threatened or endangered fish or shellfish species in or near Monticello Reservoir, or designated critical habitat for these species in the reservoir (SCDNR, 2019; USFWS, 2016). The National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service has proposed designated critical habitat for the Carolina distinct population segment of the federally endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) that would include occupied and unoccupied habitats in the Santee River basin (NOAA, 2016). Carolina Unoccupied Unit 2 would include the Broad River extending upstream to Parr Dam but would not include Parr Reservoir or Monticello Reservoir. The federally endangered freshwater mussel species Carolina heelsplitter (*Lasmigona decorata*) historically occurred in Fairfield County but none of the 11 currently known surviving populations of the species occur in the Broad River system of the Santee-Cooper River basin (USFWS, 2012). In addition, critical habitat designated for the Carolina heelsplitter does not include any streams or rivers in the Santee-Cooper River basin (USFWS, 2002). The Broad River spiny crayfish, a federal At-Risk Species, is restricted to the Broad River basin and inhabits small to medium tributaries of the Broad River that exhibit signs of flash flooding. No Broad River spiny crayfish were collectured during a 2015 study during the Parr Hydroelectric Project relicensing studies (Klienschmidt, 2016)

In March 2008, two specimens of robust redhorse (*Moxostoma robustum*), a species of conservation concern, were collected in Monticello Reservoir during a largemouth bass survey (SCDNR, 2013). These fish were believed to have been transferred into the reservoir through pump-back operations at FPSF, after having been stocked as juveniles in the Broad River upstream of Parr Reservoir (SCDNR, 2013). The robust redhorse inhabits mainstem rivers and occurs in the Broad River primarily downstream of the Neal Shoals Hydroelectric Project near Carlisle, South Carolina. The species is not listed as protected in South Carolina.

9. SUMMARY AND CONCLUSIONS

Review and analysis of available existing information and data on the aquatic biological resources in the vicinity of the VCSNS Unit 1 CWIS, including several recently conducted studies, reveal the following characteristics of the fish community and the species and life stages that may be most susceptible to impingement and entrainment:

- Monticello Reservoir supports a warmwater fish community characteristic of southeastern Piedmont reservoirs. The numerically dominant species include bluegill, gizzard shad, blue catfish, white perch, largemouth bass, whitefin shiner, pumpkinseed, channel catfish, and white catfish. The fish community shifted in species dominance toward blue catfish and white perch after their introductions in 1989 and 1995, respectively. Blue catfish, channel catfish, white catfish, white perch, and bluegill now dominate the recreational harvest. Important forage species include gizzard shad, threadfin shad, and white perch.

- Three taxa of shellfish have been documented from Monticello Reservoir (Asian clam, freshwater grass shrimp, crayfish) but none of these taxa are commercially or recreationally important in Monticello Reservoir or the Broad River.

- The species most susceptible to impingement at the VCSNS Unit 1 intake are threadfin shad and gizzard shad. Both are fragile species that are highly abundant, fecund, grow rapidly, and school in open water. Both shad species are susceptible to natural swimming impairment and mortality resulting from cold shock during winter months, which can result in episodic impingement of shad in some years. Other numerically abundant species impinged include blue catfish, channel catfish, white catfish, white perch, and yellow perch. Dominant species by biomass include white perch, blue catfish, gizzard shad, channel catfish, white catfish, and threadfin shad.

- The life stages most susceptible to impingement are juvenile and sub-adult life stages of fish. The vast majority of impinged fish are less than 6.7 inches long with mean lengths by species ranging from about 2.5 inches (threadfin shad) to 5.9 inches (white perch). Shellfish taxa are impinged in low numbers and in only a few months of the year.

- The rate of impingement documented for VCSNS Unit 1 in 2005-2006 was very low compared to other facilities located on freshwater reservoirs. Factors potentially contributing to these low impingement rates include rapid attenuation of the area of influence with increasing distance from the CWIS, restriction of cooling water withdrawals to depths greater than 9.5 ft by the existing skimmer wall, natural aging of the reservoir with reduced biological productivity due in part to limited nutrient input from the small upstream watershed, and the daily reservoir fluctuations potentially limiting the reproductive success of littoral-zone spawning species.

- Planktonic fish larvae are the life stages most susceptible to entrainment at the VCSNS Unit 1 CWIS. Previously conducted entrainment studies and the known life-stage habitats of resident fish species indicate that the species most susceptible to entrainment are threadfin shad, gizzard shad, and white perch. Each of these species is relatively abundant in the reservoir and highly fecund. Although their eggs are demersal, as the larvae grow and move into the water column of nearshore waters, they become susceptible to entrainment upon drifting toward the inlet bay to the CWIS.

- Sunfishes and catfishes are relatively abundant in the Monticello Reservoir fish community but are much less susceptible to entrainment because their larvae receive prolonged parental care in nests and reside in sheltered littoral-zone habitats away from the generally deeper waters of the CWIS area of influence.

- Larval recruitment and peak larval abundance likely follow the primary period of reproduction for most species (April-June) by several days or weeks. Ichthyoplankton surveys in the reservoir collected fish larvae from February-March through August, with peak abundance in May-June.

- Currently there are no known occurrences of federally endangered or threatened aquatic species in Monticello Reservoir that would be susceptible to impingement or entrainment at the VCSNS Unit 1 CWIS.

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TABLES

Table 1

List of Fish and Shellfish Species Known to Occur in Monticello Reservoir

Common Name	Scientific Name	Fisheries Surveys[a]	VCSNS Unit 1 Impingement Sampling[b]	Ichthyoplankton Surveys[c]
FISH:				
GARS:				
Longnose gar	*Lepisosteus osseus*	X	X	--
HERRINGS AND SHADS:				
Gizzard shad[d]	*Dorosoma cepedianum*	X	X	X
Threadfin shad[d, e]	*Dorosoma petenense*	X	X	X
Unidentified shad	*Dorosoma spp.*	--	--	X
Unidentified shad	Clupeidae	--	--	X
MINNOWS:				
Whitefin shiner	*Cyprinella nivea*	X	--	--
Common carp[e]	*Cyprinus carpio*	X	--	--
Eastern silvery minnow	*Hybognathus regius*	X	--	--
Golden shiner	*Notemigonus crysoleucas*	X	--	--
Spottail shiner	*Notropis hudsonius*	X	--	--
Swallowtail shiner	*Notropis procne*	X		
Unidentified minnow	Cyprinidae	--	--	X
SUCKERS:				
Quillback	*Carpiodes cyprinus*	X	--	--
White sucker	*Catostomus commersoni*	X	--	--
Northern hog sucker	*Hypentelium nigricans*	X	--	--
Silver redhorse	*Moxostoma anisurum*	X	--	--
Notchlip redhorse	*Moxostoma collapsum*	X	--	--
Shorthead redhorse	*Moxostoma macrolepidotum*	X	--	--
Robust redhorse[f]	*Moxostoma robustum*	X	--	--
Striped jumprock	*Moxostoma rupiscartes*	X	--	--
Unidentified sucker	Catostomidae	--	--	X
CATFISHES:				
Snail bullhead	*Ameiurus brunneus*	X	X	--
White catfish	*Ameiurus catus*	X	X	--
Yellow bullhead	*Ameiurus natalis*	X	X	--
Brown bullhead	*Ameiurus nebulosus*	X	X	--
Flat bullhead	*Ameiurus platycephalus*	X	X	--
Blue catfish[e]	*Ictalurus furcatus*	X	X	--
Channel catfish[e]	*Ictalurus punctatus*	X	X	--
LIVEBEARERS:				
Eastern mosquitofish	*Gambusia holbrooki*	X		
SILVERSIDES:				
Brook silverside	*Labidesthes sicculus*	X		
TEMPERATE BASSES:				
White perch[e]	*Morone americana*	X	X	X
White bass[e]	*Morone chrysops*	X	X	X
SUNFISHES:				
Flier	*Centrarchus macropterus*	--	X	--
Redbreast sunfish	*Lepomis auritus*	X	--	--
Green sunfish[e]	*Lepomis cyanellus*	X		

Table 1
List of Fish and Shellfish Species Known to Occur in Monticello Reservoir

Common Name	Scientific Name	Fisheries Surveys[a]	VCSNS Unit 1 Impingement Sampling[b]	Ichthyoplankton Surveys[c]
Pumpkinseed	*Lepomis gibbosus*	X	X	--
Warmouth	*Lepomis gulosus*	X	X	--
Bluegill	*Lepomis macrochirus*	X	X	--
Redear sunfish	*Lepomis microlophus*	X	X	--
Unidentified sunfish	*Lepomis sp.*	--	--	X
Smallmouth bass[e]	*Micropterus dolomieu*	X	--	--
Largemouth bass	*Micropterus salmoides*	X	X	--
White crappie[e]	*Pomoxis annularis*	X	X	--
Black crappie	*Pomoxis nigromaculatus*	X	X	X
Unidentified crappie	*Pomoxis sp.*	--	--	X
Unidentified sunfish	Centrachidae	--	--	X
PERCHES:				
Swamp darter	*Etheostoma fusiforme*	X	--	--
Tessellated darter	*Etheostoma olmstedi*	X	--	--
Yellow perch	*Perca flavescens*	X	X	X
Unidentified perch	Percidae	--	--	X
Unidentified darter	Etheostomatini	--	--	X
	Total Number of Fish Taxa	**41**	**21**	**15**
SHELLFISH:				
BASKET CLAMS:				
Asiatic clam	*Corbicula fluminea*	--	X	--
PALAEMONID SHRIMPS:				
Freshwater grass shrimp	*Palaemonetes sp.*	--	X	--
CRAYFISHES:				
Unidentified crayfish		--	X	--
	Total Number of Shellfish Taxa	**0**	**3**	**0**

[a] Fish community survey sources: Dames & Moore (1985); Christie and Stroud (1996, 1997); NRC (2004); Normandeau (2007, 2009a); SCDNR (2013).

[b] Impingement sampling sources: Dames & Moore (1985); Geosyntec (2007).

[c] Ichthyoplankton sampling sources: Dames & Moore (1985); Normandeau (2009b).

[d] Gizzard shad and threadfin shad are fragile species, as defined at 40 CFR § 125.92(m).

[e] Introduced species, not native to the Santee-Cooper River basin (Rohde et al., 2009).

[f] Species of conservation concern but not listed as federally protected or state protected in South Carolina. Occurrence in Monticello Reservoir based on two specimens collected in 2008, which were believed to have been stocked as juveniles upstream of Parr Reservoir in the Broad River and transfered into the reservoir through pump-back operations at FPSF (SCDNR, 2013).

Table 2
Relative Abundance of Fish Collected Seasonally in Monticello Reservoir, 2006-2009

Common Name	Fall 2006 & Spring 2007		Summer 2008		Winter 2009		Total Catch 2006-2009	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Bluegill	267	32.6	181	23.1	154	33.4	602	29.2
Gizzard shad	161	19.6	330	42.2	31	6.7	522	25.3
Blue catfish	90	11.0	156	19.9	14	3.0	260	12.6
White perch	78	9.5	28	3.6	99	21.5	205	9.9
Largemouth bass	71	8.7	11	1.4	35	7.6	117	5.7
Channel catfish	31	3.8	20	2.6	26	5.6	77	3.7
Black crappie	32	3.9	7	0.9	8	1.7	47	2.3
White catfish	14	1.7	11	1.4	8	1.7	33	1.6
Whitefin shiner	15	1.8	2	0.3	16	3.5	33	1.6
Shorthead redhorse	10	1.2	4	0.5	16	3.5	30	1.5
Pumpkinseed	12	1.5	6	0.8	10	2.2	28	1.4
Spottail shiner	5	0.6	4	0.5	12	2.6	21	1.0
Notchlip redhorse	0	0.0	9	1.2	8	1.7	17	0.8
Redear sunfish	7	0.9	4	0.5	2	0.4	13	0.6
Redbreast sunfish	3	0.4	3	0.4	6	1.3	12	0.6
Flat bullhead	7	0.9	2	0.3	1	0.2	10	0.5
Yellow perch	5	0.6	0	0.0	4	0.9	9	0.4
Eastern silvery minnow	0	0.0	0	0.0	8	1.7	8	0.4
Warmouth	6	0.7	0	0.0	0	0.0	6	0.3
Smallmouth bass	2	0.2	1	0.1	1	0.2	4	0.2
Northern hogsucker	1	0.1	1	0.1	2	0.4	4	0.2
White bass	2	0.2	0	0.0	0	0.0	2	0.1
Quillback	1	0.1	0	0.0	0	0.0	1	0.05
Snail bullhead	0	0.0	1	0.1	0	0.0	1	0.05
Yellow bullhead	0	0.0	1	0.1	0	0.0	1	0.05
Total	820		782		461		2,063	

Sources: Normandeau (2007, 2008, 2009a).

Table 3
Electrofishing Catch Per Unit Effort of Fish Collected Seasonally in Monticello Reservoir, 2006-2009

Common Name	Fall 2006	Spring 2007	Summer 2008	Winter 2009	Average	Percent
Bluegill	806.20	239.38	143.99	121.74	327.83	51.2
Gizzard shad	0	23.94	182.4	16.90	55.81	8.7
Largemouth bass	31.92	143.74	13.27	31.81	55.19	8.6
White perch	0	55.90	33.92	56.81	36.66	5.7
Whitefin shiner	55.92	3.99	3.98	63.79	31.92	5.0
Pumpkinseed	43.91	3.99	23.92	13.29	21.28	3.3
Channel catfish	0	31.95	11.96	35.88	19.95	3.1
White catfish	0	51.89	14.58	9.31	18.95	3.0
Notchlip redhorse	0	0	35.88	5.98	10.47	1.6
Spottail shiner	3.99	3.99	7.98	16.0	7.99	1.2
Redear sunfish	7.98	7.98	7.95	7.97	7.97	1.2
Shorthead redhorse	0	19.96	3.99	3.99	6.99	1.1
Redbreast sunfish	7.99	4.00	5.98	7.95	6.48	1.0
Yellow perch	19.98	0	0	5.32	6.33	1.0
Warmouth	23.97	0	0	0	5.99	0.9
Flat bullhead	15.97	0	7.94	0	5.98	0.9
Eastern silvery minnow	0	0	0	15.95	3.99	0.6
Northern hogsucker	0	3.99	3.99	3.99	2.99	0.5
Smallmouth bass	0	0	3.99	3.99	2.00	0.3
Black crappie	0	0	0	7.97	1.99	0.3
Blue catfish	0	0	3.97	3.99	1.99	0.3
Snail bullhead	0	0	3.97	0	0.99	0.2
Yellow bullhead	0	0	3.97	0	0.99	0.2

Sources: Normandeau (2007, 2008, 2009a).

Table 4

Relative Abundance and Biomass of Impinged Fish and Shellfish at VCSNS Unit 1

Common Name	July 2005-June 2006[a]			October 1983-September 1984[b]		
	Number of Organisms	Percent Abundance	Percent Biomass	Number of Organisms	Percent Abundance	Percent Biomass
FISH:						
Threadfin shad	288	50.2	6.9	41	0.8	0.7
Blue catfish	70	12.2	16.1	--	--	--
Channel catfish	68	11.8	12.5	66	1.3	4.7
White perch	54	9.4	36.6	--	--	--
Yellow perch	35	6.1	3.4	381	7.6	8.0
Gizzard shad	25	4.4	12.9	4,245	82.6	51.8
White catfish	15	2.6	7.4	123	2.4	17.6
Bluegill	6	1.0	1.5	77	1.5	2.1
Flat bullhead	3	0.5	1.1	10	0.2	0.5
Snail bullhead	2	0.3	0.6	--	--	--
Warmouth	1	0.2	0.1	30	0.6	2.8
Flier	1	0.2	0.0	1	0.02	0.08
Hybrid sunfish	1	0.2	0.7	--	--	--
Black crappie	--	--	--	66	1.3	2.5
Pumpkinseed	--	--	--	56	1.1	1.1
White bass	--	--	--	15	0.3	5.2
White crappie	--	--	--	15	0.3	3.3
Longnose gar	--	--	--	10	0.2	0.2
Redear sunfish	--	--	--	2	0.04	0.02
Yellow bullhead	--	--	--	1	0.02	0.08
Largemouth bass	--	--	--	1	0.02	0.01
SHELLFISH:						
Crayfish	4	0.7	0.2	--	--	--
Grass shrimp	1	0.2	0.0	X	--	--
Asiatic clam				X	--	--
Total	**574**			**5,140**		

[a] Source: Geosyntec (2007).

[b] Source: Dames & Moore (1985).

Table 5
Size Range of Impinged Fish at VCSNS Unit 1, July 2005-June 2006[a]

Species Common Name	Number of Fish Measured	Total Length (mm)		
		Minimum	Maximum	Mean
Threadfin shad	288	35	119	64
Blue catfish	70	56	290	113
Channel catfish	68	48	237	106
White perch	54	30	250	150
Yellow perch	35	44	118	97
Gizzard shad	25	56	332	117
White catfish	15	60	260	150
Bluegill	6	80	120	105
Flat bullhead	3	97	174	124
Snail bullhead	2	88	155	122
Flier	1	35	35	35
Hybrid sunfish	1	155	155	155
Warmouth	1	70	70	70

[a] Source: Geosyntec (2007).

Table 6

Extrapolated Annual Estimate of Impingement at VCSNS Unit 1 Based on Monte Carlo Simulation, July 2005-June 2006[a, b]

	Annual Estimate	Upper Confidence Limit
FISH:		
Threadfin shad	4,377	4,593
Blue catfish	1,064	1,116
Channel catfish	1,033	1,084
White perch	821	861
Yellow perch	532	558
Gizzard shad	380	399
White catfish	228	239
Bluegill	91	96
Flat bullhead	46	48
Snail bullhead	30	32
Flier	15	16
Warmouth	15	16
Hybrid sunfish	15	16
SHELLFISH:		
Crayfish	61	64
Grass shrimp	15	16
Total	**8,723**	**9,154**

[a] Source: Geosyntec (2007).

[b] Annual impingement was estimated as the "calculation baseline" as defined in the remanded Phase II rule and was adjusted upward to account for failure of a circulating water pump during part of the study.

Table 7

Known Life-Stage Habitats of Representative Fish Species Occurring in Monticello Reservoir in the Vicinity of the VCSNS Unit 1 CWIS

Family/Species	Adults	Spawning	Eggs/Larvae	Juveniles
Herrings and Shads:				
Gizzard shad (*Dorosoma cepedianum*)	Pelagic, schooling, in deep, open water of rivers, lakes, impoundments, and backwaters of low-gradient streams; occur over a variety of substrates, including heavily silted bottoms; planktivore (1, 2).	Spawns March-August near the surface in shallow water of rivers, sloughs, coves, and backwaters, and in low-gradient tributaries or ditches; spawns in large aggregations of adults (1, 2).	Eggs demersal, in ribbon-like masses, adhering to algae, rocks, vegetation, or other objects in shallow water; larvae concentrate near surface in calm water (1, 2).	School in open water, straining plankton in surface waters (2).
Threadfin shad (*Dorosoma petenense*)	Pelagic, schooling, in mid-water of lakes, reservoirs, backwaters, and pools of larger rivers; planktivore; susceptible to cold shock, which can result in massive die-offs (1, 2).	Spawns April-July along shorelines in groups over aquatic plants and other submerged structure; spawning begins at sunrise (1).	Eggs demersal, adhering to submerged plants, logs, boulders, or debris (1).	Similar to adults.
Minnows:				
Whitefin shiner (*Cyprinella nivea*)	Sand and gravel runs and riffles in larger creeks and medium rivers; also occurs along reservoir shorelines (2).	Protracted spawning season from June to August; presumably deposits eggs in crevices like other species in the genus (2).		
Eastern silvery minnow (*Hybognathus regius*)	Slow-moving large streams and rivers, moderate to low gradient; generally found in pools and backwaters over sand (1, 2).	Spawns in spring in large schools in shallows of backwaters and covers (1, 2).	Eggs shed on or above silted, unvegetated detrital areas, also in sand and gravel areas (1).	
Spottail shiner (*Notropis hudsonius*)	Wide variety of habitats; sandy and rocky pools and runs of moderate-gradient streams and rivers to often turbid and sandy-bottom rivers (1, 2).	Spawns April-June in groups or aggregations; scatters eggs in shallow riffles over sand and gravel, or over sandy bottom or filamentous algae (1, 2).	Eggs demersal and adhesive (1, 2).	
Suckers:				
Shorthead redhorse (*Moxostoma macrolepidotum*)	Moderate-gradient, medium to large streams and rivers; mainly in deeper pools with sand, gravel, rubble and bedrock; also occupies shallows of lakes and reservoirs (1, 2).	Spawns early April to May in streams on gravel shoals or in runs or pool tails over gravel, rubble, or sand (1, 2).	Eggs demersal and non-adhesive; larvae spend first several days motionless on bottom before moving into water column (14).	

Table 7

Known Life-Stage Habitats of Representative Fish Species Occurring in Monticello Reservoir in the Vicinity of the VCSNS Unit 1 CWIS

Family/Species	Adults	Spawning	Eggs/Larvae	Juveniles
Catfishes:				
White catfish (*Ameiurus catus*)	Channels and backwaters of small to large rivers, reservoirs, ponds, and brackish waters, over sand or silt (1, 2, 5).	Spawns May-July over saucer-shaped nests in sand or gravel (1, 2).	Eggs demersal and adhesive, guarded and fanned by parents (1, 5).	
Blue catfish (*Ictalurus furcatus*)	Deep swift channels of rivers and impoundments over sand, gravel, and rubble (1, 2, 5, 10).	Spawns April to June in natural cavities around piles of drift, logs, and undercut banks (10).	Eggs demersal and adhesive, guarded and fanned by parents; fry remain in nest for several days, protected by male (10).	Young-of-year feed on or near the bottom (5).
Channel catfish (*Ictalurus punctatus*)	Deep pools of large streams, rivers, ponds, lakes, and reservoirs over a variety of substrates (1, 2).	Spawns May-July in nests in sheltered areas of rivers around piles of drift logs, undercut banks, or in cavities (1, 5).	Eggs demersal and adhesive, guarded and fanned by parents; fry remain in nest for several days, protected by male (5).	Sand substrate, low velocity, and shallow depths in habitats off the main channel (6).
Temperate Basses:				
White perch (*Morone americana*)	Euryhaline, schooling; creek-like, riverine, and embayed portions of estuaries, and freshwater rivers and reservoirs (1, 2).	Semi-anadromous, moving from estuarine to fresher waters, or may migrate within reservoirs, to spawn; spawns April-early June over sand and gravel (1, 2).	Eggs demersal and adhesive, attaching to substrate; with intensive spawning, eggs may adhere to each other, and drift and incubate in current; as larvae grow they move into water column as downstream or planktonic drift (15).	Protected shoreline areas near bottom at depths of 8 to 12 feet (15).
Striped bass (*Morone saxatilis*)	Anadromous, schooling; channels of large coastal rivers, lakes, impoundments, and connecting rivers; adults return to estuaries, ocean, or reservoirs after spawning; stocked into many reservoirs (1, 2).	Ascends freshwater coastal rivers or tributary rivers (of reservoirs); spawns March-early June in near-surface spawning aggregations; broadcast eggs in moderate to strong current over rapids and boulders (1, 3).	Eggs semi-buoyant and non-adhesive, drifting downstream 2-3 days and requiring suspension above bottom to survive until hatching; streams must be of sufficient length to suspend eggs until hatching; larvae drift for several days (1, 3).	Lower rivers, coastal estuaries, or lacustrine backwaters (1, 4).

Table 7

Known Life-Stage Habitats of Representative Fish Species Occurring in Monticello Reservoir in the Vicinity of the VCSNS Unit 1 CWIS

Family/Species	Adults	Spawning	Eggs/Larvae	Juveniles
Sunfishes:				
Redbreast sunfish (*Lepomis auritus*)	Rocky and sandy pools and backwaters of streams and rivers of low to moderate gradient, often associated with woody debris, stumps, and undercut banks; pond and reservoir margins (1, 3).	Spawns late May-July in nests constructed near cover in shallow, calm pool margins on sand or fine gravel, or in shelter of large rocks or snags near swifter water (1, 3).	Eggs demersal and adhesive; male guards nest until fry depart; fry occur in shallow water near cover or vegetation (1, 5).	Shallow, vegetated littoral zones of still water (5).
Bluegill (*Lepomis macrochirus*)	Pools and backwaters of creeks and small to large rivers, swamps, oxbows, and vegetated shores of all types of impoundments (1, 2).	Spawns May-August (peak generally in June) in nests constructed in shallow water on sand or gravel; frequently nests in colonies (1, 3).	Eggs demersal and adhesive; male guards next until fry leave and migrate from littoral to limnetic zone (1, 3, 5).	Shallow, vegetated littoral zones of still water (5).
Redear sunfish (*Lepomis microlophus*)	Clear, vegetated ponds, reservoirs, and lowland swamps; sluggish, vegetated pools of streams and rivers (1, 3, 7).	Spawns spring to mid-summer in nests in shallow water near vegetation on sand, mud, or gravel, often in colonies (1, 5, 7).	Eggs demersal and adhesive; male guards nest until fry depart; fry occur in shallow water among submergent vegetation (7).	Similar to adults (7).
Largemouth bass (*Micropterus salmoides*)	Clear, low-velocity waters of lakes, ponds, oxbows, reservoirs, and large streams and rivers; usually in association with vegetation, logs, stumps, or other cover (1, 5).	Spawns April-June in nests constructed on gravel or other firm substrates along margins of coves or quiet pools at depths of 0.3 to 0.6 m and sometimes greater (1, 5).	Eggs demersal; male guards nest until fry depart; fry occur in calm water near flooded vegetation or other cover (1, 8).	Similar to adults (8).
Black crappie (*Pomoxis nigromaculatus*)	Clear backwater and pools of streams, reservoirs, ponds, oxbows, and lakes; often among vegetation, fallen trees, and stumps (1, 5).	Spawns late February-early May in nests constructed in shallow to moderately deep pools on sand or fine gravel, usually near vegetation (1, 5).	Eggs demersal and adhesive; male guards nest until fry depart; fry move to nearby shallow, vegetated areas in calm water (5, 9).	Often found over open water of considerable depth (10).
Perches:				
Tessellated darter (*Etheostoma olmstedi*)	Sandy and muddy pools and slow runs of creeks, small to medium rivers and lake shores (1, 11).	Spawns April-June in shallow water with slow to moderate current; inverts and attaches eggs on undersides of stones, flat rocks, woody debris or other objects (1, 12).	Eggs adhesive; male cleans and guards eggs (1, 12).	

Table 7

Known Life-Stage Habitats of Representative Fish Species Occurring in Monticello Reservoir in the Vicinity of the VCSNS Unit 1 CWIS

Family/Species	Adults	Spawning	Eggs/Larvae	Juveniles
Yellow perch (*Perca flavescens*)	Pools and backwaters of streams and rivers, ponds, lakes, and reservoirs; usually in clear water near vegetation; schools roam in shallows among vegetation; move to deeper, more open areas in winter (1, 11, 13).	Spawns March-May in SC at night in shallow (1-3.7 m), slow water over vegetation, woody debris, and sandy to rocky bottoms; eggs broadcast in gelatinous strands (1, 2, 13).	Eggs adhere to vegetation or bottom substrates; fry move to calm, open water (1, 13).	Similar to adults in slightly shallower water (13).

[a] Sources:

1 – Jenkins and Burkhead, 1993
2 – Rhode et al., 2009
3 – Marcy et al., 2005
4 – Rhode et al., 1994
5 – Boschung and Mayden, 2004
6 – Phelps et al., 2011
7 – Twomey, 1984
8 – Stuber et al., 1982
9 – Edwards et al., 1982
10 – Pflieger, 1997
11 – Page and Burr, 2011
12 – Page, 1983
13 – Krieger et al., 1983
14 – Ross, 2001
15 – Stanley and Danie, 1983

Table 8

Monthly Density of Ichthyoplankton, Young-of-Year, and Yearling Fish Collected in Monticello Reservoir,
September 2008-August 2009[a]

Month (2008-2009)	Species/Taxon	Life Stage[b]	Density	Total Larval Density by Month[c]
September	Channel catfish	YOY	0.19	0
October	None captured		0	0
November	None captured		0	0
December	Threadfin shad	YOY	0.17	0
January	None captured		0	0
February	None captured		0	0
March	Black crappie	PYSL	0.25	31.86
	Threadfin shad	Undetermined	0.42	
		YSL	21.76	
		PYSL	4.43	
	Darter	YSL	0.09	
	Unidentifiable larvae	Undetermined	0.29	
	White perch	YSL	3.93	
		PYSL	0.60	
	Yellow perch	PYSL	0.09	
April	Black crappie	PYSL	0.31	62.89
	Gizzard shad	YSL	2.48	
	Threadfin shad	Undetermined	3.06	
		YSL	17.97	
		PYSL	14.72	
	Catostomidae	YSL	0.10	
		PYSL	0.54	
	Cyprinidae	YSL	0.33	
		PYSL	0.31	
	Lepomis sp.	PYSL	0.11	
	White perch	YSL	15.55	
		PYSL	7.41	
May	Gizzard shad	YSL	2.99	125.15
	Threadfin shad	YSL	17.91	
		PYSL	98.27	
	Catostomidae	PYSL	0.49	
	Cyprinidae	PYSL	0.37	
	Darter	YSL	0.09	
		PYSL	0.19	

Table 8 Monthly Density of Ichthyoplankton, Young-of-Year, and Yearling Fish Collected in Monticello Reservoir, September 2008-August 2009[a]				
Month (2008-2009)	**Species/Taxon**	**Life Stage[b]**	**Density**	**Total Larval Density by Month[c]**
	Lepomis sp.	PYSL	0.92	
	White perch	YSL	0.46	
		PYSL	3.46	
June	Blue catfish	YOY	0.39	30.21
	Brown bullhead	YOY	0.09	
	Channel catfish	YOY	0.92	
	Spottail shiner	YOY	0.10	
	Threadfin shad	YOY	0.09	
	Clupeidae	YSL	0.71	
		PYSL	28.00	
	Cyprinidae	PYSL	0.69	
	Lepomis sp.	PYSL	0.52	
	White catfish	YOY	0.10	
	White perch	PYSL	0.29	
July	Blue catfish	Yearling	0.10	2.87
	Clupeidae	PYSL	1.35	
	Cyprinidae	PYSL	0.10	
	Lepomis sp.	PYSL	1.42	
August	Blue catfish	Yearling	0.21	0.41
	Clupeidae	PYSL	0.20	
	Lepomis sp.	PYSL	0.21	

[a] Source: Normandeau (2009b).

[b] Life stages: YSL = yolk-sac larvae; PYSL = post yolk-sac larvae; YOY = young-of-year; Yearling = age 1; Undetermined = damaged specimen for which life stage could not be determined.

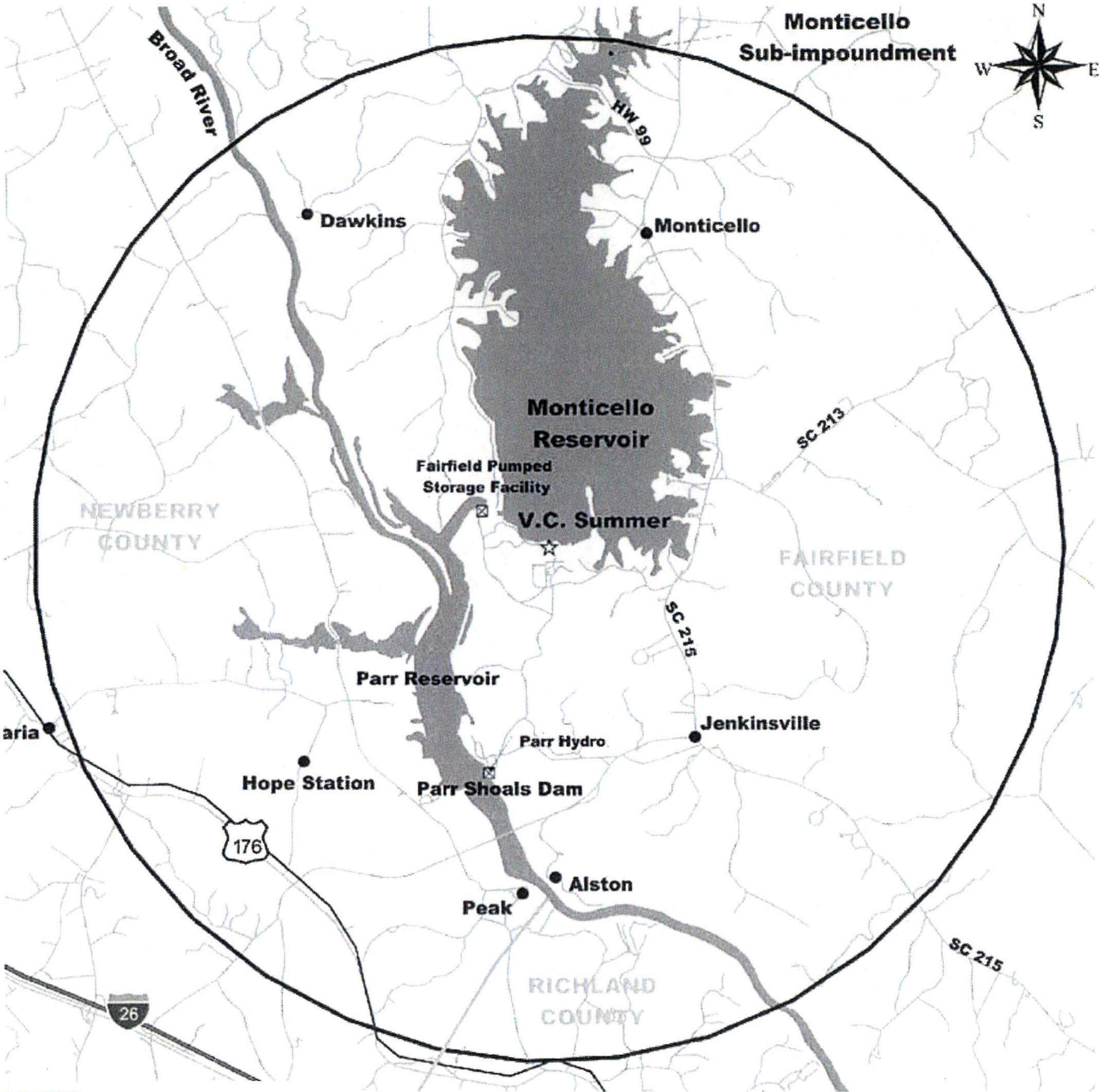
[c] Excludes YOY and yearling life stages, which are larger may be non-entrainable in size.

Table 9
Average Density and Percent Composition of Ichthyoplankton Collected in Monticello Reservoir, September 2008-August 2009[a]

Species/Taxon	Life Stage[a]	Average Density (number/100 m³)	Percent Composition
Threadfin shad	Undetermined	0.10	1.4
	YSL	1.70	22.8
	PYSL	3.45	46.4
Clupeidae	YSL	0.02	0.3
	PYSL	0.87	11.6
White perch	YSL	0.59	7.9
	PYSL	0.35	4.7
Gizzard shad	YSL	0.16	2.2
Lepomis sp.	PYSL	0.09	1.2
Cyprinidae	YSL	0.01	0.1
	PYSL	0.04	0.6
Catostomidae	YSL	<0.01	<0.1
	PYSL	0.03	0.4
Black crappie	PYSL	0.02	0.2
Darter	YSL	0.01	0.1
	PYSL	0.01	0.1
Unidentifiable larvae	Undetermined	0.01	0.1
Yellow perch	PYSL	<0.01	<0.1

[a] Life stages: YSL = yolk-sac larvae; PYSL = post yolk-sac larvae; Undetermined = damaged specimen for which life stage could not be determined.

FIGURES



LEGEND

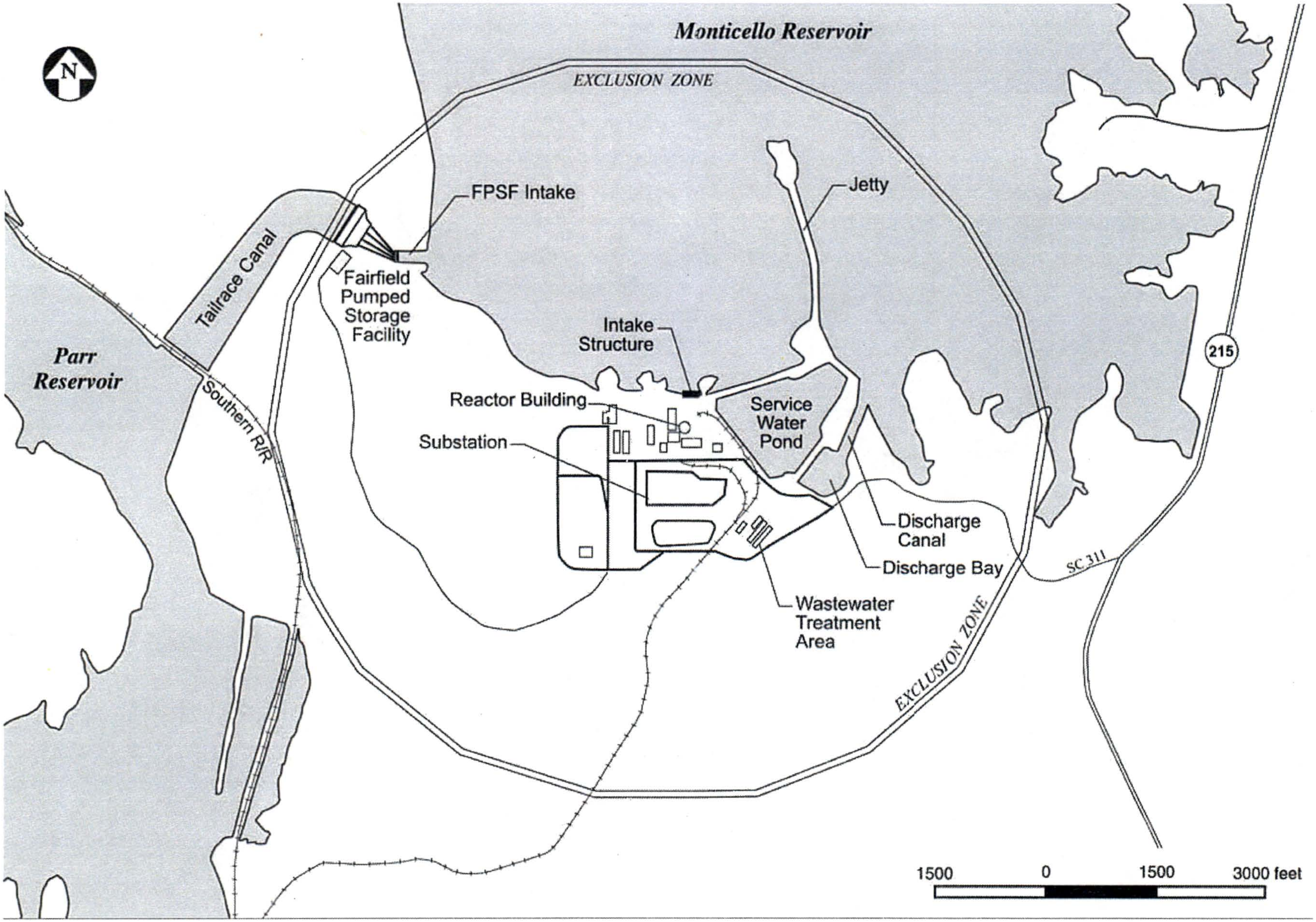
- 10-km (6-mi) radius of V.C. Summer
- Interstates
- Major Roads
- Minor Roads
- County Boundaries
- Lakes and Rivers

1 0 1 2 3 Kilometers

1 0 1 2 3 Miles

Source: NRC, 2004

Site Vicinity of VCSNS Unit 1 Jenkinsville, South Carolina	Geosyntec consultants Atlanta, Georgia — October 2016	Figure 1



Site Layout of the VCSNS Unit 1 Cooling Water Intake Structure and the Fairfield Pumped Storage Facility

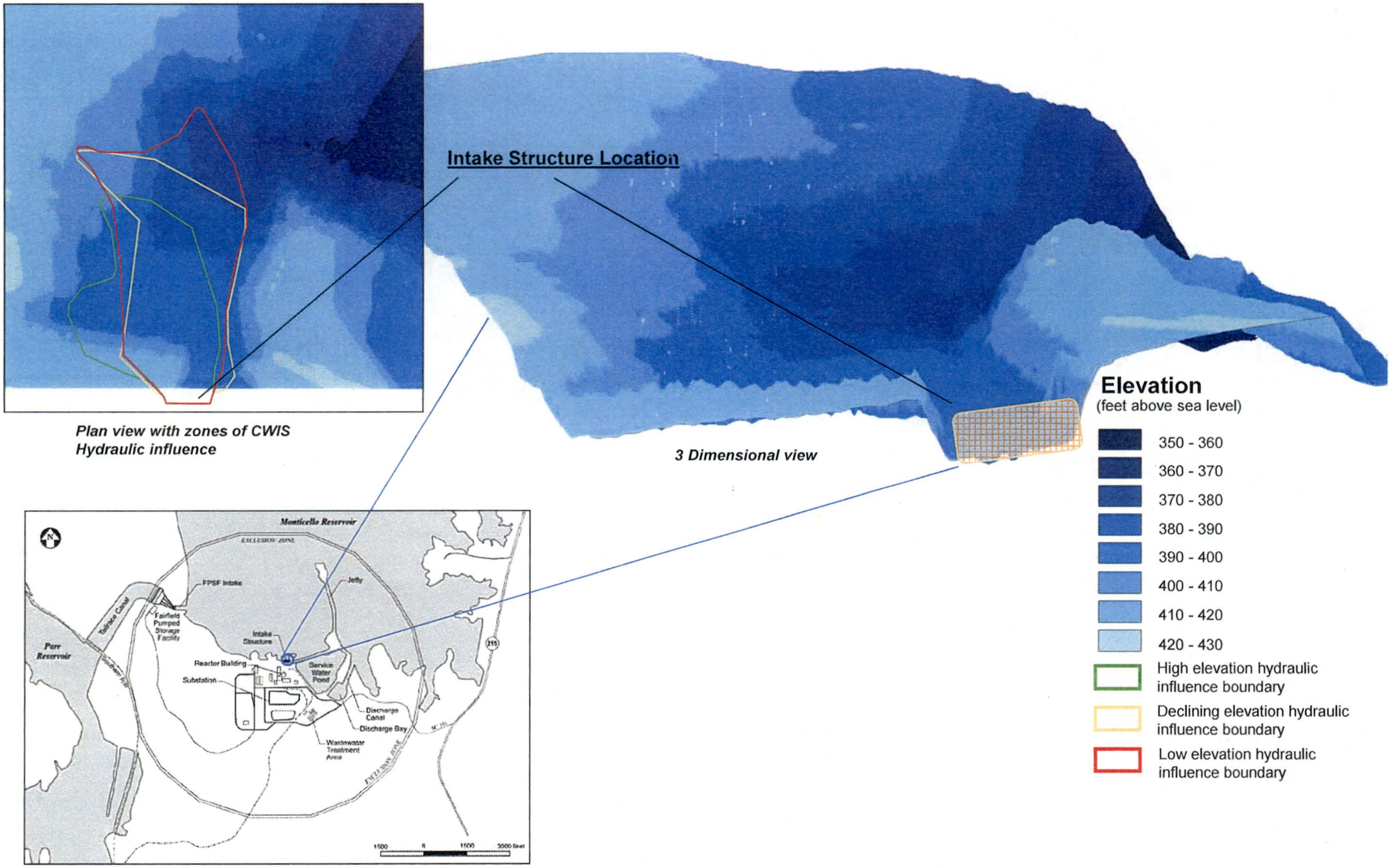
Jenkinsville, South Carolina

Geosyntec consultants

Atlanta, Georgia | October 2016

Figure 2

File: N:\N:\S\SCANA_316b_Compliance\SCANA_GK5356_SummerStation\T1-SW_PhysicalData



Bathymetric Depiction of Monticello Reservoir and the CWIS Area of Influence near VCSNS Unit 1, April 2005

Jenkinsville, South Carolina

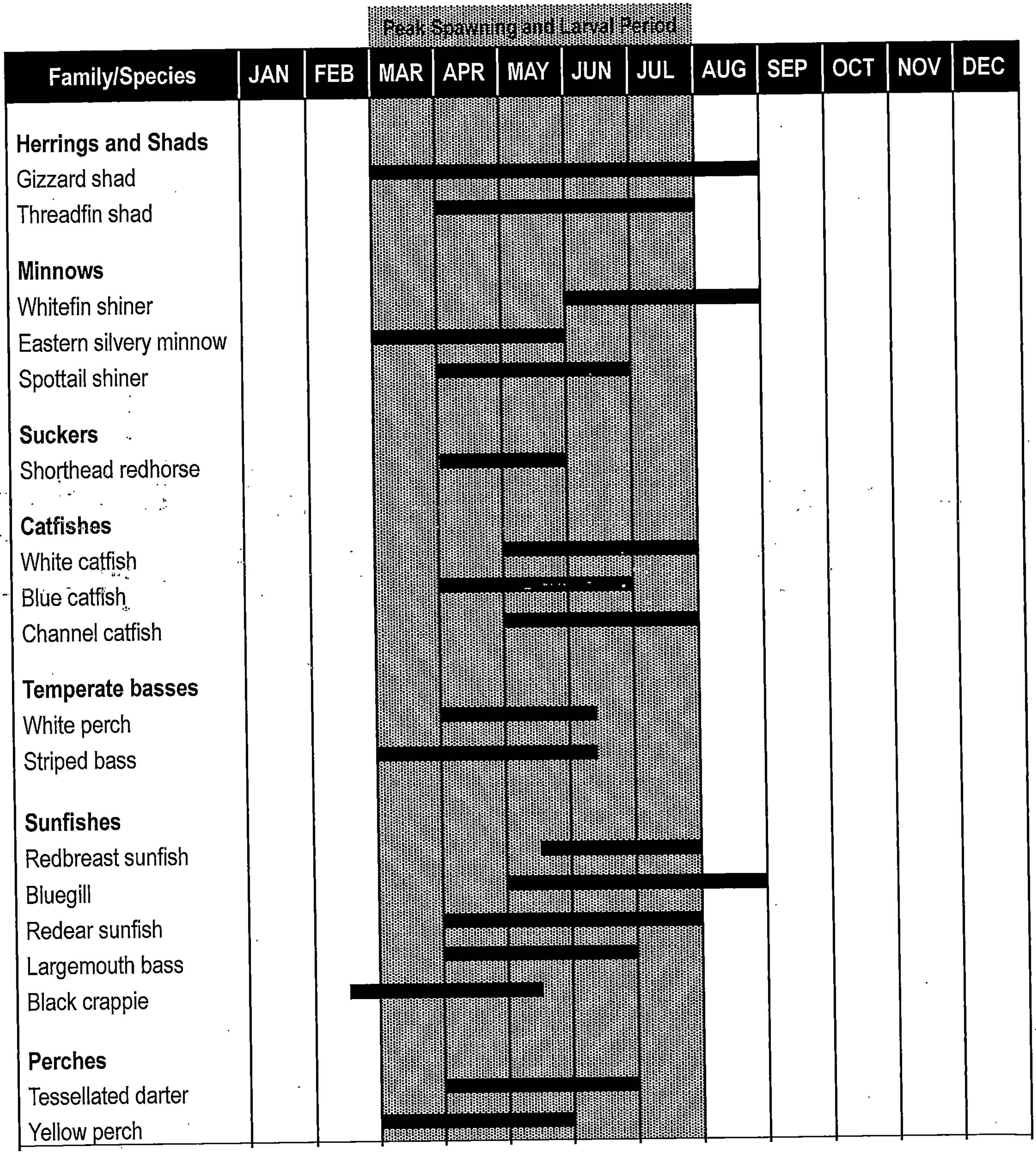
Geosyntec consultants

Atlanta, Georgia

October 2016

Figure 3

Figure 4
Spawning Seasons of Representative Fish Species Occurring in Monticello Reservoir in the Vicinity of the VCSNS Unit 1 CWIS



Appendix A

Table 4-1. Month, common name, and counts of ichthyoplankton collected in Monticello Reservoir, March through August 2016. YSL = yolk-sac larvae, PYSL = post yolk-sac larvae, ULS = undetermined larval stage, and YOY = young-of-the-year.

Month	Common name	Eggs	YSL	PYSL	ULS	YOY
March	Black Crappie			2		
	Carp and Minnow Family			4		
	Dorosoma Species	1		1		
	Golden Shiner			1		
	Largemouth Bass			1		
	White Perch			1		
	Chubsucker Species			1		
	Unidentified Osteichthyes			2		
April	Carp and Minnow Family			13		
	Dorosoma Species		72	101	70	
	Quillback		2	1		
	White Perch		2	9		
	Chubsucker Species			6		
May	Carp and Minnow Family			3		
	Dorosoma Species		39	146	8	
	Gizzard Shad			1		
	Lepomis Species			3		
June	Blue Catfish					1
	Dorosoma Species		463	186		
	Lepomis Species			15		
	Threadfin Shad			2		
July	Channel Catfish					1
	Dorosoma Species			2		
	Lepomis Species			94		
	Threadfin Shad			30	5	
August	Channel Catfish					3
	Darter Species		2			
	Lepomis Species			11		
	Threadfin Shad			2		
	Unidentified Osteichthyes			2	2	
Total		**1**	**580**	**640**	**85**	**5**

Table 4-6. Mean ichthyoplankton density (no./100 m^3), listed in decreasing order of overall density, for each fish taxon, life stage and sampling depth at VC Summer Nuclear Station, averaged over diel and sample periods from 1 March through 31 August 2016. YSL = yolk-sac larvae, PYSL = post yolk-sac larvae, ULS = undetermined larval stage, and YOY = young-of-the-year.

Taxon	Life Stage	Surface (n=24)		Midwater (n=24)		Overall (n=48)	
		Mean	%	Mean	%	Mean	%
Dorosoma Species	YSL	18.24	62.9	2.54	14.7	10.39	44.9
Dorosoma Species	PYSL	5.52	19.1	10.23	59.2	7.87	34.0
Lepomis Species	PYSL	2.43	8.4	1.41	8.2	1.92	8.3
Dorosoma Species	ULS	1.24	4.3	1.36	7.9	1.30	5.6
Threadfin Shad	PYSL	0.24	0.8	0.84	4.9	0.54	2.3
Carp and Minnow Family	PYSL	0.48	1.6	0.20	1.2	0.34	1.5
White Perch	PYSL	0.16	0.6	0.18	1.0	0.17	0.7
Chubsucker Species	PYSL	0.25	0.9	0.00	0.0	0.12	0.5
Threadfin Shad	ULS	0.09	0.3	0.06	0.4	0.08	0.3
Channel Catfish	YOY	0.00	0.0	0.13	0.7	0.06	0.3
Unidentified Osteichthyes	PYSL	0.05	0.2	0.06	0.4	0.06	0.3
Black Crappie	PYSL	0.07	0.2	0.00	0.0	0.04	0.2
Quillback	YSL	0.07	0.2	0.00	0.0	0.03	0.1
White Perch	YSL	0.03	0.1	0.04	0.2	0.03	0.1
Darter Species	YSL	0.00	0.0	0.06	0.4	0.03	0.1
Unidentified Osteichthyes	ULS	0.00	0.0	0.06	0.4	0.03	0.1
Gizzard Shad	PYSL	0.00	0.0	0.04	0.2	0.02	0.1
Blue Catfish	YOY	0.00	0.0	0.04	0.2	0.02	0.1
Dorosoma Species	Egg	0.04	0.1	0.00	0.0	0.02	0.1
Golden Shiner	PYSL	0.04	0.1	0.00	0.0	0.02	0.1
Quillback	PYSL	0.03	0.1	0.00	0.0	0.02	0.1
Largemouth Bass	PYSL	0.00	0.0	0.03	0.2	0.02	0.1
Total		**28.98**	**100.0**	**17.29**	**100.0**	**23.13**	**100.0**

Table 4-7. Mean depth-averaged ichthyoplankton density (no./100 m^3) by fish taxon, life stage, diel period and month at VC Summer Nuclear Station representative of the period from 1 March through 31 August 2016. YSL = yolk-sac larvae, PYSL = post yolk-sac larvae, ULS = undetermined larval stage, and YOY = young-of-the-year.

Taxon		Mar		Apr		May		Jun		Jul		Aug	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
Black Crappie	PYSL		0.43										
Blue Catfish	YOY								0.23				
Carp and Minnow Family	PYSL		0.85	0.82	1.80		0.62						
Channel Catfish	YOY										0.20		0.56
Chubsucker Species	PYSL		0.21	0.89	0.38								
Darter Species	YSL												0.38
Dorosoma Species	Egg		0.21										
	PYSL	0.22		4.52	15.90	12.11	19.55	10.22	31.63	0.18	0.18		
	ULS				13.96		1.69						
	YSL			1.67	12.47	2.27	6.00	5.21	97.04				
Gizzard Shad	PYSL						0.23						
Golden Shiner	PYSL		0.21										
Largemouth Bass	PYSL		0.18										
Lepomis Species	PYSL						0.70	0.66	2.70	10.85	6.12	1.12	0.91
Quillback	PYSL			0.21									
	YSL			0.41									
Threadfin Shad	PYSL								0.46	1.40	4.23	0.19	0.19
	ULS									0.74	0.18		
Unidentified Osteichthyes	PYSL		0.39										0.32
	ULS												0.37
White Perch	PYSL		0.21	0.65	1.17								
	YSL			0.21	0.20								
Total		0.22	2.70	9.38	45.88	14.37	28.79	16.09	132.07	13.18	10.91	1.30	2.74