William S. Lee III Nuclear Station National Pollutant Discharge Elimination System Permit Application

VOLUME I

Submitted by:

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P.O. Box 1006 Mail Code EC09D
Charlotte, NC 28202

Submitted to:
South Carolina Department of Health and Environmental Control

August 2011

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WILLIAM S. LEE III NUCLEAR STATION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT APPLICATION

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Table of Contents, concluded

WILLIAM S. LEE III NUCLEAR STATION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT APPLICATION

Preface

This National Pollutant Discharge Elimination System (NPDES) Permit Application (Permit Application) for the William States Lee III Nuclear Station (Lee Nuclear Station) is being submitted to the South Carolina Department of Health and Environmental Control (SCDHEC) for review and issuance of an NPDES permit. This preface is intended to provide guidance to the reviewer on contents and structure of this Permit Application.

Structure of the Permit Application

This Permit Application presents a complete package in a two-volume format containing all information necessary for SCDHEC's consideration and issuance of an NPDES Permit, including a Clean Water Act § 316(b) Compliance Demonstration.

Volume 1

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APPENDICES

A General Application Information Required Under § 125.86(a)(2) and § 122.21(r)

B Cooling Water Intake Structures Hydraulic Zone of Influence

C Engineering Calculations: Standard Raw Water System Traveling Screen Calculation and Standard Raw Water System Passive Screen Calculation

D Thermal Stratification

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F Air Quality

Preface, cont'd

Considerations when Reviewing the Permit Application

Note 1 – Rounding. Rounding of numbers (values) within this document based on significant digits may have produced minor discrepancies between uses.

Note 2 – Terminology. Certain features/components of the proposed Lee Nuclear Station have multiple nomenclatures depending on the context of use. In particular, terminology used in this SCDHEC/EPA compliance document varies from terminology of the same feature/component in the Nuclear Regulatory Commission (NRC) compliance documents. To assist in understanding and consistency, a crosswalk of terminology between contexts is provided in Volume 2, Part VII, Section 1.0, Table 1-2.

Note 3 – Flow Values. This document includes numerous references to various flow values that are germane to this Permit Application. To assist the reviewer a Table of Flow Values (immediately following this preface) is provided as a quick reference tool for understanding flow values and descriptions.

Note 4 – Files Provided on CD. CDs providing the Environmental Report (ER), Environmental Report Supplement (ER-S), and other references are provided.

Table of Flow Values

Broad River Flows	
98 cfs	5% Broad River mean annual flow (2001–2010)
125 cfs	5% Broad River mean annual flow (1926–2010)
464 cfs	Broad River 7Q10 Critical Low Flow
483 cfs	Lowest minimum flow to be released from the dam as specified in the Ninety Nine Islands Dam FERC license; Lee Nuclear Station consumptive water withdrawal from Broad River ceases
538 cfs	Broad River flow at which Lee Nuclear Station begins withdrawal from drought contingency ponds (483 cfs + 55 cfs avg consumptive loss)
1,956 cfs	Broad River mean annual flow (2001–2010)
2,495 cfs	Broad River mean annual flow (1926–2010)
Lee Nuclear Station Operation	
18 cfs	Average blowdown
23 cfs	Average non-consumptive withdrawal (18 cfs blowdown + 5 cfs screen wash)
55 cfs	Average consumptive water loss
63 cfs	Maximum consumptive water loss
78 cfs	Average withdrawal from Broad River (55 cfs consumptive + 18 cfs blowdown + 5 cfs screen wash)
River Intake	
5 cfs	Primary section screen wash
6 cfs	Maximum drought contingency section river intake screen wash
20 cfs	Average drought contingency refill available from primary section of river intake (98 cfs capacity -78 cfs average)
98 cfs	Primary section river intake capacity
200 cfs	Maximum refill capacity of drought contingency section of river intake
206 cfs	Maximum withdrawal drought contingency section river intake (200 cfs + 6 cfs screen wash)
304 cfs	Maximum total withdrawal river intake (98 cfs primary + 206 cfs drought contingency)
Pond A	
5 cfs	Pond A screen wash
139 cfs	Pond A total intake capacity (5 cfs screen wash + 134 cfs intake)
Ponds B and C	
67 cfs	Pond B intake capacity
67 cfs	Pond C intake capacity

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Acronyms and Abbreviations

7Q10	Seven-day, consecutive low flow with a 10-year return frequency; the lowest stream flow for 7 consecutive days that would be expected to occur
ac	acre
ACC	Air Cooled Condensers
ac-ft	acre-feet
AP1000	Westinghouse Advanced Passive Pressurized Water Reactor
BTU	British thermal units
°C	degrees Celsius
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
cells/mL	cells per milliliter
CFR	U.S. Code of Federal Regulations
cfs	cubic feet per second
CO_2	carbon dioxide
COL	Combined Construction and Operating License
CPCN	Certificate of Environmental Compliance and Public Convenience and Necessity
CPUE	Catches Per Unit Effort
CPI	Consumer Price Index
CWA	Federal Water Pollution Control Act
Duke Energy	Duke Energy Carolinas, LLC
Duke Power	Duke Power Company
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ESA	Endangered Species Act
°F	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
fps	feet per second
FSC	Federal species of concern
ft	feet
GHG	greenhouse gas

Acronyms and Abbreviations, cont'd

gpm	gallons per minute
Hg	mercury
HZI	Hydraulic Zone of Influence
IRP	Integrated Resources Plan
kV	Kilovolt
Lee Nuclear Station	William States Lee III Nuclear Station
m^2	square meters
m^3	cubic meters
MGD	million gallons per day
Moody's	Moody's Analytics, Inc.
MOU	Memorandum of Understanding
msl	mean sea level
MWe	megawatts electric
N	North
NAAQS	National Ambient Air Quality Standard
NCDENR	North Carolina Department of Environment and Natural Resources
ND	Non-Discharge
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NWI	National Wetland Inventory
O&M	Operation and Maintenance
PES	Pacific Environmental Services
Phase I Rule	§316(b) Rule for New Facilities
$PM_{2.5}$	fine particulate matter
ppm	parts per million
PWR	pressurized water reactor
RRCC	Robust Redhorse Conservation Committee
RWS	Raw Water System
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SD	standard deviation
SE	State endangered
Shaw Nuclear	The Shaw Group Inc.

Acronyms and Abbreviations, concluded

SIP	State Implementation Plan
SO_2	sulfur dioxide
SOP	standard operating procedure
sq mi	square miles
ST	State threatened
TDD	Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities
US 29	U.S. Highway 29
USACE	U.S. Army Corps of Engineers
USDOE	U.S. Department of Energy
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
W	West
WMP	Water Management Plan
WWTP	Wastewater Treatment Plant
µg/L	micrograms per liter

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WILLIAM S. LEE III NUCLEAR STATION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT APPLICATION

Checklist of NPDES Permit Application Components

Component	Required Information	Location in Document	Completed & Included
EPA FORM I, GENERAL INFORMATION		Volume 1, Part I	☑
	I. EPA ID Number		☑
	II. Pollutant Characteristics		☑
	III. Facility Name		☑
	IV. Facility Contact		☑
	V. Facility Mailing Address		☑
	VI. Facility Location		☑
	VII. SIC Code		☑
	VIII. Operator Information (A-H)		☑
	IX. Indian Lands		☑
	X. Existing Environmental Permits: SCR100000 General Stormwater Permit for Construction Activities		☑
	XI. Topographic Map		☑
	XII. Nature of Business		☑
	XIII. Certification Signature		☑
EPA FORM 2D, NEW SOURCES AND NEW DISCHARGERS		Volume 1, Part II	☑
	I. Outfall Location (lat and long)		☑
	II. Discharge Date		☑
	III. Flows, Sources of Pollution, and Treatment Technologies		☑
	IV. Production		☑
	V. Effluent Characteristics		☑
	VI. Engineering Report on Wastewater		☑

Checklist of NPDES Permit Application Components, cont'd

Component	Required Information	Location in Document	Completed & Included
	VII. Other Information		☑
	VIII. Certification Signature		☑
PRELIMINARY ENGINEERING REPORT		Volume 1, Part III	☑
	Overview of Station Outfall and Discharges		☑
	Description of Station Waste Streams		☑
	Water Balance		☑
	Antidegradation Alternatives Evaluation	Appendix A	☑
LOCATION SUPPLEMENT FOR NPDES PERMIT APPLICATION		Volume 1, Part IV	☑
	Location Supplement for ND and NPDES Permit Applications Form		☑
	Item 1: Plant Location		☑
	Item 2: Description of Discharge Point Location		☑
	Item 3: USGS Quad Map with Discharge Identified		☑
SLUDGE DISPOSAL SUPPLEMENT		Volume 1, Part V	☑
	Sludge Disposal Supplement Form		☑
MIXING ZONE REQUEST		Volume 1, Part VI	☑
	Mixing Zone Request for Surface Water Discharges Form		☑
	Supporting information for formal requests for Thermal and Whole Effluent Toxicity (WET) mixing zones		☑
CWA 316(b) COMPLIANCE DEMONSTRATION		Volume 2, Part VII	☑
	Source water physical data	Appendix A	☑
	Cooling water intake structure data	Appendix A	☑
	Source water biological data	Appendix A	☑
	Management of Intake Flow at Levels Commensurate with Closed-Cycle Recirculating Cooling Water System	Subsection 2.2.1; Subsection 3.1.1; Appendix A	☑

Checklist of NPDES Permit Application Components, concluded

Component	Required Information	Location in Document	Completed & Included
	Maintaining Through-Screen Design Intake Velocity of 0.5 fps (Velocity Limitation)	Subsection 2.2.2; Subsection 3.1.2; Appendix C	☑
	Design Intake Flow Requirements: Freshwater Rivers or Streams (Proportional Flow Limitation)	Subsection 2.2.3.1; Section 3.2; Appendices E–L	☑
	Design Intake Flow Requirements: Lakes or Reservoirs (Thermal Stratification Limitation)	Subsection 2.2.3.2; Subsection 3.1.3; Appendix D	☑
	Technologies of Operational Measures that Minimize Impingement Mortality and Entrainment of Aquatic Species	Subsection 2.2.4; Subsection 3.1.4; Appendices A and B	☑
	Alternative Requirements Demonstration	Section 2.3; Section 3.2; Appendices E–L	☑

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Part I

EPA Form 1

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Please print or type in the unshaded areas only. Form Approved. OMB No. 2040-0086.

FORM 1 GENERAL

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER

S		T/A	C
F			D
1	2 13	14	15

LABEL ITEMS	
I. EPA I.D. NUMBER	PLEASE PLACE LABEL IN THIS SPACE
III. FACILITY NAME	
V. FACILITY MAILING ADDRESS	
VI. FACILITY LOCATION	

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix it in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill-in area below. Also, if any of the preprinted data is absent *(the area to the left of the label space lists the information that should appear)*, please provide it in the proper fill-in area(s) below. If the label is complete and correct, you need not complete Items I, III, V, and VI *(except VI-B which must be completed regardless)*. Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of **bold-faced terms**.

SPECIFIC QUESTIONS	YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	YES	NO	FORM ATTACHED
A. Is this facility a **publicly owned treatment works** which results in a **discharge** to **waters of the U.S.**? (FORM 2A)	16	X 17	18	B. Does or will this facility *(either existing or proposed)* include a **concentrated animal feeding operation** or **aquatic animal production facility** which results in a **discharge** to **waters of the U.S.**? (FORM 2B)	19	X 20	21
C. Is this a facility which currently results in **discharges** to **waters of the U.S.** other than those described in A or B above? (FORM 2C)	22	X 23	24	D. Is this a proposed facility *(other than those described in A or B above)* which will result in a **discharge** to **waters of the U.S.**? (FORM 2D)	X 25	26	X 27
E. Does or will this facility treat, store, or dispose of **hazardous wastes**? (FORM 3)	28	X 29	30	F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)	31	X 32	33
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)	34	X 35	36	H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)	37	X 38	39
I. Is this facility a proposed **stationary source** which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)	40	X 41	42	J. Is this facility a proposed **stationary source** which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an **attainment area**? (FORM 5)	43	X 44	45

III. NAME OF FACILITY

C	SKIP	
1		WILLIAM STATES LEE III NUCLEAR STATION
15	16 – 29	30 69

IV. FACILITY CONTACT

C	A. NAME & TITLE *(last, first, & title)*	B. PHONE *(area code & no.)*
2	Wylie, Robert Environmental Project Manager	(704) 382-4669
15	16 45	46 48 49 51 52- 55

V. FACILTY MAILING ADDRESS

C	A. STREET OR P.O. BOX
3	P.O. Box 1006 , Mail Code EC09D
15	16 45

C	B. CITY OR TOWN	C. STATE	D. ZIP CODE
4	Charlotte	NC	28202
15	16 40	41 42	47 51

VI. FACILITY LOCATION

C	A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER
5	1313 McKowns Mountain Road
15	16 45

B. COUNTY NAME
Cherokee
46 70

C	C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE *(if known)*
6	Gaffney	SC	29349	
15	16 40	41 42	47 51	52 -54

EPA Form 3510-1 (8-90)

CONTINUE ON REVERSE

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VII. SIC CODES (4-digit, in order of priority)

A. FIRST		B. SECOND	
7 4911	(specify) steam electric generating	7	(specify)
C. THIRD		**D. FOURTH**	
7	(specify)	7	(specify)

VIII. OPERATOR INFORMATION

A. NAME: 8 Duke Energy Carolinas, LLC

B. Is the name listed in Item VIII-A also the owner? ☑ YES ☐ NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box: if "Other," specify.)

F = FEDERAL
S = STATE
P = PRIVATE
M = PUBLIC (other than federal or state)
O = OTHER (specify)

P — (specify) Electric Utility

D. PHONE (area code & no.): A (704) 382-4669

E. STREET OR P.O. BOX: P.O. Box 1006, Mail Code EC09D

F. CITY OR TOWN: B Charlotte

G. STATE: NC

H. ZIP CODE: 28202

IX. INDIAN LAND

Is the facility located on Indian lands? ☐ YES ☑ NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water)	D. PSD (Air Emissions from Proposed Sources)	
9 N	9 P	
B. UIC (Underground Injection of Fluids)	**E. OTHER (specify)**	
9 U	9 SCR100000	(specify) General Stormwater Permit for Construction Activities
C. RCRA (Hazardous Wastes)	**E. OTHER (specify)**	
9 R	9	(specify)

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers, and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Nuclear fueled steam electric generation

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

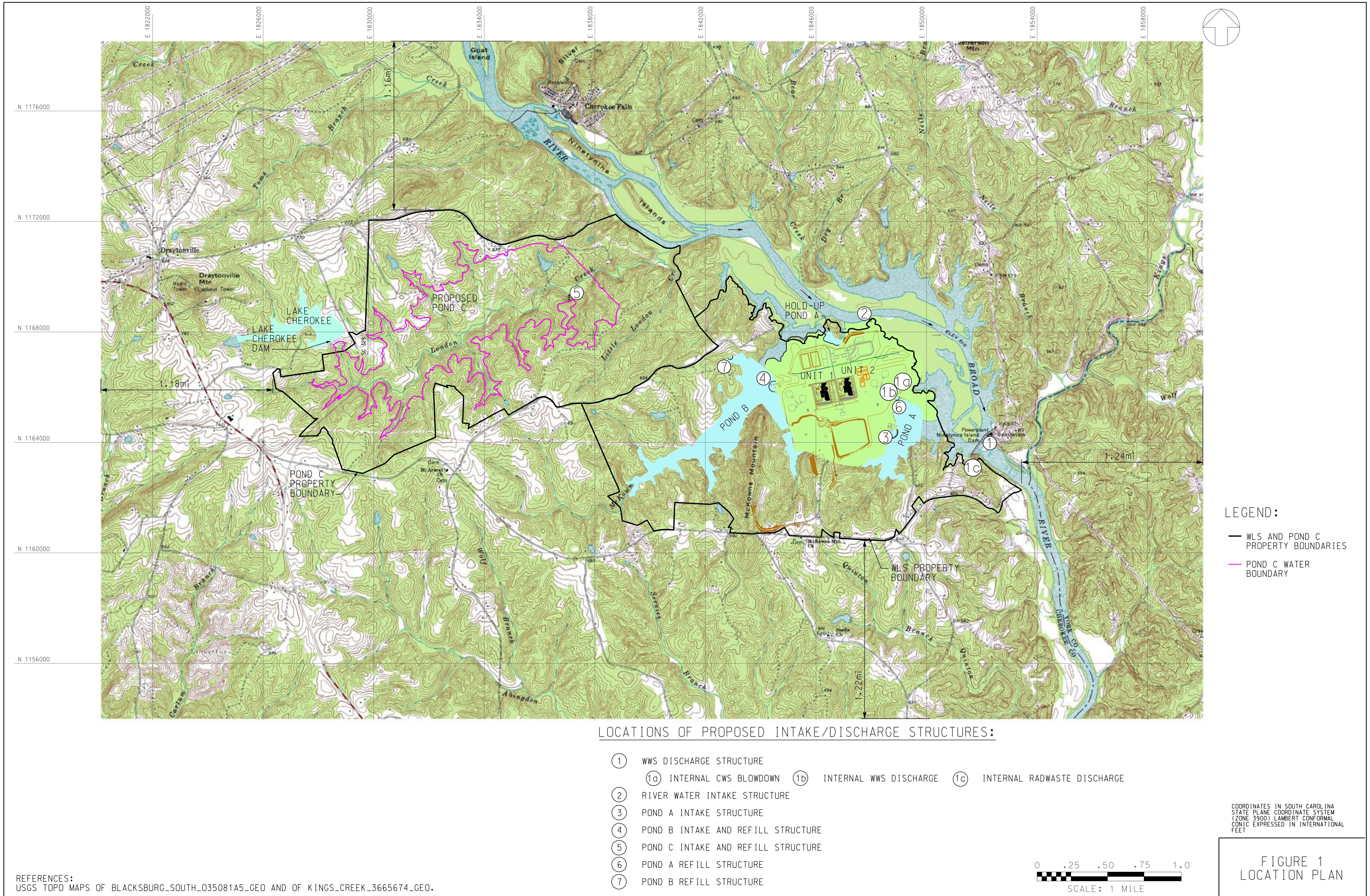
A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED
Ronald A. Jones SVP, Nuclear Development	[signature]	8-11-11

COMMENTS FOR OFFICIAL USE ONLY

C

EPA Form 3510-1 (8-90)

Figure 1: Location Map



Form Approved. OMB No. 2040-0086. Approval expires 8-31-98.

Please print or type in the unshaded areas only	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	

Form 2D NPDES EPA

New Sources and New Dischargers
Application for Permit to Discharge Process Wastewater

I. Outfall Location

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

Outfall Number (*list*)	Latitude			Longitude			Receiving Water (*name*)
	Deg.	Min.	Sec.	Deg.	Min.	Sec.	
001a	35	2	10	-81	30	15	Internal Outfall
001b	35	2	10	-81	30	15	Internal Outfall
001c	35	1	47	-81	29	46	Internal Outfall
001	35	1	54	-81	29	39	Broad River (Ninety Nine Islands Reservoir)

II. Discharge Date (When do you expect to begin discharging?)

05/01/2020

III. Flows, Sources of Pollution, and Treatment Technologies

A. For each outfall, provide a description of: (1) All operations contributing wastewater to the effluent, including process wastewater, sanitary wastewater, cooling water, and storm water runoff; (2) The average flow contributed by each operation; and (3) The treatment received by the wastewater. Continue on additional sheets if necessary.

Outfall Number	1. Operations Contributing Flow (*List*)	2. Average Flow (*Include Units*)	3. Treatment (*Description or List codes from Table 2D-1*)
001a	Cooling Tower Blowdown	8,087 gpm	None
001b	Wastewater Treatment	1,500 gpm (Intermittent)	1-U , 2-K
001c	Liquid Radwaste	30 gpm (Intermittent)	2-J, 2-K
001	Final Combined Discharge	8,216 gpm	4-A

B. Attach a line drawing showing the water flow through the facility. Indicate sources of intake water, operations contributing wastewater to the effluent, and treatment units labeled to correspond to the more detailed descriptions in Item III-A. Construct a water balance on the line drawing by showing average flows between intakes, operations, treatment units, and outfalls. If a water balance cannot be determined (e.g., for certain mining activities), provide a pictorial description of the nature and amount of any sources of water and any collection or treatment measures.

C. Except for storm runoff, leaks, or spills, will any of the discharges described in Items III-A be intermittent or seasonal?

☑ YES (*complete the following table*) ☐ NO (*go to Section IV*)

Outfall Number	1. Frequency		2. Flow		
	a. Days Per Week (*specify average*)	b. Months Per Year (*specify average*)	a. Maximum Daily Flow Rate (*in mgd*)	b. Maximum Total Volume (*specify with units*)	c. Duration (*in days*)
001b	1 day per two weeks	12	2.16 mgd	2.5 mgal	26 days/yr
001c	1 day per week	12	0.15 mgd	120,000 gal	59 days/yr

IV. Production

If there is an applicable production-based effluent guideline or NSPS, for each outfall list the estimated level of production (projection of actual production level, not design), expressed in the terms and units used in the applicable effluent guideline or NSPS, for each of the first 3 years of operation. If production is likely to vary, you may also submit alternative estimates (attach a separate sheet).

Year	A. Quantity Per Day	B. Units Of Measure	c. Operation, Product, Material, etc. (*specify*)
		NA	NA

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001 (Conc. Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	28,023 gpm	8,216 gpm	4 and Design
BOD	4 mg/l	3 mg/l	4 and background water analysis
COD	33 mg/l	31 mg/l	4 and background water analysis
TOC	10 mg/l	8 mg/l	4 and background water analysis
TSS	6 mg/l	4 mg/l	4 and background water analysis
Ammonia as (N)	1.1 mg/l	0.1 mg/l	4 and background water analysis
Temperature (winter)	73.4 F	70.6 F	3 and 4
Temperature (summer)	91.0 F	85.9 F	3 and 4
pH	8.7 SU	7.7 SU	3
Bromide	2.9 mg/l	2.9 mg/l	4 and background water analysis
TRC	*	*	3
Color	49 SU	45 SU	4 and background water analysis
Fecal Coliform	*	*	3
Fluoride	0.3 mg/l	0.3 mg/l	4 and background water analysis
Nitrate-Nitrite	2.2 mg/l	1.6 mg/l	4 and background water analysis
Oil and Grease	0.3 mg/l	0.007 mg/l	4 and background water analysis
Phosphorus (as P) Total	1.2 mg/l	0.6 mg/l	4 and background water analysis
Alpha Total	0.12 pCi/l	0.012 pCi/l	3
Beta Total	141 pCi/l	3.4 pCi/l	3
Radium, Total	0.12 pCi/l	0.009 pCi/l	3
Radium 226, Total	0.12 pCi/l	0.009 pCi/l	3
Sulfate (as SO4)	81.1 mg/l	30.9 mg/l	4 and background water analysis

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001 (Conc. Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	0.001 mg/l	0.00003 mg/l	3, 4 and background water analysis
Sulfite (SO3)	0.032 mg/l	0.001 mg/l	3, 4 and background water analysis
Surfactants	0.015 mg/l	0.002 mg/l	3, 4 and background water analysis
Aluminum, Total	2.4 mg/l	0.99 mg/l	4 and background water analysis
Barium, Total	0.15 mg/l	0.079 mg/l	4 and background water analysis
Boron, Total	6 mg/l	0.13 mg/l	4
Cobalt, Total	*	*	3
Iron, Total	1.4 mg/l	1.3 mg/l	4 and background water analysis
Magnesium, Total	6.8 mg/l	6.4 mg/l	4 and background water analysis
Molybdenum, Total	0.13 mg/l	0.005 mg/l	4 and background water analysis
Manganese, Total	0.79 mg/l	0.25 mg/l	4 and background water analysis
Tin, Total	0.1 ug/l	0.002 ug/l	3
Titanium, Total	0.01 ug/l	0.0005 ug/l	3
Antimony, Total	*	*	3
Arsenic, Total	7.3 ug/l	4.8 ug/l	4 and background water analysis
Beryllium, Total	*	*	3
Cadmium, Total	0.01 ug/l	0.007 ug/l	3
Chromium, Total	0.03 mg/l	0.007 mg/l	4 and background water analysis
Copper, Total	0.015 mg/l	0.006 mg/l	4 and background water analysis
Lead, Total	0.016 mg/l	0.005 mg/l	4 and background water analysis
Mercury, Total	0.02 ug/l	0.001 ug/l	4 and background water analysis
Nickel, Total	0.0002 mg/l	0.0001 mg/l	4 and background water analysis

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001 (Conc. Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	0.4 ug/l	0.04 ug/l	3
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	0.04 mg/l	0.02 mg/l	4 and background water analysis
Cyanide, Total	0.00001 ug/l	0.000003ug/l	3
Phenols, Total	0.012 ug/l	0.0008 ug/l	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Base/Neutral Compounds	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001 (Mass Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	29,627 gpm	8,087 gpm	4 and Design
BOD	716 lbs	365 lbs	4 and background water analysis
COD	6,005 lbs	3,419 lbs	4 and background water analysis
TOC	1,856 lbs	896 lbs	4 and background water analysis
TSS	1,016 lbs	524 lbs	4 and background water analysis
Ammonia (as N)	139 lbs	78 lbs	4 and background water analysis
Temperature (winter)	NA	NA	
Temperature (summer)	NA	NA	
pH	NA	NA	
Bromide	543 lbs	315 lbs	4 and background water analysis
TRC	NA	NA	
Color	NA	NA	
Fecal Coliform	NA	NA	
Fluoride	57 lbs	34 lbs	4 and background water analysis
Nitrate-Nitrite (as N)	422 lbs	167 lbs	4 and background water analysis
Oil and Grease	31 lbs	5 lbs	4 and background water analysis
Phosphorus (as P), Total	232 lbs	56 lbs	4 and background water analysis
Alpha, Total	NA	NA	
Beta, Total	NA	NA	
Radium, Total	NA	NA	
Radium 226, Total	NA	NA	
Sulfate (as SO4)	15,413 lbs	3,677 lbs	4 and background water analysis

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001 (Mass Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	0.09 lbs	0.03 lbs	4
Sulfite (SO3)	3.7 lbs	0.9 lbs	4
Surfactants	0 lbs	1.8 lbs	4
Aluminum, Total	480 lbs	99 lbs	4 and background water analysis
Barium, Total	30 lbs	8.2 lbs	4 and background water analysis
Boron, Total	1,872 lbs	12 lbs	4
Cobalt	NA	NA	4
Iron, Total	276 lbs	100 lbs	4 and background water analysis
Magnesium, Total	1,317 lbs	673 lbs	4
Molybdenum, Total	15 lbs	5 lbs	4
Manganese, Total	116 lbs	64 lbs	4
Tin, Total	0.006 lbs	0.002 lbs	4
Titanium, Total	0.001 lbs	0.0004 lbs	4
Antimony, Total	*	*	4
Arsenic, Total	1.5 lbs	0.5 lbs	4
Beryllium, Total	*	*	4
Cadmium, Total	0.001 lbs	0.0004 lbs	4 and background water analysis
Chromium, Total	6.0 lbs	0.7 lbs	4 and background water analysis
Copper, Total	2.9 lbs	0.6 lbs	4 and background water analysis
Lead, Total	3.2 lbs	0.5 lbs	4
Mercury, Total	0.002 lbs	0.001 lbs	4
Nickel, Total	0.21 lbs	0.12 lbs	4

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001 (Mass Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	0.05 lbs	0.05 lbs	4
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	7.9 lbs	2.1 lbs	4 and background water analysis
Cyanide, Total	0.00001 lbs	0.000002 lbs	4
Phenols, Total	1.4 lbs	0.9 lbs	4
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Bass/Neutral	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001a (Conc. Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	28,023 gpm	8,087 gpm	4 and Design
BOD	3 mg/l	3 mg/l	4 and background water analysis
COD	31 mg/l	31 mg/l	4 and background water analysis
TOC	9.9 mg/l	8.2 mg/l	4 and background water analysis
TSS	4 mg/l	4 mg/l	4 and background water analysis
Ammonia	0.08 mg/l	0.08 mg/l	4 and background water analysis
Temperature (winter)	73.4 F	70.6 F	3 and 4
Temperature (summer)	91.0 F	85.9 F	3 and 4
pH	8 SU	7 SU	3
Bromide	2.97 mg/l	2.97 mg/l	4 and background water analysis
TRC	*	*	3
Color	45 SU	45 SU	4 and background water analysis
Fecal Coliform	*	*	3
Fluoride	0.32 mg/l	0.32 mg/l	4 and background water analysis
Nitrate-Nitrite	2.4 mg/l	1.6 mg/l	4 and background water analysis
Oil and Grease	*	*	4 and background water analysis
Phosphorus, Total	1.4 mg/l	0.6 mg/l	4 and background water analysis
Alpha, Total	*	*	3
Beta, Total	*	*	3
Radium, Total	*	*	3
Radium 226, Total	*	*	3
Sulfate (as SO4)	84.0 mg/l	30.8 mg/l	4 and background water analysis

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001a (Conc.Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	*	*	3
Sulfite (SO3)	*	*	3
Surfactants	*	*	3
Aluminum, Total	2.8 mg/l	1.0 mg/l	4 and background water analysis
Barium, Total	0.17 mg/l	0.079 mg/l	4 and background water analysis
Boron, Total	*	*	3
Cobalt, Total	*	*	3
Iron, Total	1.6 mg/l	1.0 mg/l	4 and background water analysis
Magnesium, Total	7.5 mg/l	6.5 mg/l	4 and background water analysis
Molybdenum, Total	*	*	3
Manganese, Total	0.33 mg/l	0.22 mg/l	3
Tin, Total	*	*	3
Titanium, Total	*	*	3
Antimony, Total	*	*	3
Arsenic, Total	8.7 ug/l	4.9 ug/l	4 and background water analysis
Beryllium, Total	*	*	3
Cadmium, Total	*	*	3
Chromium, Total	0.036 mg/l	0.007 mg/l	4 and background water analysis
Copper, Total	0.017 mg/l	0.006 mg/l	4 and background water analysis
Lead, Total	0.019 mg/l	0.005 mg/l	4 and background water analysis
Mercury, Total	*	*	3
Nickel, Total	*	*	3

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001a (Conc. Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	*	*	3
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	44.6 ug/l	17.4 ug/l	4 and background water analysis
Cyanide, Total	*	*	3
Phenols, Total	*	*	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Base/Neutral Compounds	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001a (Mass Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	28,023 gpm	8,087 gpm	4 and Design
BOD	505 lbs	291 lbs	4 and background water analysis
COD	5,216 lbs	3,011 lbs	4 and background water analysis
TOC	1,666 lbs	796 lbs	4 and background water analysis
TSS	673 lbs	389 lbs	4 and background water analysis
Ammonia (as N)	13.5 lbs	7.8 lbs	4
Temperature (winter)	NA	NA	
Temperature (summer)	NA	NA	
pH	NA	NA	
Bromide	500 lbs	289 lbs	4
TRC	NA	NA	
Color	NA	NA	
Fecal Coliform	NA	NA	
Fluoride	54 lbs	31 lbs	4 and background water analysis
Nitrate-Nitrite (as N)	404 lbs	155 lbs	4
Oil and Grease	0 lbs	0 lbs	4 and background water analysis
Phosphorus (as P), Total	229 lbs	54.4 lbs	4
Alpha, Total	NA	NA	
Beta, Total	NA	NA	
Radium, Total	NA	NA	
Radium 226, Total	NA	NA	
Sulfate (as SO4)	14,135 lbs	2,991 lbs	4 and background water analysis

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001a (Mass Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	*	*	4
Sulfite (SO3)	*	*	4
Surfactants	*	*	4
Aluminum, Total	478 lbs	98 lbs	4 and background water analysis
Barium, Total	30 lbs	8 lbs	4 and background water analysis
Boron, Total	*	*	4
Cobalt	NA	NA	4
Iron, Total	269 lbs	97.1 lbs	4 and background water analysis
Magnesium, Total	1,255 lbs	629 lbs	4
Molybdenum, Total	*	*	4
Manganese, Total	56.2 lbs	20.9 lbs	4
Tin, Total	*	*	4
Titanium, Total	*	*	4
Antimony, Total	*	*	4
Arsenic, Total	1.5 lbs	0.5 lbs	4
Beryllium, Total	*	*	4
Cadmium, Total	*	*	4
Chromium, Total	6 lbs	0.7 lbs	4 and background water analysis
Copper, Total	2.9 lbs	0.6 lbs	4 and background water analysis
Lead, Total	3.2 lbs	0.5 lbs	4
Mercury, Total	*	*	4
Nickel, Total	*	*	4

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001a (Mass Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	*	*	3
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	7.5 lbs	1.7 lbs	4 and background water analysis
Cyanide, Total	*	*	3
Phenols, Total	*	*	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Bass/Neutral	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001b (Conc. Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	1,500 gpm	1,500 gpm	4
BOD	7.2 mg/l	3.4 mg/l	3
COD	30.4 mg/l	20.7 mg/l	3
TOC	5.6 mg/l	4.8 mg/l	3
TSS	18.2 mg/l	7.4 mg/l	3
Ammonia as (N)	6.9 mg/l	3.9 mg/l	3
Temperature (winter)	54.2 F	47.5 F	3
Temperature (summer)	82.3 F	81.9 F	3
pH	7.8 SU	6.5 SU	3
Bromide	1.3 mg/l	1.3 mg/l	3
TRC	*	*	3
Color	75 SU	50 SU	3
Fecal Coliform	*	*	3
Fluoride	0.1 mg/l	0.1 mg/l	3
Nitrate-Nitrite	1.0 mg/l	0.6 mg/l	3
Oil and Grease	*	*	3
Phosphorus (as P) Total	0.05 mg/l	0.05 mg/l	3
Alpha (Total)	0.8 pCi/l	0.8 pCi/l	3
Beta (Total)	4.6 pCi/l	4.2 pCi/l	3
Radium, Total	0.7 pCi/l	0.5 pCi/l	3
Radium 226, Total	0.7 pCi/l	0.5 pCi/l	3
Sulfate (as SO4)	70.5 mg/l	38 mg/l	3

CONTINUED FROM THE FRONT	EPA I.D. NUMBER *(copy from Item 1 of Form 1)*	Outfall Number 001b (Conc. Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	*	*	3
Sulfite (SO3)	*	*	3
Surfactants	0.1 mg/l	0.1 mg/l	3
Aluminum	0.09 mg/l	0.09 mg/l	3
Barium	0.03 mg/l	0.03 mg/l	3
Boron, Total	0.4 mg/l	0.2 mg/l	3
Cobalt, Total	*	*	3
Iron	0.2 mg/l	0.1 mg/l	3
Magnesium	3.3 mg/l	2.4 mg/l	3
Molybdenum, Total	0.3 mg/l	0.2 mg/l	3
Manganese, Total	3.3 mg/l	2.4 mg/l	3
Tin, Total	*	*	3
Titanium, Total	*	*	3
Antimony, Total	*	*	3
Arsenic, Total	*	*	3
Lead, Total	*	*	3
Beryllium, Total	*	*	3
Cadmium, Total	*	*	3
Chromium	*	*	3
Copper, Total	0.01 mg/l	0.005 mg/l	3
Mercury, Total	0.1 ug/l	0.08 ug/l	3
Nickel, Total	0.01 mg/l	0.006 mg/l	3

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001b (Conc.Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	0.003 mg/l	0.003 mg/l	3
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	0.025 mg/l	0.025 mg/l	3
Cyanide, Total	*	*	3
Phenols, Total	0.08 mg/l	0.05 mg/l	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Base/Neutral Compounds	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001b (Mass Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	1,500 gpm	1,500 gpm	3
BOD	130 lbs	61 lbs	3
COD	548 lbs	373 lbs	3
TOC	101 lbs	86 lbs	3
TSS	328 lbs	133 lbs	3
Ammonia as (N)	124 lbs	70 lbs	3
Temperature (winter)	NA	NA	
Temperature (summer)	NA	NA	
pH	NA	NA	
Bromide	23 lbs	23 lbs	3
TRC	NA	NA	
Color	NA	NA	
Fecal Coliform	NA	NA	
Fluoride	2.3 lbs	2.3 lbs	3
Nitrate-Nitrite	18 lbs	11.5 lbs	3
Oil and Grease	*	*	3
Phosphorus (as P) Total	0.9 lbs	0.8 lbs	3
Alpha (Total)	NA	NA	
Beta (Total)	NA	NA	
Radium, Total	NA	NA	
Radium 226, Total	NA	NA	
Sulfate (as SO4)	1,270 lbs	685 lbs	3

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001b (Mass Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	*	*	
Sulfite (SO3)	*	*	
Surfactants	*	1.8 lbs	
Aluminum, Total	1.6 lbs	1.6 lbs	3
Barium, Total	0.5 lbs	0.5 lbs	3
Boron, Total	7 lbs	4 lbs	3
Cobalt, Total	NA	NA	3
Iron, Total	4 lbs	2.5 lbs	3
Magnesium, Total	59 lbs	43 lbs	3
Molybdenum, Total	6 lbs	3.6 lbs	
Manganese, Total	59 lbs	43 lbs	
Tin, Total	*	*	
Titanium, Total	*	*	
Antimony, Total	*	*	
Arsenic, Total	*	*	
Beryllium, Total	*	*	
Cadmium, Total	*	*	
Chromium, Total	*	*	
Copper, Total	0.0002 lbs	0.000009 lbs	
Lead, Total	*	*	
Mercury, Total	0.002 lbs	0.0014 lbs	
Nickel, Total	0.2 lbs	0.1 lbs	

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001b (Mass Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium,Total	0.05 lbs	0.05 lbs	3
Silver,Total	*	*	3
Thallium,Total	*	*	3
Zinc,Total	0.45 lbs	0.45 lbs	3
Cyanide,Total	*	*	3
Phenol, Total	1.4 lbs	0.9 lbs	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Base/Neutral Compounds	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001c (Conc. Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	104 gpm	30 gpm	3
BOD	64.9 mg/l	33.5 mg/l	3
COD	193 mg/l	98.9 mg/l	3
TOC	71.7 mg/l	37.1 mg/l	3
TSS	12 mg/l	6 mg/l	3
Ammonia as (N)	0.71 mg/l	0.45 mg/l	3
Temperature (winter)	67.1 F	57.6 F	3
Temperature (summer)	84.8 F	76.6 F	3
pH	9.2 SU	6.4 SU	3
Bromide	16 mg/l	9.1 mg/l	3
TRC	*	*	3
Color	20 SU	12.5 SU	3
Fecal Coliform	*	*	3
Fluoride	0.56 mg/l	0.42 mg/l	3
Nitrate-Nitrite	0.17 mg/l	0.1 mg/l	3
Oil and Grease	25 mg/l	15 mg/l	3
Phosphorus (as P) Total	1.99 mg/l	1.67 mg/l	3
Alpha (Total)	*	*	3
Beta (Total)	13100 pCi/l	6894 pCi/l	3
Radium, Total	0.909 pCi/l	0.68 pCi/l	3
Radium 226, Total	0.909 pCi/l	0.68 pCi/l	3
Sulfate (as SO4)	6.64 mg/l	3.4 mg/l	3

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001c (Conc. Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	0.072 mg/l	0.072 mg/l	3
Sulfite (SO3)	3 mg/l	2.5 mg/l	3
Surfactants	*	*	3
Aluminum, Total	0.068 mg/l	0.05 mg/l	3
Barium, Total	0.017 mg/l	0.009 mg/l	3
Boron, Total	2,700 mg/l	237 mg/l	4
Cobalt, Total	*	*	3
Iron, Total	2.38 mg/l	1.21 mg/l	3
Magnesium, Total	1.75 mg/l	0.89 mg/l	3
Molybdenum, Total	6.97 mg/l	3.5 mg/l	3
Manganese, Total	0.048 mg/l	0.026 mg/l	3
Tin, Total	0.005 mg/l	0.005 mg/l	3
Titanium, Total	0.001 mg/l	0.001 mg/l	3
Antimony, Total	*	*	3
Arsenic, Total	*	*	3
Beryllium, Total	*	*	3
Cadmium, Total	1.02 ug/l	1 ug/l	3
Chromium, Total	20.6 ug/l	12.8 ug/l	3
Copper, Total	0.072 mg/l	0.04 ug/l	3
Lead, Total	14.8 ug/l	8.4 ug/l	3
Mercury, Total	0.059 ug/l	0.053 ug/l	3
Nickel, Total	25.9 ug/l	18.7 ug/l	3

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001c (Conc. Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	*	*	3
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	0.28 ug/l	0.14 ug/l	3
Cyanide, Total	0.007 ug/l	0.006 ug/l	3
Phenols, Total	0.058 ug/l	0.035 ug/l	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Base/Neutral Compounds	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001c (Mass Est. Page 1 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Flow	104 gpm	30 gpm	3
BOD	81 lbs	12 lbs	3
COD	241 lbs	36 lbs	3
TOC	89 lbs	13 lbs	3
TSS	15 lbs	2.2 lbs	3
Ammonia as (N)	0.9 lbs	0.2 lbs	3
Temperature (winter)	NA	NA	
Temperature (summer)	NA	NA	
pH	NA	NA	
Bromide	20 lbs	3.3 lbs	3
TRC	NA	NA	
Color	NA	NA	
Fecal Coliform	NA	NA	
Fluoride	0.7 lbs	0.2 lbs	3
Nitrate-Nitrite	0.2 lbs	0.04 lbs	3
Oil and Grease	31 lbs	5 lbs	3
Phosphorus (as P) Total	2.5 lbs	0.6 lbs	3
Alpha (Total)	NA	NA	
Beta (Total)	NA	NA	
Radium, Total	NA	NA	
Radium 226, Total	NA	Na	
Sulfate (as SO4)	8.3 lbs	1.2 lbs	3

 CONTINUE ON REVERSE

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number 001c (Mass Est. Page 2 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Sulfide (as S)	0.09 lbs	0.026 lbs	3
Sulfite (SO3)	3.7 lbs	0.9 lbs	3
Surfactants	*	*	3
Aluminum, Total	0.085 lbs	0.018 lbs	3
Barium, Total	0.02 lbs	0.003 lbs	3
Boron, Total	1,872 lbs	12 lbs	3
Cobalt Total	NA	NA	3
Iron, Total	2.9 lbs	0.4 lbs	3
Magnesium, Total	2.2 lbs	0.3 lbs	3
Molybdenum, Total	8.7 lbs	1.3 lbs	3
Manganese, Total	0.06 lbs	0.009 lbs	3
Tin, Total	0.006 lbs	0.0018 lbs	3
Titanium, Total	0.001 lbs	0.0004 lbs	3
Antimony, Total	*	*	
Arsenic, Total	*	*	
Beryllium, Total	*	*	
Cadmium, Total	0.001 lbs	0.0004 lbs	3
Chromium, Total	0.026 lbs	0.005 lbs	3
Copper, Total	0.0001 lbs	0.00001 lbs	3
Lead, Total	0.02 lbs	0.003 lbs	3
Mercury, Total	0.0001 lbs	0.00002 lbs	3
Nickel, Total	0.032 lbs	0.007 lbs	3

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	Outfall Number
		001c (Mass Est. Page 3 of 3)

V. Effluent Characteristics

A and B: These items require you to report estimated amounts (*both concentration and mass*) of the pollutants to be discharged from each of your outfalls. Each part of this item addresses a different set of pollutants and should be completed in accordance with the specific instructions for that part. Data for each outfall should be on a separate page. Attach additional sheets of paper if necessary.

General Instructions *(See table 2D-2 for Pollutants)*
Each part of this item requests you to provide an estimated daily maximum and average for certain pollutants and the source of information. Data for all pollutants in Group A, for all outfalls, must be submitted unless waived by the permitting authority. For all outfalls, data for pollutants in Group B should be reported only for pollutants which you believe will be present or are limited directly by an effluent limitations guideline or NSPS or indirectly through limitations on an indicator pollutant.

1. Pollutant	2. Maximum Daily Value *(include units)*	3. Average Daily Value *(include units)*	4. Source *(see instructions)*
Selenium, Total	*	*	3
Silver, Total	*	*	3
Thallium, Total	*	*	3
Zinc, Total	0.0003 lbs	0.0001 lbs	3
Cyanide, Total	0.00001 lbs	0.000002 lbs	3
Phenol, Total	0.00007 lbs	0.00001 lbs	3
2,3,7,8,Tetrachlorodibenzo-	*	*	3
Volatile Compounds	*	*	3
Acid Compounds	*	*	3
Base/Neutral Compounds	*	*	3
Pesticides	*	*	3
			The symbol * indicates that at the
			referenced similar station (in operation)
			the values on the Form 2C were reported
			as either less than or believed absent.

CONTINUED FROM THE FRONT	EPA I.D. NUMBER (*copy from Item 1 of Form 1*)	

C. Use the space below to list any of the pollutants listed in Table 2D-3 of the instructions which you know or have reason to believe will be discharged from any outfall. For every pollutant you list, briefly describe the reasons you believe it will be present.

1. Pollutant	2. Reason for Discharge
None	

VI. Engineering Report on Wastewater Treatment

A. If there is any technical evaluation concerning your wastewater treatment, including engineering reports or pilot plant studies, check the appropriate box below.

☑ Report Available ☐ No Report

B. Provide the name and location of any existing plant(s) which, to the best of your knowledge resembles this production facility with respect to production processes, wastewater constituents, or wastewater treatments.

Name	Location
Catawba Nuclear Station	York County, South Carolina

EPA I.D. NUMBER (*copy from Item 1 of Form 1*)

VII. Other Information *(Optional)*

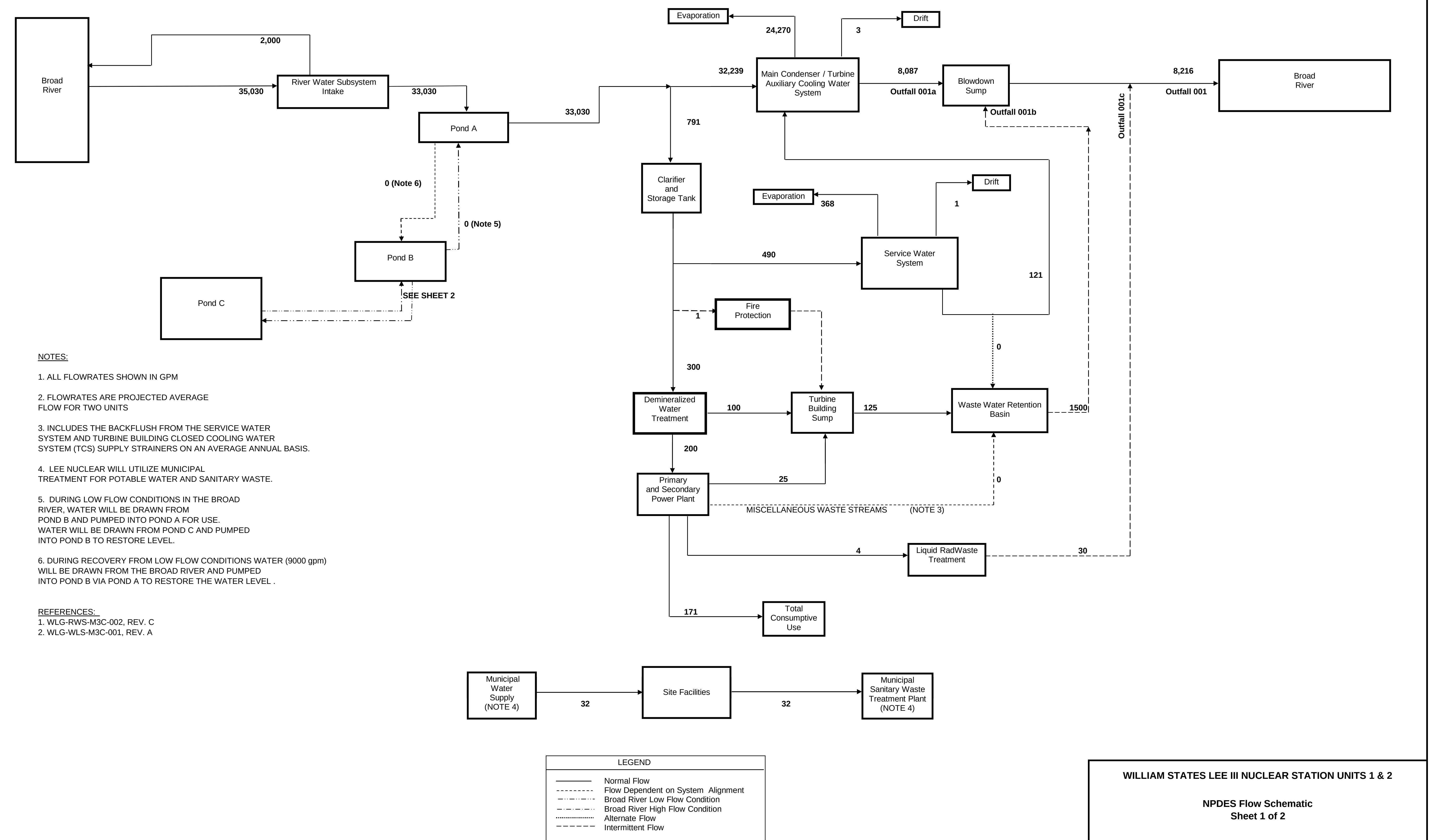
Use the space below to expand upon any of the above questions or to bring to the attention of the reviewer any other information you feel should be considered in establishing permit limitations for the proposed facility. Attach additional sheets if necessary.

See attached documents

VIII. CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name and Official Title (*type or print*)	B. Phone No.
Ronald A. Jones, Senior Vice President Nuclear Development	(704) 382-8149
C. Signature	D. Date Signed 8-11-11



NOTES:

1. ALL FLOWRATES SHOWN IN GPM

2. FLOWRATES ARE PROJECTED AVERAGE FLOW FOR TWO UNITS

3. INCLUDES THE BACKFLUSH FROM THE SERVICE WATER SYSTEM AND TURBINE BUILDING CLOSED COOLING WATER SYSTEM (TCS) SUPPLY STRAINERS ON AN AVERAGE ANNUAL BASIS.

4. LEE NUCLEAR WILL UTILIZE MUNICIPAL TREATMENT FOR POTABLE WATER AND SANITARY WASTE.

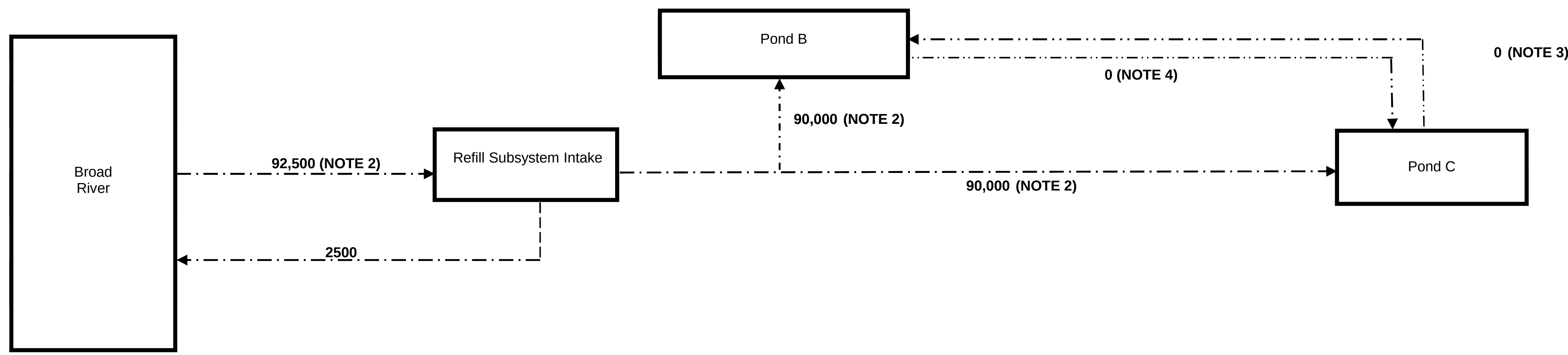
5. DURING LOW FLOW CONDITIONS IN THE BROAD RIVER, WATER WILL BE DRAWN FROM POND B AND PUMPED INTO POND A FOR USE. WATER WILL BE DRAWN FROM POND C AND PUMPED INTO POND B TO RESTORE LEVEL.

6. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER (9000 gpm) WILL BE DRAWN FROM THE BROAD RIVER AND PUMPED INTO POND B VIA POND A TO RESTORE THE WATER LEVEL .

REFERENCES:
1. WLG-RWS-M3C-002, REV. C
2. WLG-WLS-M3C-001, REV. A

WILLIAM STATES LEE III NUCLEAR STATION UNITS 1 & 2

NPDES Flow Schematic
Sheet 1 of 2



NOTES:

1. All FLOW RATES SHOWN IN GPM.

2. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER MAY BE DRAWN FROM THE BROAD RIVER AND PUMPED INTO POND B AND /OR C TO RESTORE WATER LEVEL.

3. DURING LOW FLOW CONDITIONS WATER (30,000 gpm) WILL BE DRAWN FROM POND C AND PUMPED INTO POND B TO RESTORE LEVEL.

4. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER (6,000 gpm) MAY BE DRAWN FROM POND B AND PUMPED INTO POND C TO RESTORE WATER LEVEL.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

NPDES Flow Schematic
Sheet 2 of 2

Part III

Preliminary Engineering Report

NPDES APPLICATION SUPPLEMENT

D H E C

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

Antidegradation/Alternatives Analysis
for
New or Expanded NPDES Discharges
(includes new/increased loadings)

NPDES #: To Be Provided

Project Owner: Duke Energy Carolinas, LLC

Project Name: William States Lee III Nuclear Station

County: Cherokee

Summary of Alternatives Analysis

TYPE OF ALTERNATIVES EVALUATED	EVALUATED ALTERNATIVES TO ELIMINATE/MINIMIZE DISCHARGE (Note PER Reference Below)
Water recycle or reuse	See WLG-0000-X0R-005, Appendix A, Section B (1)
Use of other discharge location	See WLG-0000-X0R-005, Appendix A, Section B (2)
Connection to other WWTPs	See WLG-0000-X0R-005, Appendix A, Section B (3)
Land application	See WLG-0000-X0R-005, Appendix A, Section B (4)
Product or raw material substitution	See WLG-0000-X0R-005, Appendix A, Section B (5)
Other treatment options/alternatives	See WLG-0000-X0R-005, Appendix A, Section B (6)

On behalf of the project owner, I certify that I have completed an evaluation of the discharge alternatives identified above, pursuant to S.C. Reg. 61-67.200.D.1.k, and have reached the conclusions indicated.

Signature [illegible]
(S.C. Professional Engineer)

PE Registration # 5871

Date August 11, 2011

SOUTH CAROLINA REGISTERED No. 5871 PROFESSIONAL ENGINEER ROBERT M. DULIN, JR.

SOUTH CAROLINA CERTIFICATE OF AUTHORIZATION STONE & WEBSTER, INC. NO. C02388

Complete this sheet with PER in accordance with R.61-67.200.D.1.k, if applicable or with NPDES application.
Instructions on back.

AP1000

Shaw® The Shaw Group Inc.®
Shaw Nuclear

Project Technical Report

Report No.WLG-0000-X0R-005
Rev. No.: 1
Page 1 of 45

Preliminary Engineering Report Accompanying the NPDES Permit Application for the Proposed William States Lee III Nuclear Station

Prepared for:
Duke Energy Carolinas, LLC

Project No:
118879

8/11/2011

SOUTH CAROLINA CERTIFICATE OF AUTHORIZATION STONE & WEBSTER, INC. NO. C02386

SOUTH CAROLINA REGISTERED PROFESSIONAL ENGINEER No. 5871 ROBERT M. DULIN, JR.

Prepared By: [signature] 8/11/2011

Concurrence: [signature] 8/11/2011

Approved By: [signature] 8/11/2011
Project Engineer

Shaw Group
Charlotte, NC 28202

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FIGURES:

ATTACHMENT

APPENDIX

SUMMARY

The objective of this report is to describe the operation of the William States Lee III Nuclear Station (Lee Nuclear Station or station) as those operations affect water use and water discharge quality. The report provides the information necessary for the South Carolina Department of Health and Environmental Control (SC DHEC) National Pollution Discharge Elimination System (NPDES) permit writer to understand the station's range of operating conditions, the waste streams that will be produced, the pollutants expected to be present in each waste stream, and the anticipated concentrations of those pollutants in the station's discharge. This report compares the characteristics of the discharge from the station's outfall (Outfall Number 001) under the full range of expected operating levels with applicable technology-based effluent standards and the SC DHEC water quality standards for the Broad River.

This report identifies the source of each waste stream encompassed by the discharge and the treatment applied to each waste stream prior to commingling. This report uses data and information on the quality of the source water and constituents expected to be used in the process of generating electric power at the station to predict the water quality of the discharge. The report then compares the predicted quality of the discharge to the SC DHEC water quality standards.

1.0 DEFINITIONS AND ACRONYMS

ACRONYMS	DEFINITION
ALARA	*As Low As Reasonably Achievable*
CMC	*Criteria Maximum Concentration*
COL	*Combined Construction and Operating License*
COC	*Cycles of Concentration*
CCC	*Criterion Continuous Concentration*
ER	*Environmental Report*
FERC	*Federal Energy Regulatory Commission*
IST	*In Service Testing*
NPDES	*National Pollution Discharge Elimination System*
SC DHEC	*South Carolina Department of Health and Environmental Control*
TDS	*Total Dissolved Solids*
TSS	*Total Suspended Solids*

2.0 INTRODUCTION/OBJECTIVE

This Preliminary Engineering Report is submitted to SC DHEC as part of the NPDES Operating Permit application for the Lee Nuclear Station. The report describes the operational functions of the proposed station involving water use and wastewater discharge.

Several pre-application meetings were held at the SC DHEC offices in Columbia, South Carolina, between 2009 and 2011, to discuss the process and requirements for filing the Operating NPDES and wastewater facilities construction permit applications. Duke Energy agreed with the SC DHEC's recommendation that the operating permit application be submitted prior to the wastewater facilities construction permit application.

As a part of the approval for construction of the wastewater treatment facilities, a supplemental information package which includes design drawings and specifications will be submitted to SC DHEC as part of the SC R61-67 construction permit application. The wastewater treatment facilities will be designed to meet the discharge limits imposed by SC DHEC in the NPDES operating permit.

3.0 GENERAL DESCRIPTION OF THE LEE NUCLEAR STATION PROJECT

The William States Lee III Nuclear Station, hereafter referred to as the Lee Nuclear Station, will be operated by Duke Energy Carolinas, LLC (a subsidiary of Duke Energy Corporation). Duke Energy Carolinas, LLC (Duke Energy), through its integrated resource planning process, has identified a need for additional base load generation in the 2021 time

period. This demand will be satisfied through a number of means, including the proposed Lee Nuclear Station.

The Lee Nuclear Station will be constructed on the site of the former Duke Power Cherokee Nuclear Station. The property is owned by Duke Energy, and Duke Energy will operate the facility. The Lee Nuclear Station is a dual-unit site with Westinghouse AP1000 pressurized water reactors. Each reactor has a rated core thermal power of 3,400 Megawatts thermal (MWt) and a nuclear steam supply system thermal output of 3,415 MWt. The rated gross electrical power is 1,199.5 Megawatts electric (MWe). The rated net electrical power is at least 1,000 MWe. The two units at Lee Nuclear Station are each comprised of five principal building structures, consisting of the Nuclear Island, Turbine Building, Annex Building, Diesel Generator Building, and Radwaste Building. The structures that make up each Nuclear Island are the Containment Building, Shield Building, and Auxiliary Building.

The current site was selected on the basis of an in-depth review of alternative sites. Criteria such as seismic characteristics, demographics, emergency planning, exclusion area, transmission access, and water availability were used in the site selection analysis. The site meets the desired characteristics necessary to support the construction and operation of a new nuclear power station.

This site is located in the eastern portion of Cherokee County in north-central South Carolina. Figure 1 shows the location of Lee Nuclear Station. The Lee Nuclear Station is on the west side of the Ninety-Nine Islands Reservoir, an impoundment of the Broad River, at a point about 1,000 feet (ft.) upstream from the Ninety-Nine Islands Hydroelectric Station. Within Cherokee County, the site is 8 miles (mi.) southeast of Gaffney, 7.5 mi. southeast of East Gaffney, 6 mi. south of Blacksburg, and 2.6 mi. southeast of the unincorporated village of Cherokee Falls. The site is 40 mi. southwest of Charlotte, 24 mi. northeast of Spartanburg, and 51 mi. northeast of Greenville (Reference 8.1).
In the early 1970s, the site was evaluated for construction of three nuclear units designated as the Cherokee Nuclear Station. In 1975, the Nuclear Regulatory Commission (NRC) granted a construction permit (NUREG-75/089) to Duke Power Company. Approximately 750 ac. of ground on the site were disturbed by the subsequent construction, which began in 1977 and was halted in 1982. However, the construction resulted in extensive alteration of the site, which involved vegetation clearing; establishment of on-site construction roads; establishment of a railroad spur to the site; extensive excavation and grading with heavy equipment; building of on-site warehouses, shops, and construction support facilities; and construction of portions of one nuclear unit, including about half of its associated reactor containment/shield building (Reference 8.1).

These construction activities occurred in the large open area that currently is visible on the site. As a result, the site consists of open, partially developed industrial land with low groundcover vegetation and scattered areas of sparse tree growth.

The proposed two units at Lee Nuclear Station will be constructed within this cleared area. The overall site encompasses approximately 2000 acres (ac.) of property, which includes

the station and two ponds, known as Ponds A and B. The topography in this area ranges from a low elevation of 512 ft. above mean sea level (msl) along the river bank to a high elevation of 659 ft. above msl northwest of the existing excavation. The elevation of McKowns Mountain is 816 ft. above msl, the highest point on the Lee Nuclear Site (Reference 8.1).

Additional on-site areas are expected to be cleared for the water intake and refill structures and the wastewater discharge structures. The location of each of these structures is illustrated in Table 1, which provides latitude and longitude based on the Universal Transverse Mercator grid coordinates (NAD 83) for each location.

The Ninety-Nine Islands Reservoir, which has a pool elevation of approximately 511 ft. above msl, is the nearest major body of surface water to the Lee Nuclear Site. The reservoir was formed by the Ninety-Nine Islands Dam, also owned by Duke Energy, which impounds the Broad River. The Ninety-Nine Islands Reservoir is regulated by the Federal Energy Regulatory Commission. The site is located adjacent to the reservoir, which bounds it to the north and east. Land along the south boundary of the site is private property.

In addition to structures and ponds on the station site, Duke Energy proposes to create a third pond, known as Pond C, by impounding approximately 620 acres of land in the London Creek watershed adjacent to the site. Pond C will be created by constructing a 132 ft. high earthen dam with multiple saddle dikes. Pond C impoundment will have a water surface elevation of 650 ft. and will hold approximately 22,000 acre-ft of water. The impoundment will be filled with water from the London Creek watershed area (approximately 2,500 acres) and inflow from the existing Lake Cherokee reservoir upstream of the site, and by pumping water directly from the Broad River as authorized by the NPDES permit.

Waste heat from the station will be dissipated by closed-cycle mechanical induced-draft wet cooling towers. Make-up water for the cooling towers will be withdrawn from the Broad River through the river water intake structure. Ponds B and C will be available to provide additional water when low flow conditions in the Broad River warrant curtailment of river withdrawals for consumptive needs. Based on a review of historical data, use of these reservoirs is expected to be infrequent. Cooling tower blowdown will be discharged via a diffuser attached to Ninety-Nine Islands Dam (Reference 8.1).

3.1 WATER USE AND MANAGEMENT

Station water needs will be met using water from the Broad River and Ponds A, B and C via several intake and refill structures. Coordinates for the locations of these structures are noted in Table 1 and locations of these structures are shown on Figure 1 of this report. The main source of water for the station will be the Broad River. The station will withdraw water from the river via an intake structure located north of the station. The river water intake will have two distinct sections: a primary section and drought contingency section. The NPDES

permit package provides sketches that illustrate plan views and sections of the river water intake and Ponds A, B and C intake/refill structures.

Duke Energy's Water Management Plan is set forth in the Volume 2 Part VII of the NPDES Operating Permit Application package. Duke Energy believes this plan reflects the best technology available for minimizing adverse environmental impacts at the Lee Nuclear Station pursuant to the criteria established in SC DHEC's § 316(b) implementing regulations. Further details on the river and pond intakes and their compliance with the requirements of Clean Water Act Section 316(b) and corresponding South Carolina law are provided in the Volume 2 Part VII of the permit application package.

4.0 OverView of STATION OUTFALL AND DISCHARGEs In addition, the project will have four overflows from on-site ponds that discharge to the Broad River. These overflows are from Ponds A, B, proposed Pond C and Hold-Up Pond A. Storm water collected in storm drains at the station will be directed to Ponds A, B, Hold-Up Pond A and the Broad River. Duke Energy plans to permit all the storm water discharges for the Lee Nuclear Station separately under the program for the NPDES Multi-Sector General Permit for storm water discharges associated with industrial activity. Therefore, these storm water discharges are not included with this NPDES Preliminary Engineering Report.

4.1 STATION DISCHARGE (OUTFALL 001)

Continuous cooling tower blowdown and intermittent process wastes from the Waste Water System will be combined into a single effluent prior to discharge. Along with intermittent discharges from the Liquid Radwaste System, the wastewater will be discharged to the Broad River. During normal station operation, 18 cubic feet per second (cfs) of wastewater, comprised mainly of Circulating Water System cooling tower blowdown, will be continuously discharged through a diffuser into the river. Figure 6 shows the pipe layout for the wastewater discharge to the diffuser. The station discharge location is shown on Figure 1 and listed in Table 1. The diffuser details are illustrated on Figure 7.

The station outfall ends in a multiport diffuser constructed from a 36-inch nominal internal diameter pipe which will be attached to the upstream face of the Ninety-Nine Islands Dam. The station outfall piping will run along the dam and end before the intake of the Ninety-Nine Islands Hydroelectric Station. The center line of the multiport diffuser is approximately 6 ft. below the full pond elevation of the Ninety-Nine Islands Reservoir. Thus, the top of the multiport diffuser is approximately 4.5 ft. below full pond. The multiport diffuser is perforated with holes and the end is capped, which creates a dispersal effect for the exiting water. Only the upstream face of the diffuser is perforated, allowing the discharge to be directed into the Ninety-Nine Island Reservoir and then by induced flow into the inlet of the Ninety-Nine Islands Hydroelectric Station. The diffuser maximizes thermal and chemical distribution in the receiving water. Directional flow of reservoir water will pull the plume toward the intake of the Ninety-Nine Islands Hydroelectric Station. Detailed information on the mixing projected to occur is discussed in Mixing Zone Request, which is included in Volume 1 Part VI of the NPDES Operating Permit Application Package.

Sediment buildup around the discharge diffuser is not expected to be significant due to the discharge exit velocity and the velocity of water in the vicinity of the Ninety-Nine Islands Hydroelectric Station.

It will be possible to monitor each waste stream, as well as the combined effluent, separately. These monitoring points will be 1) the flow measurement on the cooling tower blowdown lines; 2) a sampling point at the Waste Water System line; 3) a sampling point on the discharge effluent to Broad River. In addition, the Liquid Radwaste System includes radiation monitoring equipment to ensure the controlled release of low level radioactive liquid waste satisfies the NRC criteria.

4.2 INTAKE SCREEN WASH WATER

4.2.1 RIVER INTAKE SCREEN WASH WATER

The screen wash system on the river intake removes fish and debris from the traveling screens. The screen wash system will withdraw and discharge water back to the Broad River after the water has washed any accumulated river debris from the traveling screens.

This water will be drawn into the intake with screen wash water pumps located downstream of the screens. This water removes fish and debris from the screens into a sluice that will be returned to the river downstream of the intake structure.

The screen wash will discharge at a normal, continuous flow rate of 2,000 gallon per minute (gpm), with a maximum design flow rate of 2,500 gpm. The discharge water quality should closely match the river water quality with no change in chemical composition or temperature, given that screen wash will be continuous and the screen wash will not be in contact with any internal station processes. The discharge may contain debris in higher density than that of the river water as a result of the screening process, but the quality of the water should be unaffected by passage through the screen wash system.

The screen wash water discharge structure will be located adjacent to the river intake and on the downstream side of the structure. A location downstream of the intake will ensure that debris is discharged beyond the expected influence of the intake withdrawal to prevent recirculation back to the intake screens.

4.2.2 POND A SCREEN WASH WATER

Most of the water in Pond A originates from the Broad River. Once the Lee Nuclear Station is fully operational, the water quality in Pond A should be very similar to that in the river.

The screen wash water discharge structure is located outside the hydraulic zone of influence of the Pond A intake structure. The screen wash will discharge at normal, continuous flow rate of 2,000 gpm, with a maximum design flow rate of 2,500 gpm. The screen wash discharge water quality from the Pond A screen wash should closely match the Pond A water quality with no change in chemical composition or temperature, given that screen wash is continuous and there is no storage of flow. The discharge may contain debris in higher density than that found in Pond A as a result of the screening process, but the quality of the water should be unaffected by passage through the screen wash system.

4.2.3 PONDS B AND C SCREEN WASH WATER

The Ponds B and C intakes will be intermittently operated. For those times when the intakes are required to be in service (e.g., during river low flow conditions), a screening system that can be manually placed in service will be used. Those intakes will use cylindrical drum screens that can be removed from the normal operating position, raised to the deck level, and manually cleaned to remove accumulated debris.

Each pond will provide screen wash water for its own intake, and the screen wash will be returned to the pond from which it came. The screens will be washed with a water hose or similar temporary manual wash nozzle. The water flow will be intermittent and considerably less than the 2,000 gpm normal flow rate estimated for the river intake or the Pond A screen wash water flow.

The screen wash water quality should closely match the quality of the pond from which it originates, with no change in chemical composition or temperature, given that there is no storage of flow. The screen wash water may contain fine debris in higher density than that found in Ponds B and C as a result of the screening process, but the quality of the water should be unaffected.

5.0 BROAD RIVER AMBIENT WATER QUALITY

5.1 HISTORICAL FLOWS

Figure 2 shows the average of monthly flows for the past 85 years, as well as the maximum monthly average flow and the minimum monthly average flow. Mean annual daily flow for the period of record (1926-2010) is illustrated in Figure 3.

The annual average flow is 2,495 cubic feet per second (cfs) and there is a seasonal pattern to the flow rates. Slightly higher flows generally occur in the winter and spring with lower flows in the summer and fall.

Figure 3 illustrates the mean annual daily flow at the Gaffney U.S. Geological Survey gage. The river displays periodic fluctuations, most likely in response to fluctuations in annual precipitation. The mean annual daily flow data over the period of record do not indicate any discernable increasing or decreasing trends.

5.2 HISTORICAL WATER QUALITY OF THE RECEIVING WATER

The Broad River will be the primary source of process and raw water for the Lee Nuclear Station. The Broad River is classified as freshwater river by the SC DHEC per R 61-68. Water will be withdrawn from the Broad River and stored in Ponds A, B and C. Cooling tower blowdown and process wastewater from the facility will be combined and discharged via a diffuser located in the Ninety Nine Islands Reservoir.

The results of water quality studies conducted in the river near the Lee Nuclear Station in 2006 to 2009 have established baseline water quality characteristics for the Broad River. While information on seasonal and climatic impacts on water quality are necessarily limited by conditions occurring during these investigations, general estimates can be made regarding water quality in the vicinity of the Lee Nuclear Station. Figure 4 illustrates the location of sampling points on the Broad River. These results are presented in the Lee Nuclear Station Environmental Report (Reference 8.1).

Parameters such as water temperature, pH, dissolved oxygen, and conductivity were compared to characterize surface water conditions and stability. Study results indicate that surface water temperatures were heavily influenced by ambient air temperatures in water quality investigations, given that samples collected near the surfaces of water bodies were typically at or nearly the same as ambient air temperatures. Additionally, apparent mixing in lotic waters resulted in relatively constant temperatures with depth in the Broad River and its backwater areas, while a thermocline was observed in Ponds A and B.

The results of the 2006 to 2009 water quality studies showed that pH and alkalinity measurements appear to be relatively consistent with those reported for the Cherokee Nuclear Station study conducted in 1970s. The field-measured pH of the Ninety-Nine Islands Reservoir and Broad River ranged from 5.3 to 8.2, with a mean pH slightly above 7 standard units. The SC DHEC quality standards for fresh waters are 6.0 to 8.5 standard units. During the 2006-2009 studies, the waters of the Broad River and Ninety-Nine Islands Reservoir were observed to be more acidic in spring and summer and more alkaline in fall and winter. Total alkalinity in the Broad River and its backwater areas ranged from 16 to 27 mg/l and averaged 23 mg/l, suggesting a poorly buffered water system with low resistance to a change in pH. Historical alkalinity values suggest even poorer buffering capacity in the past. The dissolved oxygen levels ranged from 4.5 to 12.0 mg/l in Broad River and Ninety Nine Islands Reservoir.

Dissolved oxygen in the on-site impoundments approached anoxic conditions with depth. The deeper impoundment water also exhibited a general increase in dissolved metals (e.g., iron and manganese) and specific conductance with depth, suggesting release from the sediments below the thermocline. This is characteristic of water bodies with an anoxic hypolimnion (characterized by low oxygen levels in the colder, dense, deep water layers in a thermally stratified lake). Figure 5 illustrates the depth to the hypolimnion during the

summer quarter for both the Ponds A and B at approximately 36 ft. below water surface (Reference 8.1).

5.3 WATER QUALITY DATA FOR BROAD RIVER

Duke Energy collected surface water samples from Broad River in the vicinity of the planned cooling water intake structure over the period of 2006 to the first calendar quarter of 2011. The samples were analyzed for conventional pollutants and metal constituents (total recoverable). Ten metal constituents plus ammonia were detected in the influent/ambient Broad River.

Figure 4 shows the Broad River surface water sampling locations used to characterize the quality of these waters (Reference 8.1). Rule 61-68 of SC DHEC provides no ambient water quality aquatic life criteria for aluminum, barium, iron, magnesium, or manganese (Reference 8.9). For the remaining constituents detected in ambient river water (i.e. ammonia, arsenic, chromium, copper, lead, and zinc), SC DHEC Rule 61-68 provides aquatic life criteria.

6.0 DESCRIPTION OF LEE NUCLEAR STATION WASTE STREAMS

The type of waste expected at the Lee Nuclear Station is industrial wastewater collected from station equipment, building floor drains, process fluids, and system flushing wastes. All sanitary waste will be discharged offsite to the Gaffney Board of Public Works Wastewater Treatment Plant.

The station will have three primary wastewater streams (see Attachment 1):

- Continuous blowdown from the cooling towers (nominally 8,087 gpm)
- Intermittent process wastes (approximately 1500 gpm) from the Waste Water System
- Intermittent discharges from the Liquid Radwaste System (approximately 30 gpm)

6.1 COOLING TOWER BLOWDOWN

The purpose of the Circulating Water System cooling towers is to reduce the temperature of the cooling water before returning it to the station condensers. The cooling towers generate a blowdown waste stream. This blowdown, which is used to control concentrations of solids in the Circulating Water System, comprises the majority of the station discharge flow.

The cooling towers are designed for four cycles of concentration (COC) under normal conditions. This will limit the potential for formation of scale, lessen the potential for salt-induced corrosion, and provide a blowdown suitable for discharge and mixing back to the Broad River. The cooling tower blowdown rates and cooling tower basin refill flow are determined by the evaporative rates of the cooling towers.

The normal design blowdown flow for four cycles of concentration will be approximately 8,087 gpm. The maximum blowdown flow for operation at two cycles of concentration will be 28,023 gpm. This maximum blowdown will occur only during extreme high river flow conditions, when cycles of concentration must be reduced to limit sediment loads on the system.

6.1.1 COOLING TOWER BLOWDOWN FLOW AND WATER TREATMENT

Duke Energy operates the Catawba Nuclear Station which draws its intake water from Lake Wylie on the Catawba River. The Catawba River drains the water shed immediately to the East of the Broad River Basin. Based on a similarity of the water chemistry produced by the two watersheds and the similarity in construction of the cooling towers for these plants, the chemicals used at the Lee Nuclear Station will be consistent with those currently chosen by Catawba Nuclear Station (NPDES Permit # SC0004278).

This station will use sodium hypochlorite and sodium bromide to control bio-fouling and limit algae growth. The biocide application frequencies are not expected to vary seasonally. The oxidizing chemistry will be consumed in the system; so, chlorine will be non-detectable in the cooling tower blowdown stream. During the chlorination period, the blowdown to the station outfall will be halted. Only after the chlorination period has ended and measurements indicate that residual chlorine is undetectable in the basin will discharges from the cooling tower resume.

Sulfuric acid may also be added to balance the pH and limit scale growth in the cooling tower fill and piping systems. It is expected to be consumed in the system (making it non-detectable).

During the periods of high river water turbidity or other conditions when deposition may lead to an increase in micro-fouling, silt dispersants such as polyacrylate may be used to minimize deposition within the system. Any silt dispersant added to the system will discharge with the blowdown to the Broad River. Concentrations in waste streams are expected to be less than 10 ppm.

The Service Water System is another station cooling water system that will use cooling towers to reduce the temperature of the cooling water supplied to various systems in the station. The Service Water System cooling towers will also generate a blowdown stream. This blowdown is used to control the solids concentration in the Service Water System. Under normal operating conditions, this blowdown will be routed to the Circulating Water System cooling tower basins. Based on four cycles of concentration, the normal blowdown flow rate is expected to be approximately 121 gpm (see Attachment 1). At the maximum heat load, the maximum blowdown flow rate is anticipated to be approximately 410 gpm (Reference 8.1, Figure 3.3-1). The maximum blowdown flow reflects an interim operating condition associated with plant shut down and will be infrequent. The Service Water

System cooling tower blowdown rates and cooling tower basin refill flow are determined by the evaporative rates of the cooling towers.

The station will use the same chemicals in the Service Water System cooling tower as those described for use in the Circulating Water System cooling tower. Chemicals for both sets of towers will be supplied by the Turbine Island Chemical Feed System. The relatively small Service Water System blowdown flow has a negligible impact on Circulating Water System operation. Similar to the operation of Circulating Water System, the Service Water System blowdown will be halted during addition of chlorine bearing chemicals and not resume until the residual chlorine is undetectable in the cooling tower basins.

During periods when the Service Water System is in service and the Circulating Water System cooling tower basins are not available, the Service Water System blowdown will be directed to the Waste Water Retention Basins. All planned discharges from the Waste Water Retention Basins will be sampled before discharge; if there is detectable residual chlorine in the effluent, the Waste Water Retention Basins will not discharge.

The active ingredients in each of these water treatment chemicals (i.e. chlorine and sulfuric acid) are designed to be consumed by the system, with residual concentrations (typically low concentrations of common salts) remaining in the effluent at trace or non-detectable levels. Chemical concentrations will be measured through analysis of grab samples. Chlorine residual will be measured to monitor the effectiveness of the biocide treatment. No impact to water quality is anticipated. Thus, the current station design does not anticipate any additional treatment of water in the cooling tower. However, if the need for further treatment with additional chemicals is determined, these chemicals will be introduced only after approval by SC DHEC. Additionally, the chemicals used for the treatment of cooling tower blowdown will be limited by 40 CFR 423.15(j) (1).

6.1.2 TEMPERATURE

The Circulating Water System cooling tower blowdown is taken off from the pump discharge, downstream of the cooling towers. The cooling tower blowdown temperature will be very close to the temperature of the water supplied to the station main condensers by the Circulating Water System. The Circulating Water System maximum supply temperature is 91°F (Table 10.4.1-1, Reference 8.4). Thus, 91°F (instantaneous maximum) can be expected at the cooling tower blowdown (as well as the station effluent discharge) flow. The blowdown temperature is related to the ambient air wet bulb temperature. The station design wet-bulb temperature is 76 °F (Reference 8.2) with 1% exceedance. The cooling towers will be designed based on the 76°F maximum ambient wet-bulb temperature. Thus, it is likely that approximately 1% of the time, the cooling tower blowdown temperature will exceed 91°F (instantaneous maximum), when the ambient wet-bulb temperature exceeds 76°F. However, the monthly average blowdown temperature is expected to be below 90°F. The details of the potential impacts of this thermal release to the Broad River are modeled and discussed in the Mixing Zone Request provided as Volume 1 Part VI of the NPDES Operating Permit Application package.

The Service Water System cooling tower blowdown is taken off from the Service Water System downstream of where heat energy has been transferred to the Service Water System from the Component Cooling Water System (CCS) heat exchangers. Thus, the Service Water System cooling tower blowdown temperature will be very close to the inlet temperature to the Service Water System cooling towers, which is expected to range from 40°F to 125°F. The relatively small Service Water System blowdown flow will have a negligible impact on Circulating Water System or Waste Water System operation.

6.2 CONVENTIONAL INDUSTRIAL (NONRADIOACTIVE) WASTE WATER

A number of nonradioactive waste streams are expected at the Lee Nuclear Station. Those waste streams include nonradioactive effluents that may contain water-treatment chemicals or biocides, water-treatment wastes, floor and equipment drains, and laboratory waste. Due to the size of Waste Water Retention Basins, process wastewater discharges are intermittent.

6.2.1 WASTE WATER SYSTEM

The Waste Water System is designed to collect and process wastewater received from various nonradioactive building areas (Reference 8.7). The Waste Water System collects system flushing wastes during startup, collects and processes fluids drained from equipment or systems during maintenance or inspection activities, and collects nonradioactive equipment leaks and floor drains.

The Waste Water System is designed to remove oil and suspended solids from these miscellaneous station waste streams. These waste streams will be transferred to, and collected in, two Turbine Building sumps. The Turbine Building sump pumps will then route the wastewater from either of these two sumps to the oil/water separator for removal of any oily waste. The diesel fuel oil area sump pump also will route wastewater to this oil/water separator. The oil/water separator will have a small reservoir for storage of the separated oily waste. Oily waste collected in that reservoir will flow by gravity to a waste oil storage tank that provides temporary storage prior to removal by truck for offsite disposal. A sampling connection will be provided on the tank, to allow verification that the oil does not require handling and disposal as a hazardous waste. A bypass line will allow for the oil/water separator to be out of service for maintenance.

The wastewater from the oil/water separator will flow to the Waste Water Retention Basins for settling of suspended solids and treatment, if required, prior to discharge. There will be one Waste Water Retention Basin per unit, located to the northwest of the power block area. Each basin will be constructed such that wastewater and the dissolved or suspended materials in the wastewater do not penetrate the liner and leach into the ground. Each basin will be designed to receive waste streams for holdup for treatment to meet specific environmental discharge requirements. Each basin will have a capacity of approximately 5,000,000 gallons. The configuration and size of the Waste Water Retention Basins will

allow settling of solids larger than 10 microns which may be suspended in the wastewater stream. Wastewater can be sampled prior to discharge from the Waste Water Retention Basins. The wastewater after the discharge from the Waste Water Retention Basins will achieve the total suspended solids and oil and grease limits prescribed in 40 CFR 423.15(c).

The wastewater basin transfer pumps are designed to send the basin effluent (treated wastewater) from the Waste Water Retention Basins to the common blowdown sump. Controls are provided for manual operation of the pumps based on the level of fluid in the retention basins.

As discussed in the previous section, the active ingredients in the water treatment chemicals are designed to be consumed by the systems, with residual concentrations (typically low concentrations of common salts) remaining in the effluent at trace or non-detectable levels. No impact to receiving water quality is anticipated.

6.2.2 CLARIFICATION SUBSYSTEM

Water from Pond A (the vast majority of which will originate from the Broad River) will be used as make-up water for the Circulating Water System and in the on-site clarification subsystem. The clarification subsystem will be used to reduce the amount of total suspended solids (TSS) in the water pumped from Pond A before providing it to the service water system cooling tower basin and demineralized water treatment system. Raw water entering the clarifier will be treated with a coagulant and polymer to initiate the formation of settleable solids. Water chemistry will be controlled by package equipment supplied with the clarifier. After settling, these solids will be removed from the clarifier and dewatered in a filter press. The coagulant and polymer will be consumed by the process and removed when the dewatered solids are transported to an offsite location for disposal at a landfill. Liquids from the dewatering process will be recycled back to the clarifier inlet. The only chemicals processed through the clarification system will be used for pH control and disinfection.

The clarification subsystem will treat the raw water with sodium hypochlorite to control microbiological growth. Dose concentration of sodium hypochlorite will be 0.2 ppm (approximately). The levels of sulfate, chlorite, and sodium (measured as total dissolved solids (TDS)) leaving the clarifier by way of the processed water and, ultimately, ending up in the Waste Water Retention Basins as station system effluents and blowdown will have no significant effect on the overall station discharge concentrations of these constituents. If required, an adjustment will be made for pH control (using sulfuric acid) to optimize the coagulation and flocculation process. Sulfuric acid will be consumed in the system and, as a result, its concentration in the waste stream will be non-detectable.

Disinfection will be performed downstream of the clarifier and some chlorine residual is expected in the water routed to the various station systems.

6.2.3 DEMINERALIZED WATER TREATMENT SYSTEM

Demineralized water used in the station will be generated by the Demineralized Water Treatment System. The Demineralized Water Treatment System will be a high-purity water treatment system consisting of three distinct treatment processes (Reference 8.8):

- Filtration - cartridge filtration (CF)
- Primary demineralization - reverse osmosis (RO)
- Secondary demineralization - electrodeionization (EDI)

Demineralized water will be produced from the disinfected, clarified water. Cartridge Filtration is the filtration treatment process designed to remove suspended solids in the influent prior to Reverse Osmosis treatment. Removal of the suspended solids prior to Reverse Osmosis minimizes the potential reduction in Reverse Osmosis recovery efficiency and helps to extend membrane life. Reverse Osmosis will serve as the primary demineralization treatment process, reducing solids, salts, organics, and colloids through the membrane filtration prior to the secondary demineralization treatment process, electrodeionization. Electrodeionization will serve as the polishing phase of treatment, producing water for distribution to the station.

Connections are provided upstream of the cartridge filters for the injection of pH, scale inhibitor, and de-chlorinating chemicals for influent pretreatment. The chlorine residual in the Demineralized Water Treatment System will be removed upstream of the cartridge filtration units by the addition of sodium bisulfite. Dechlorination with sodium bisulfite is a necessary pretreatment step. Other than the sodium released, the reducing agent is non-detectable and consumed in the system as it releases chlorine to the atmosphere. Sulfuric acid is expected to be used for pH control and polyacrylate is expected to be added for anti-scalant. The intermittent use of sulfuric acid and polyacrylate chemicals in the Demineralized Water Treatment System will produce sulfate and TDS concentrations, respectively, in the waste stream ultimately routed to the Waste Water Retention Basins. But, they will have a negligible influence on the overall station discharge.

The filter cartridges will not be backwashed; instead, they will be replaced once they become dirty. The only waste stream from the cartridges will be a small amount of drainage from the filter housing during cartridge replacement.

Reverse Osmosis treatment will produce treated water product (permeate) and concentrated wastewater stream (brine). The brine will either be recycled back to the upstream Reverse Osmosis unit or piped to the Waste Water System, depending on the mode of operation. The permeate will be further de-ionized (polished) in the electrodeionization stacks. Each Reverse Osmosis unit is individually designed to process 540 gpm of incoming clarified raw water (filtered influent) and produce 380 gpm of demineralized water. A maximum of 160 gpm (per unit) of brine will be generated from Reverse Osmosis treatment.

The electrodeionization will process Reverse Osmosis permeates and produce the highest water quality. The electrodeionization system is designed to process 380 gpm of Reverse Osmosis permeate and produce 360 gpm of high-purity demineralized water based on 95 percent water recovery. The electrodeionization will split incoming Reverse Osmosis permeate into two streams: dilute and brine. Flow paths through the membranes for the dilute and brine streams will be formed by membrane spacers. These spacers will be arranged to individually manifold the dilute and brine water paths. The combination of membranes and spacers will create a cell pair. These cell pairs allow the dilute and brine water streams to flow in parallel paths through their respective dilute (i.e., ion-diluting) and brine (i.e., ion-concentrating) compartments. The dilute flow path will be filled with high-grade ion exchange resin to reduce conductivity and demineralize the dilute stream.

The dilute stream will be a once-through flow. The Reverse Osmosis feed pump will supply the required head to overcome the electrodeionization stack pressure drop. A resin trap in the electrodeionization stack dilute outlet header upstream of the electrodeionization product transfer pump will minimize the risk of resin leaks into downstream systems. After treatment, the electrodeionization product water will be pumped to the Demineralized Water Treatment System by the electrodeionization product transfer pump. If at any time the Demineralized Water Treatment System effluent does not meet the required water quality, the electrodeionization three-way outlet motor-operated valve will switch and recirculate the flow back to the inlet of the Reverse Osmosis cartridge filter.

Whereas the dilute stream will be a once-through flow, the brine stream will recirculate through the electrodeionization stacks and electrode compartments. In order to control mineral concentrations and prevent scaling of the membrane stack, a portion of the brine stream, (i.e. brine blowdown) will be bled off continuously. Under normal conditions, the brine stream blowdown will be 5 percent of the total incoming Reverse Osmosis permeate flow and will be discharged to the Waste Water System. Recirculation of the brine to the inlet of the Reverse Osmosis is an option, to be considered in the final Demineralized Water Treatment System design. Make-up water consisting of the incoming permeate stream will be added continuously to maintain the required brine flow rate. An electrodeionization brine pump will recirculate the brine through the electrodeionization stacks. To prevent cross-leak contamination, the dilute-stream pressure will be greater than the brine stream. The electrodeionization brine stream also will include a side stream of brine used for flushing the electrode compartments. The brine used for flushing the electrode compartments will be a once-through flow, which will be routed to the Waste Water System.

Because Reverse Osmosis/electrodeionization systems often foul and lose performance, the Reverse Osmosis/electrodeionization treatment process also will include a "clean-in-place" (CIP) skid. The "clean-in-place" skid will include a 500-gallon tank to mix cleaning chemicals (acid or alkaline) at proper concentrations. The chemical solution is heated with an inline heater and filtered prior to circulating through the Reverse Osmosis/electrodeionization modules. The elevated cleaning solution temperature assists in dissolving membrane contaminants, while the filter protects the membranes from solid

contaminants in the cleaning solution. The cleaning solution will be circulated by the pump through the offline Reverse Osmosis/electrodeionization modules. The cleaning solution must be neutralized prior to discharging to waste. The cleaning and neutralizing chemical will be added by a drum and mounted pump arrangement.

6.2.4 STEAM GENERATOR BLOWDOWN SYSTEM (BDS)

The Steam Generator Blowdown System controls and maintains the steam generator secondary cycle water chemistry during normal plant operation. It will do this by removing impurities that are concentrated in the steam generator. During normal operation, the Steam Generator Blowdown System will be aligned to recycle purified water back to the main condenser. However, during outages, the Steam Generator Blowdown System will be used to drain the steam generators and feedwater piping. This effluent will be processed by the Waste Water System.

The chemicals described below are typical for operating plants with recirculating steam generators similar to the Lee Nuclear Station. The identified chemicals represent a responsive treatment strategy that conforms to current industry guidance. The chemical inventory and waste stream concentrations are based on operating experience at a plant with a slightly larger feedwater volume, and thus should be considered conservative. These chemicals will produce chemical constituent concentrations that are negligible in the overall station discharge.

Methoxypropylamine and dimenthylamine are used for pH adjustment. The concentration of the methoxypropylamine in the blowdown stream will be less than 9 ppm and the dimenthylamine will be less than 100 ppb. The pH of the Steam Generator Blowdown System waste stream entering the Waste Water System is not expected to interfere with the station's ability to discharge within a pH range of 6 to 8.5, which is consistent with the SC DHEC water quality standards for pH.

Oxygen scavenging chemicals (hydrazine/carbohydrazide) also are expected to be used in the Steam Generator Blowdown System. The concentration of these chemicals (hydrazine/carbohydrazide) in the Steam Generator Blowdown System stream is expected to be less than 100 ppb. Based on Duke Energy's operating experience in other similar facilities, it may be necessary to oxidize these persistent chemicals, with the use of hypochlorite (sodium or calcium) or hydrogen peroxide.

6.2.5 CONDENSATE POLISHING SYSTEM

The Condensate Polishing System is designed to remove corrosion products and ionic impurities from the Condensate System during station startup, hot standby, power operation with abnormal secondary cycle chemistry, safe shutdown, and cold shutdown operations. The Condensate Polishing System is a secondary cycle condensate cleanup system, which will consist of ion exchanger vessels with spent resin holdup tanks, piping, valves, and instrumentation. During the rinse operation, condensate flow from the

Condensate System will be used to rinse the resin beds. Rinsing will be performed after resin filling (once per operating cycle), and the resulting pressurized drain effluent will be routed to the Turbine Building Sumps. The Condensate Polishing System resin rinse will not be sent to the oil/water separator because the Condensate Polishing System resin rinse does not contain any oil that would require processing. Condensate Polishing System resin rinse will contain resin fines (1.5 to 15 microns), which will settle in the Waste Water Retention Basins before the waste streams are discharged to the station outfall.

6.2.6 SERVICE WATER SYSTEM

The Waste Water Retention Basin is also the alternate discharge path for the Service Water System blowdown and a normal discharge path for its strainers backwash. As discussed above in section 6.1.1, water treatment chemicals used in those systems may include sodium hypochlorite, sodium bromide, sulfuric acid, and silt dispersants. For the reasons discussed in section 6.1.1, these chemicals are unlikely to be discharged at detectable levels.

6.3 LOW LEVEL RADIOACTIVE LIQUID WASTES

The Liquid Radwaste System is designed to control, collect, process, handle, store, monitor and dispose of liquid radioactive waste generated as the result of normal operation, including anticipated operational occurrences (e.g. high primary coolant system leakage, high use of decontamination water, refueling, etc). Discharges from liquid radwaste are intermittent. The Liquid Radwaste System treatment processes are designed to remove mixed fission and activation products in order to meet NRC regulatory requirements. The liquid radioactive wastes include borated reactor-grade wastewater, floor drains and other wastes with potentially high suspended solids content, detergent, and chemical wastes. The borated reactor-grade wastewater consists of the reactor coolant system effluents received through sampling sink drains, equipment leakoffs and drains. Floor drains and other wastes with potentially high suspended solids content are the inputs collected from various building floor drains and sumps.

The Liquid Radwaste System includes tanks, pumps, ion exchangers, and filters that are designed to control, collect, process, handle, store, and dispose of liquid radioactive waste generated in the station. These generally low-level radioactive wastes will be collected, analyzed, and discharged with sufficient supplemental flow (from the cooling tower blowdown) such that at the point of discharge the discharge standards are met for all radiological wastes.

The radioactivity level of the liquid radwaste will be below discharge limits when mixed with the cooling tower blowdown. The station operator will select the dilution flow rates to ensure that the effluent concentration limits of 10 CFR 20, the annual offsite dose limits in 10 CFR 50 Appendix I, and any local requirements are continuously met. If the available dilution is low, the discharge rate can be reduced to maintain acceptable concentrations. Detection of radiation levels exceeding the limit in the discharge stream automatically stops the

discharge flow and operator action is required to re-establish discharge. The Raw Water System, which provides make-up water for the Circulating Water System cooling towers, is used as a backup source for dilution water when cooling tower blowdown is not available for the discharge path from either unit.

The Liquid Radwaste System is designed and will be maintained to meet the requirements of Federal Regulations, 10 CFR 20 and 10 CFR 50, Appendix I. In accordance with the requirements of 10 CFR 20.1406, the Liquid Radwaste System is designed to minimize, to the extent practical, contamination of the facility and the environment, facilitate decommissioning, and minimize, to the extent practical, the generation of radioactive waste. This is accomplished through appropriate selection of design technology for the system, and incorporation of the ability to update the system to use the appropriate technology to meet As Low As Reasonably Achievable (ALARA) requirements throughout the life of the station. The design of the system for the release of liquid effluents complies with the NRC Regulatory Guide 1.112, Revision 1, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Nuclear Power Reactors."

The Liquid Radwaste System will have permanently installed processing capacity of 75 gpm through the ion exchange/filtration train (per unit). The Liquid Radwaste System design can accept equipment malfunctions without affecting the capability of the system to handle both anticipated liquid waste flows and possible surge load due to excessive leakage. There is adequate capacity to meet the anticipated processing requirements of the station.

Based on the current AP1000 Standard Plant design, boron is expected to be present in the Liquid Radwaste System waste discharge (see Volume 1 Part II of the NPDES Operating Permit Application package). The Liquid Radwaste System includes provisions to monitor and dilute the processed wastewater. Before any liquid radioactive waste is discharged, it is designed to be pumped to a monitor tank. A representative sample of the monitor tank contents is analyzed to confirm that radionuclide concentrations and activity levels are within acceptable limits. The results are recorded to keep a record of planned releases of radioactive liquid waste. The liquid waste is discharged from the monitor tank in a batch operation. The discharge flow rate is restricted by station operator as necessary to maintain an acceptable concentration when mixed with circulating water blowdown flow. The discharge line contains radiation monitoring with diverse methods of stopping the discharge. On a high radiation reading, an isolation valve in the discharge line will close, and the monitor tank pumps will automatically trip to prevent further discharge. The valve automatically closes and an alarm is actuated if the activity in the discharge stream reaches the monitor setpoint. These provisions protect against uncontrolled releases of radioactivity.

Detergent waste water will be produced by the station hot sinks and showers, and some cleanup and decontamination processes. The waste water generally has low concentrations of radioactivity. The detergent waste water is collected in the chemical waste tank. When sufficient detergent waste water is produced and treatment is necessary,

the station design incorporates space for mobile processing equipment. This mobile equipment will be brought into one of the Radwaste Building bays on an as-needed basis, and either will treat liquid waste water on-site or remove the waste water for off-site disposal.

Chemical waste water will be produced by the laboratory and other relatively small volume sources. The waste water may be mixed hazardous and radioactive wastes or other radioactive waste water with high dissolved-solids content. Under normal conditions, chemical waste water will be directed to the chemical waste tank. The waste water will be generated at a low rate. This waste water is only collected. Chemicals can be added to the tank for pH or other adjustment. Since the volume is low, the waste water will be treated by the use of mobile equipment or by shipment offsite for disposal.

6.4 STORM WATER TREATMENT OF OIL STORAGE AREAS

As noted above, storm water discharges will be covered under a General Permit for storm water associated with industrial facilities. However, the design of the Lee Nuclear Station includes redundant provisions for treatment, as well as retention and testing storm water flows from the transformer basin and diesel fuel oil storage area for each unit. These provisions provide secondary containment structure around transformer and diesel fuel oil storage tanks for containment of oil leaks, and collection and testing of storm water.

Diesel generators at the two units are air-cooled and have closed loop cooling. These generators do not require water for cooling and will not generate wastewater.

6.5 AUXILIARY COOLING AND STORMWATER DRAINS AND DISCHARGES

The Passive Containment Cooling System (PCS) will normally contain demineralized water with fire protection water as a back-up supply. To control against algae growth the system is planned to be maintained at approximately a 50 ppm hydrogen peroxide concentration. Testing and maintenance activities will require discharge of process water from this system. These activities will occur infrequently. Discharges from these activities will be routed to an approved treatment system.

6.6 SLUDGE DISPOSAL

Duke Energy does not anticipate that the station will generate significant quantities of sludge. All of the sludge generated by the station will be disposed in an off site SC DHEC-permitted landfill. The sludge and/or sediments generating sources in the station are the clarifier, Waste Water Retention Basins, Pond A, Hold-Up Pond A, and the water intake structures. As described in the section 6.2.2, the settled solids collected at the bottom of the clarifier will be dewatered in a filter press before they are transferred to an off site facility. The sludge and/or sediments from the Waste Water Retention Basins, Pond A, Hold-Up Pond A and water intake structures will be dredged, and disposed off site.

6.7 EQUIPMENT SERVICE FAILURE OR SHUTDOWN

6.7.1 WASTE WATER SYSTEM

The Waste Water System is important to the reliability and availability of the secondary plant systems that are located in the nonradioactive section of the Auxiliary Building. Since the Waste Water System provides significant retention basin wastewater storage capacity and contains redundant equipment, any equipment failure associated with the Waste Water System can be repaired within a reasonable time without significant impact on other secondary plant systems or primary plant systems located in the nonradioactive portion of the Auxiliary Building.

The Waste Water Retention Basins are divided into two large equal sized compartments, each having an electrically powered vertical sump pump. Basin effluent can be discharged to either compartment of its primary retention basin or it can be discharged to the retention basin compartments of the alternate generating unit for operational and maintenance flexibility. Treated wastewater is pumped from the retention basins to the common blowdown sump for mixing with circulating cooling tower blowdown prior to being discharged to the Broad River.

Turbine Building sump pumps are air operated, double diaphragm types that are capable of significant suction lifts. These pumps can process slurries with high solids fractions, can run deadheaded, and can run dry without damage. These pumps can operate over a wide range of flow conditions by varying the driving air input.

In the event that a failure of one or more redundant wastewater treatment systems cannot be repaired quickly or transferred for treatment to the alternate unit Waste Water System, then the operator can shut down the discharge of the Waste Water System for an extended period of time without discharging untreated wastewater to the Broad River. Based on past experience of operating similar Waste Water System systems at currently operating nuclear plants, this scenario is not likely or anticipated.

6.7.2 LIQUID RADWASTE SYSTEM

The Liquid Radwaste System design accommodates equipment malfunctions without affecting the capability of the system to handle both anticipated liquid waste flows and possible surge load due to excessive leakage. The system operates in a batch mode, so that repairs can be made during a normally idle period. If there is a problem with a component during a batch operation, much of the system has redundant equipment and the capability to bypass or use an alternate flow path to accomplish processing even with a failure, and many repairs can be made with the Liquid Radwaste System on line if necessary. If completion of the batch operation is not possible due to a failure, redundancy in the system and holdup capacity of the system tanks should permit continued plant operation with the Liquid Radwaste System shutdown until repairs can be made. Ample surge capacity of the system and the low load factor of the processing equipment permits

the system to accommodate waste until failures can be repaired and normal system operation resumed.

7.0 SUMMARY AND CONCLUSIONS

This Preliminary Engineering Report has evaluated current water quality of the Broad River and the wastewater treatment systems that are planned to be installed at the proposed William States Lee III Nuclear Station.

The Broad River is classified by SC DHEC as a freshwater river. The station effluent (treated wastewater and cooling tower blowdown discharges) will be discharged to the Broad River through a diffuser (Outfall 001) located on the upstream face of the Ninety-Nine Islands Dam. This station discharge (18 cfs) will be at a much lower flow than the Broad River's 7Q10 flow (critical low flow) of 464 cfs. It is approximately 4% of the 7Q10 flow.

Suspended sediment concentration in the effluent discharge is expected to be lower than that in the river as a result of passage of the river water through the Ponds A, B, C and/or the waste water retention basins. The ponds and basins will act as sedimentation basins. Studies confirm that more than 50 percent of the sediments will drop out of the water in the Pond A (Reference 8.5). The cooling tower basins and waste water retention basins will add additional capacity to retain suspended sediments from the wastewater and cooling tower blowdown before being discharged back to the river.

The primary source of pollutants is from the background ambient water. The pollutant load is not increased but the concentration may increase as a result of the cooling tower operation. Treatment systems will be installed to sufficiently treat the wastewater such that the discharge will meet the discharge limitations.

Based on the Mixing Zone Request (Volume 1 Part VI NPDES Operating Permit Application Package), the effluent discharge will have minimum impact on the river temperatures at the edge of mixing zone. Based on the small mixing zone requested, the temperature increase at the boundary of the mixing zone is not significant.

8.0 REFERENCES

8.1 Duke Energy W.S. Lee III Unit 1 & 2 COLA, Environmental Report, Revision 1, March 30, 2009.

8.2 Duke Energy W.S. Lee III Unit 1 & 2 COLA, Final Safety Analysis Report, Revision 3, December 17, 2010

8.3 Westinghouse RFI Response, Shaw Nuclear RFI Number (RFI-SSWN-LEE-000037) "AP1000 Discharge to Plant Outfall", November 11, 2008

8.4 Westinghouse AP1000 Standard Plant Design Control Document, Rev. 19: APP-GW-GL-700

8.5 Sediment Transport Modeling, William States Lee III Nuclear Station, Pond A, Prepared by Geosyntec Consultants, June 7, 2011

8.6 Hydrology Report for Proposed Lee Nuclear Station, prepared by HDR/DTA, July 2011

8.7 AP1000 Standard Plant Waste Water System Specification Document, APP-WWS-M3-001, Rev. 0, November 30, 2009

8.8 AP1000 Standard Plant Demineralized Water Treatment System Specification Document, APP-DTS-M3-001, Rev. 0, November 16, 2009,

8.9 South Carolina Regulation 61-68 Water Classification and Standards, Effective April 25, 2008. Bureau of Water, South Carolina Department of Health and Environmental Control; Columbia, SC, April 25, 2008.

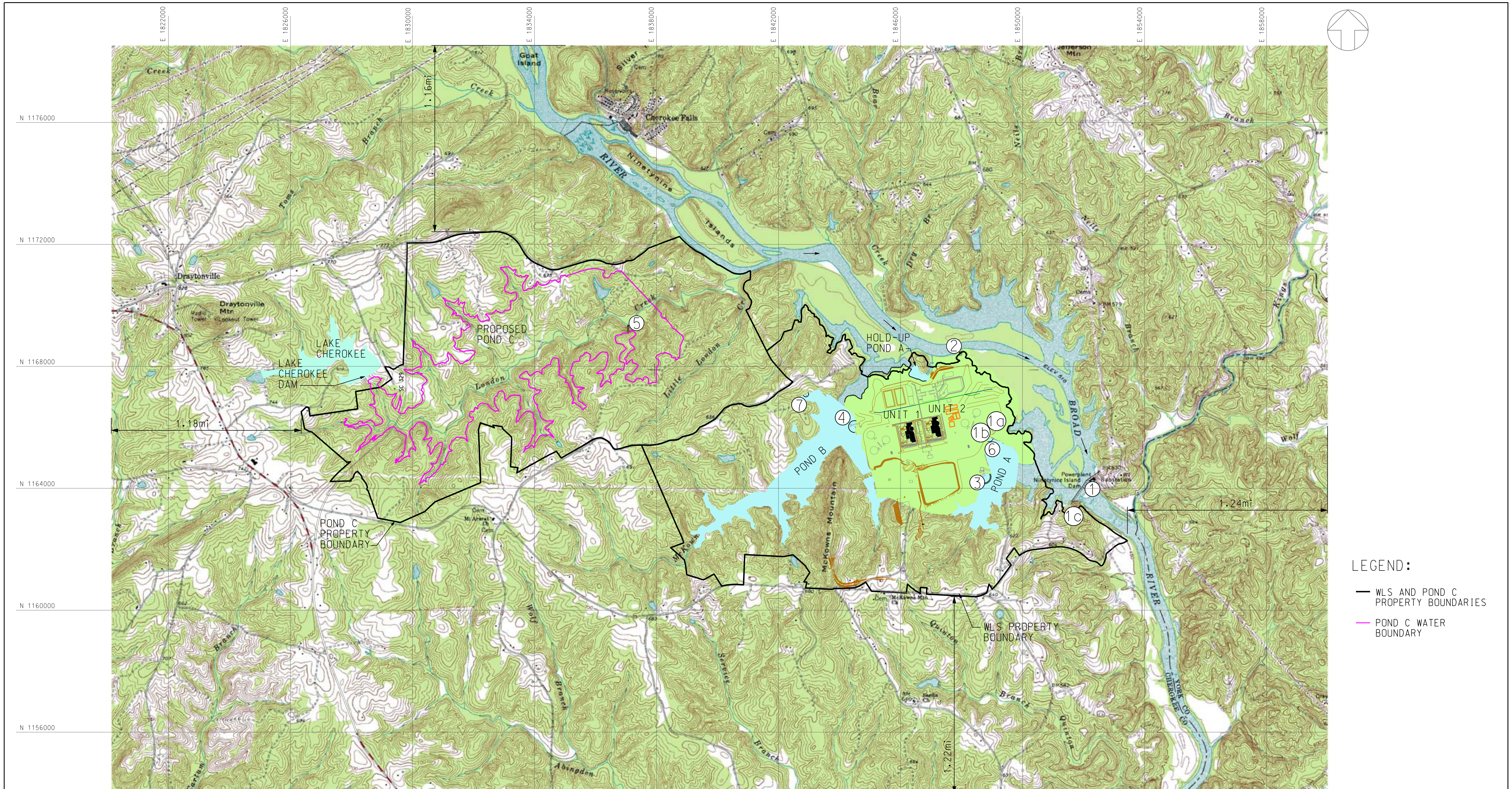
8.10 Mixing Zone Request, William States Lee III Nuclear Station NPDES Permit Cherokee County, South Carolina prepared by Geosyntec Consultants, August 10, 2011

Table 1: Locations of Intake, Refill, and Discharge Structures

	Location	Latitude	Longitude
1	Waste Water System Discharge Structure (Outfall)	35° 01’ 54”	-81° 29’ 39”
1a/1b	Cooling Tower Blowdown and Waste Water Discharge (Internal)	35° 02’ 10”	-81° 30’ 15”
1c	Liquid Radwaste Discharge (Internal)	35° 01’ 47”	-81° 29’ 46”
2	River Water Intake Structure	35° 02’ 37”	-81° 30’ 28”
3	Pond A Intake Structure	35° 01’ 57”	-81° 30’ 19”
4	Pond B Intake and Refill Structure	35° 02’ 13”	-81° 31’ 11”
5	Pond C Intake and Refill Structure	35° 02’ 45”	-81° 32’ 39”
6	Pond A Refill Structure	35° 02’ 09”	-81° 30’ 16”
7	Pond B Refill Structure	35° 02’ 23”	-81° 31’ 29”

The datum used is South Carolina State Plan Coordinate System NAD 83, zone 3900

Figure 1: Location Map



LOCATIONS OF PROPOSED INTAKE/DISCHARGE STRUCTURES:

1. WWS DISCHARGE STRUCTURE
   - 1a INTERNAL CWS BLOWDOWN
   - 1b INTERNAL WWS DISCHARGE
   - 1c INTERNAL RADWASTE DISCHARGE
2. RIVER WATER INTAKE STRUCTURE
3. POND A INTAKE STRUCTURE
4. POND B INTAKE AND REFILL STRUCTURE
5. POND C INTAKE AND REFILL STRUCTURE
6. POND A REFILL STRUCTURE
7. POND B REFILL STRUCTURE

COORDINATES IN SOUTH CAROLINA STATE PLANE COORDINATE SYSTEM (ZONE 3900) LAMBERT CONFORMAL CONIC EXPRESSED IN INTERNATIONAL FEET

0 .25 .50 .75 1.0
SCALE: 1 MILE

FIGURE 1
LOCATION PLAN

REFERENCES:
USGS TOPO MAPS OF BLACKSBURG_SOUTH_035081A5_GEO AND OF KINGS_CREEK_3665674_GEO.

Figure 2: Broad River Flows (1926-2010)
Gaffney, SC

Source: Reference 8.6

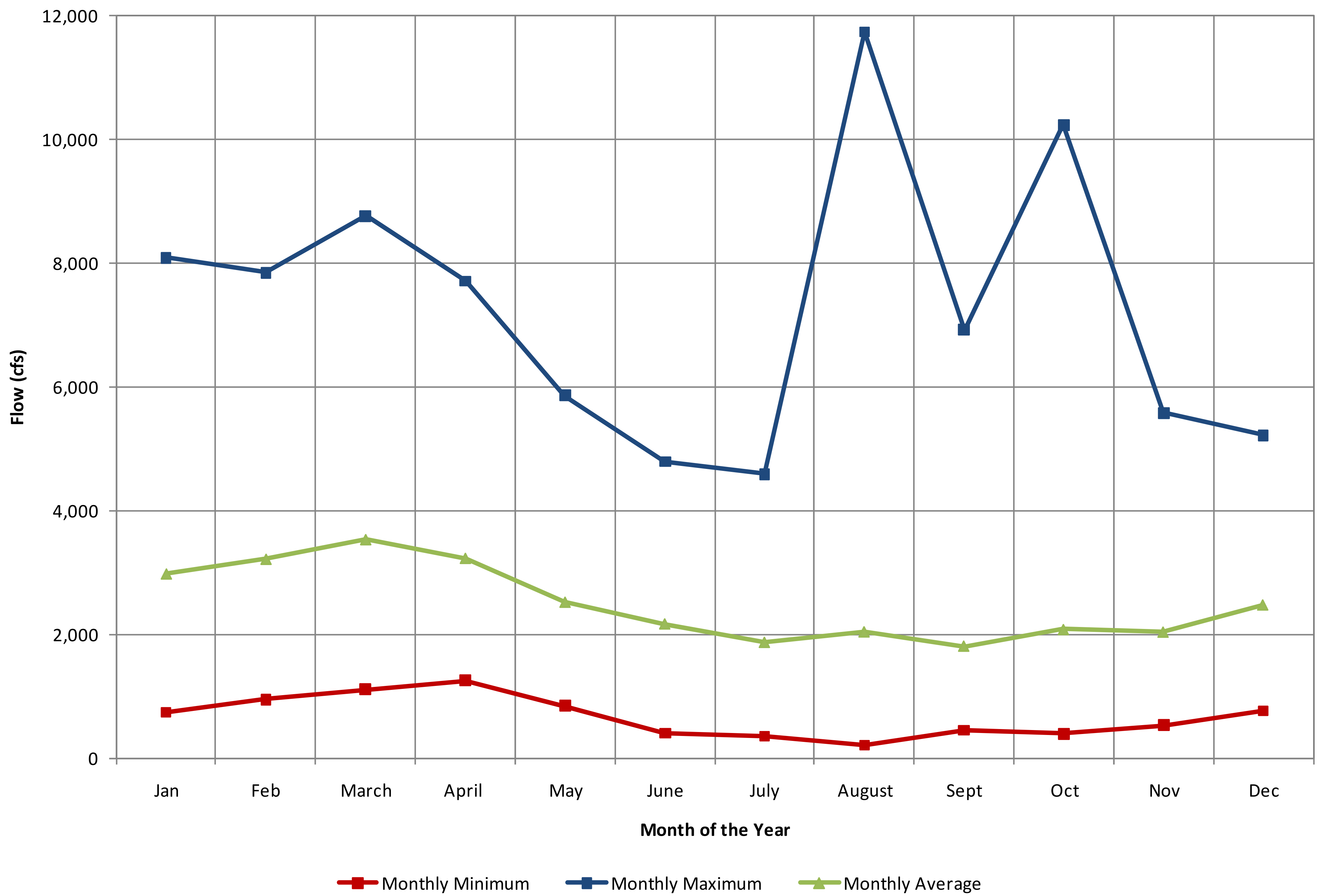


**Figure 3: Broad River Mean Annual Daily Flow (1926-2010)
at Gaffney (USGS 2153500)**

Reference: 8.6

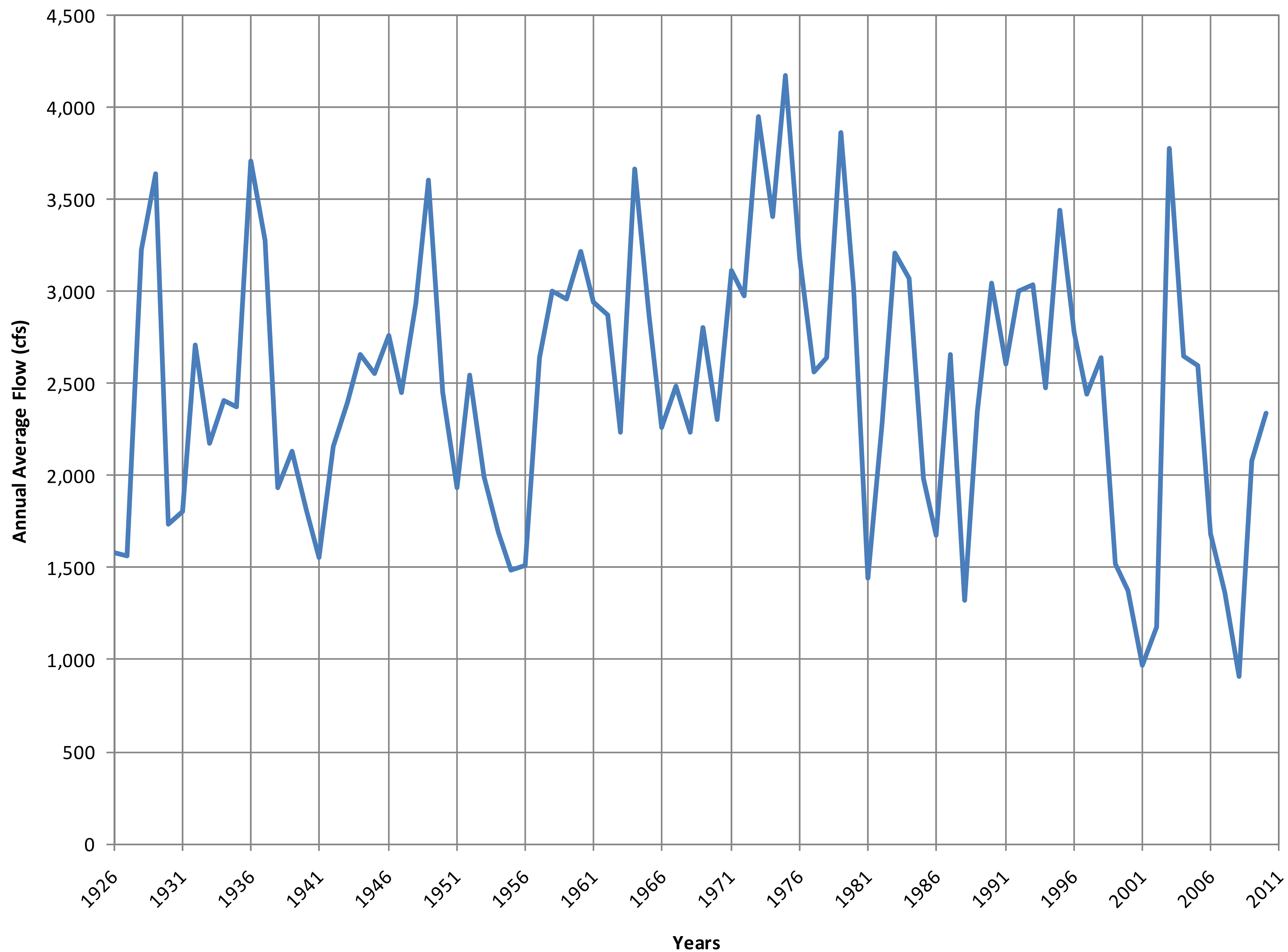
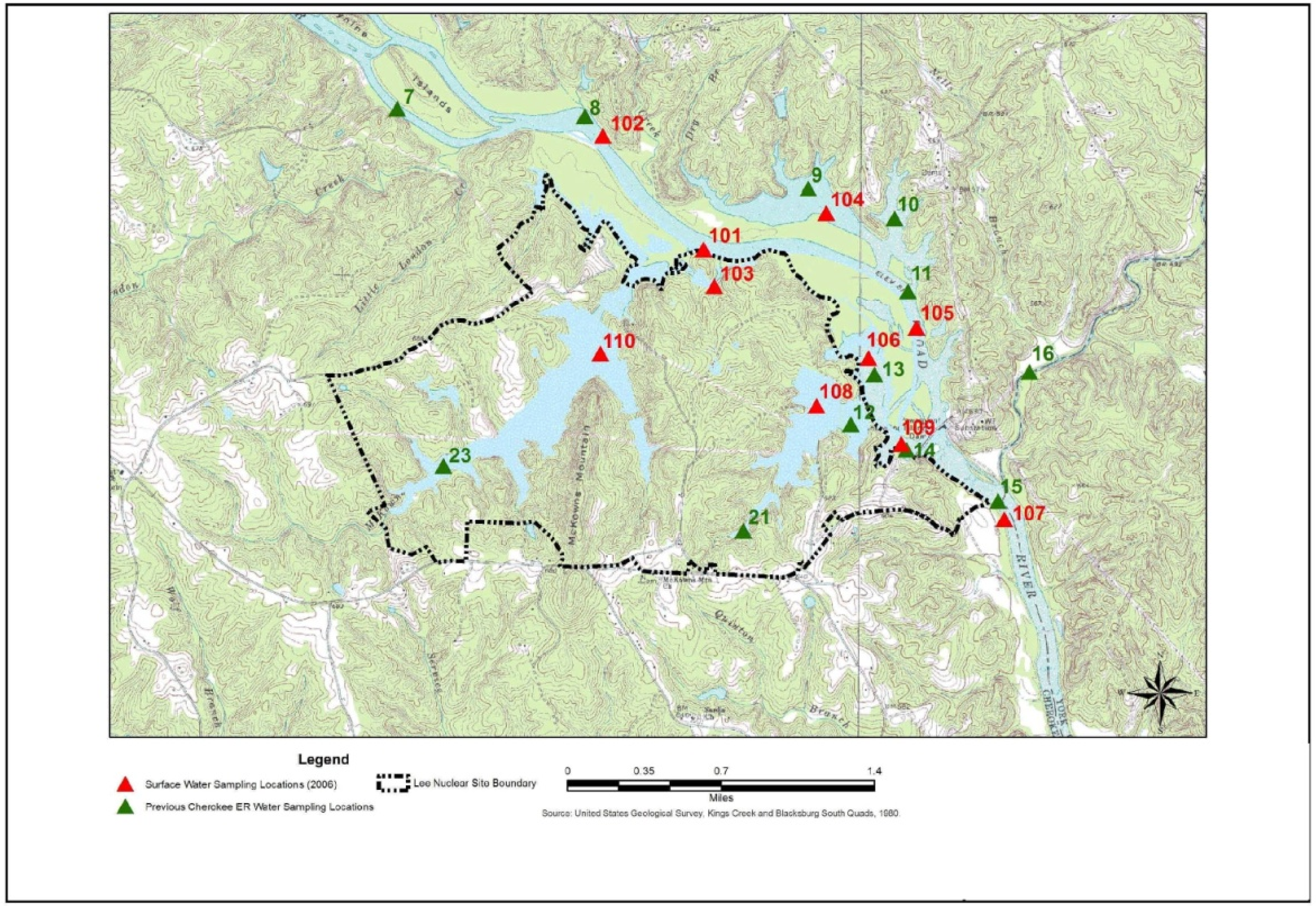
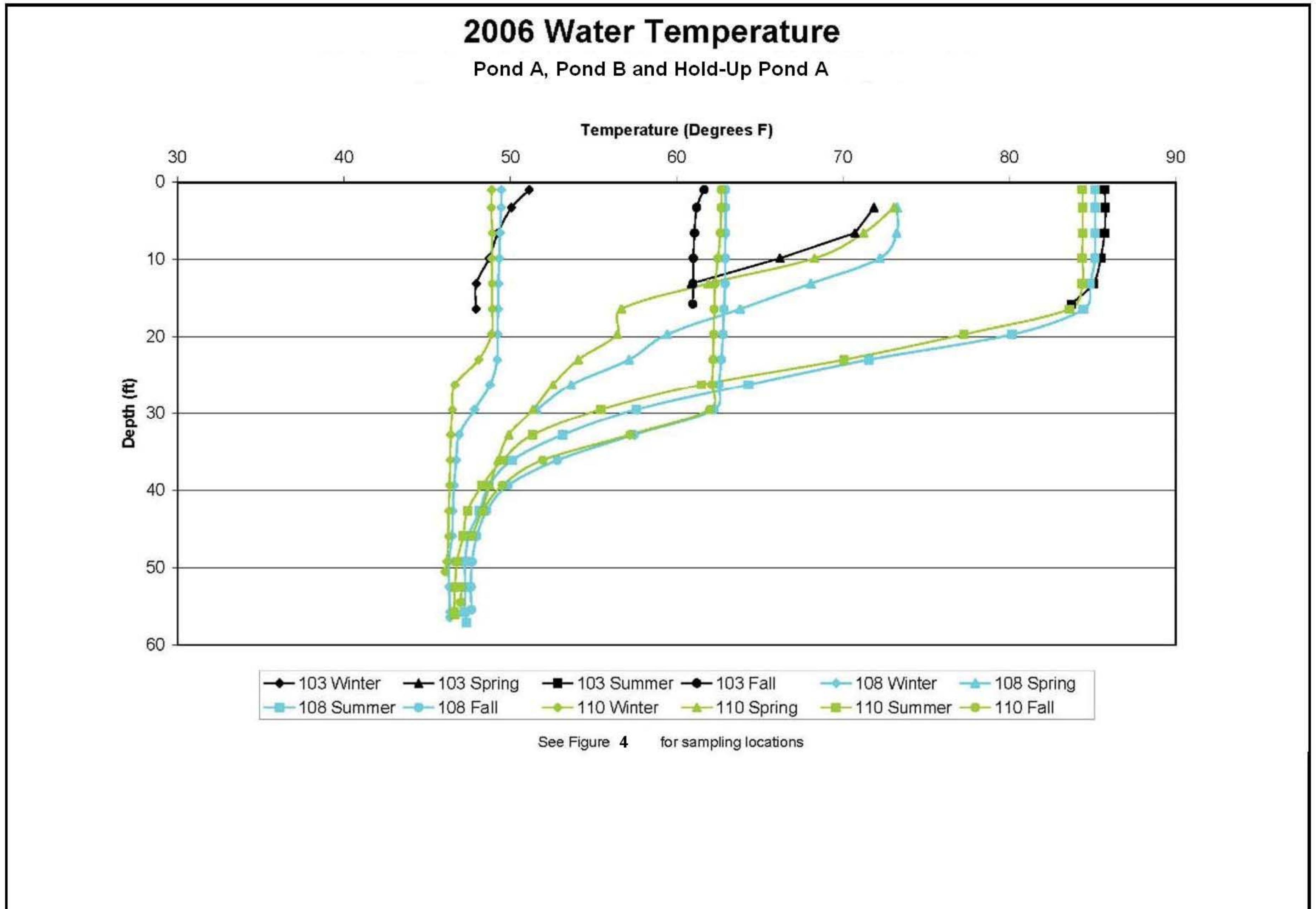


Figure 4: Broad River Water Sampling Locations



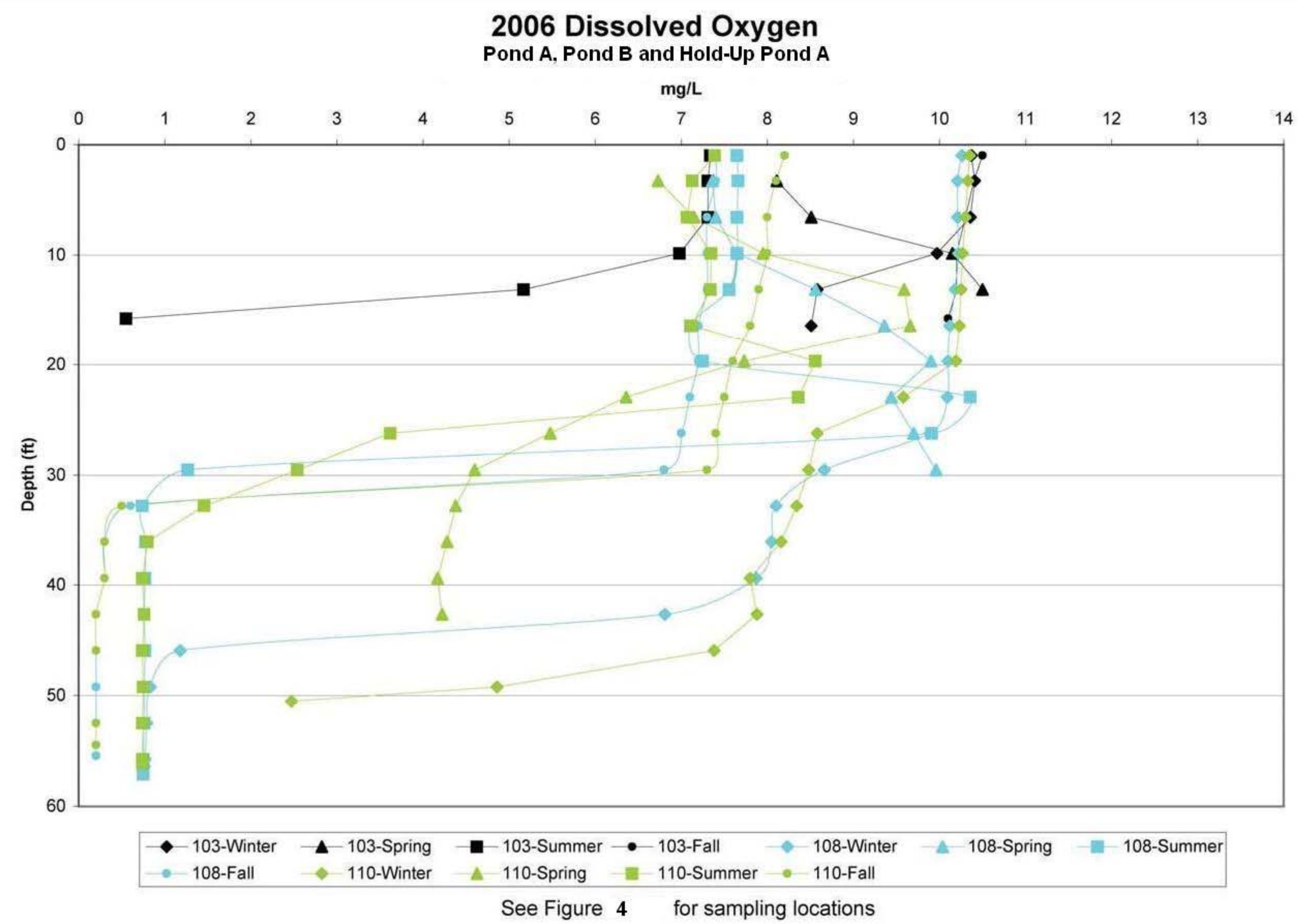
Reference: 8.1 (Fig. 2.3-21)

Figure 5 (Sheet 1 of 2): Graphical Analysis of Surface Water Quality



Reference: 8.1 (Fig. 2.3-22 Sheet 3)

Figure 5 (Sheet 2 of 2): Graphical Analysis of Surface Water Quality



Reference: 8.1 (Fig. 2.3-22 Sheet 8)

Figure 6: RWS, WWS and WLS Pipe Layout

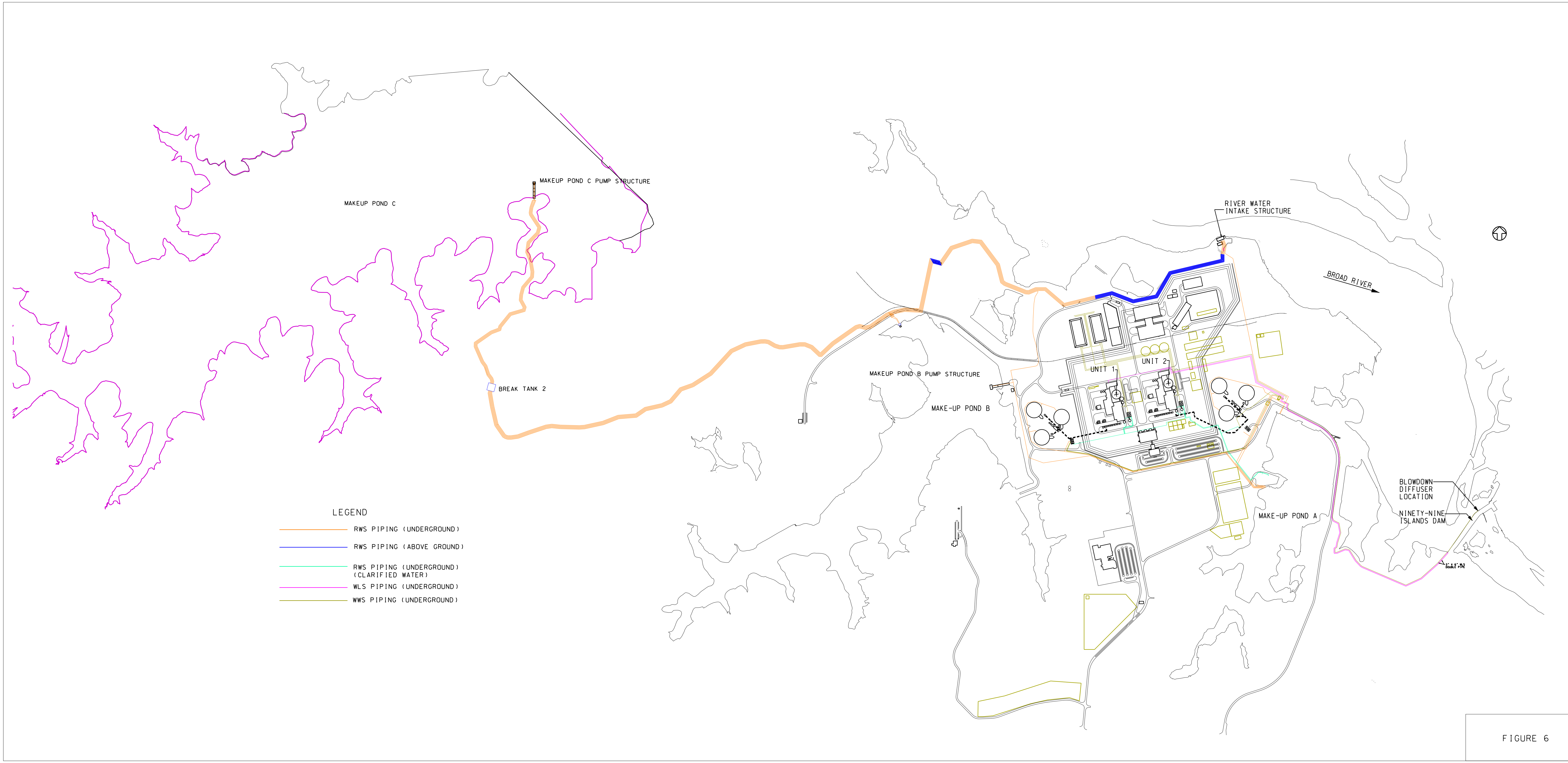
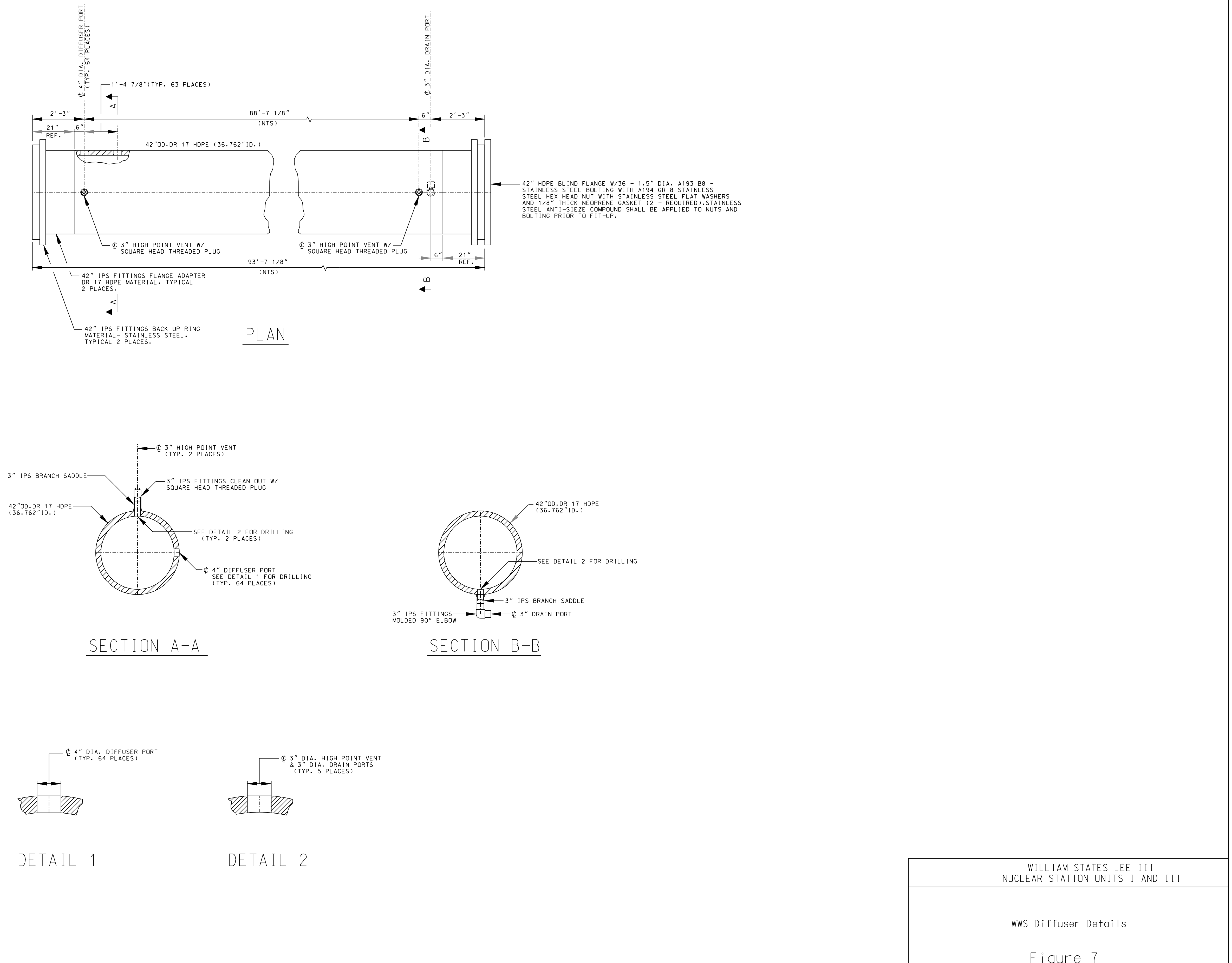
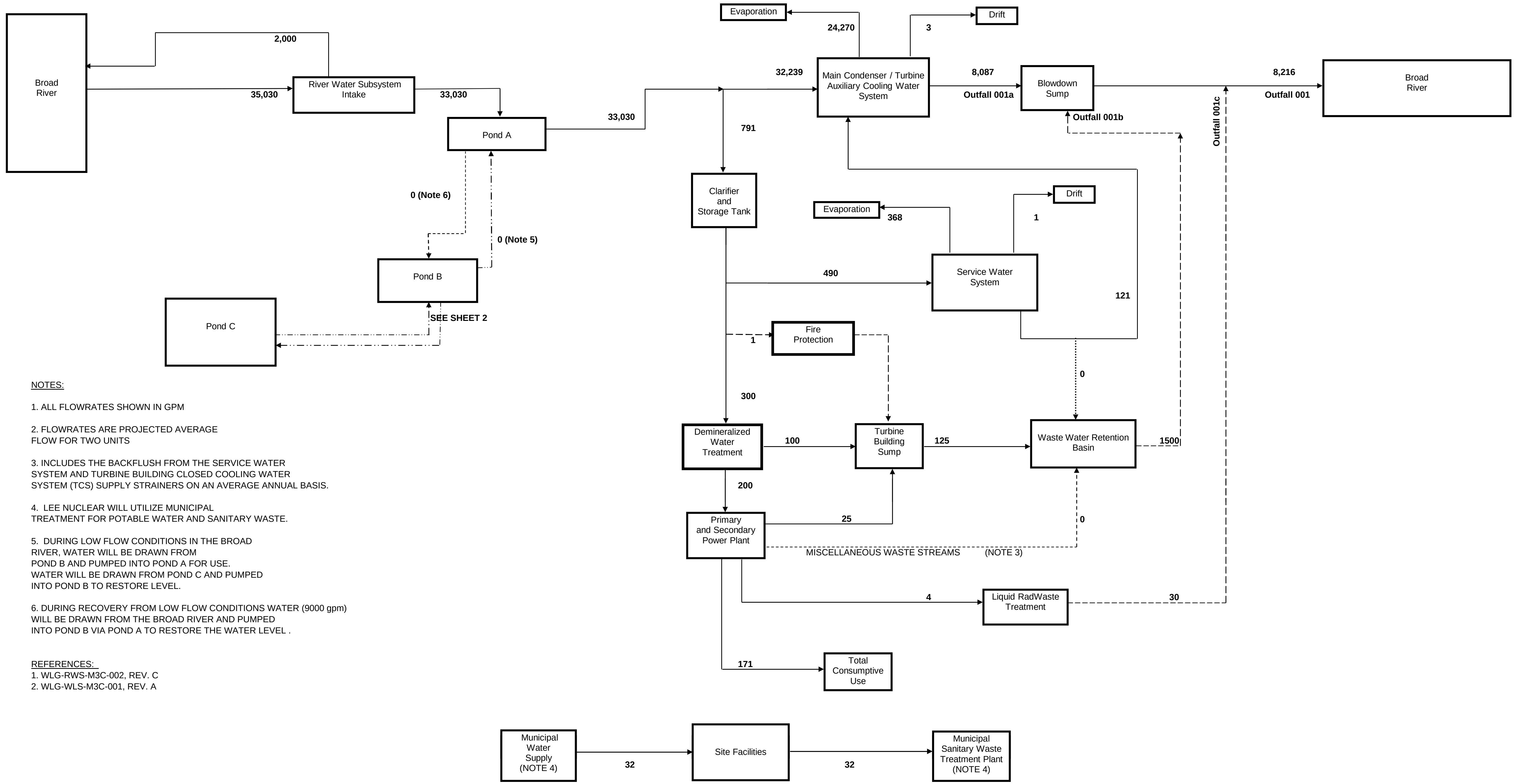


Figure 7: WWS Discharge Diffuser Details



ATTACHMENT 1:

NPDES FLOW SCHEMATIC



NOTES:

1. ALL FLOWRATES SHOWN IN GPM

2. FLOWRATES ARE PROJECTED AVERAGE FLOW FOR TWO UNITS

3. INCLUDES THE BACKFLUSH FROM THE SERVICE WATER SYSTEM AND TURBINE BUILDING CLOSED COOLING WATER SYSTEM (TCS) SUPPLY STRAINERS ON AN AVERAGE ANNUAL BASIS.

4. LEE NUCLEAR WILL UTILIZE MUNICIPAL TREATMENT FOR POTABLE WATER AND SANITARY WASTE.

5. DURING LOW FLOW CONDITIONS IN THE BROAD RIVER, WATER WILL BE DRAWN FROM POND B AND PUMPED INTO POND A FOR USE. WATER WILL BE DRAWN FROM POND C AND PUMPED INTO POND B TO RESTORE LEVEL.

6. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER (9000 gpm) WILL BE DRAWN FROM THE BROAD RIVER AND PUMPED INTO POND B VIA POND A TO RESTORE THE WATER LEVEL .

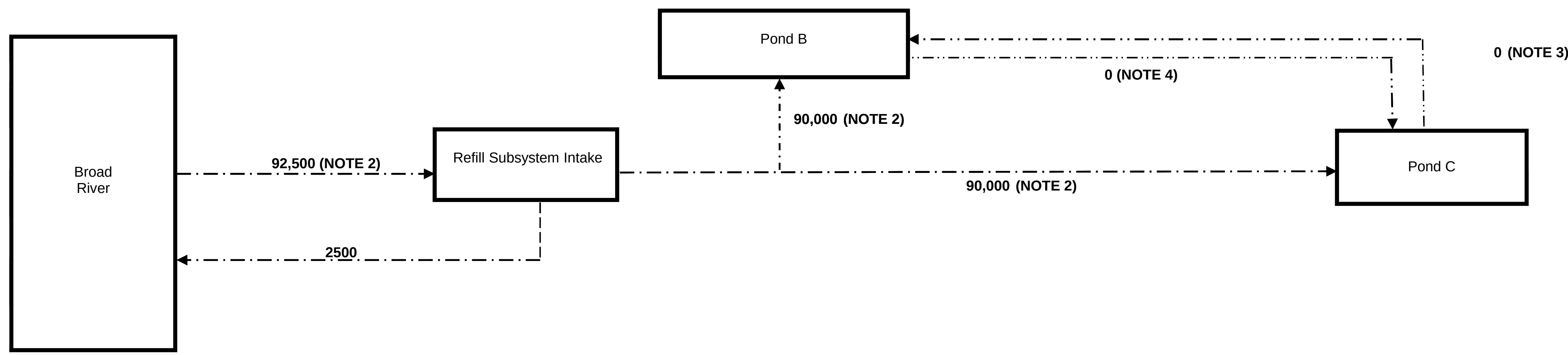
REFERENCES:
1. WLG-RWS-M3C-002, REV. C
2. WLG-WLS-M3C-001, REV. A

LEGEND

Normal Flow
Flow Dependent on System Alignment
Broad River Low Flow Condition
Broad River High Flow Condition
Alternate Flow
Intermittent Flow

WILLIAM STATES LEE III NUCLEAR STATION UNITS 1 & 2

NPDES Flow Schematic
Sheet 1 of 2



NOTES:

1. All FLOW RATES SHOWN IN GPM.

2. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER MAY BE DRAWN FROM THE BROAD RIVER AND PUMPED INTO POND B AND /OR C TO RESTORE WATER LEVEL.

3. DURING LOW FLOW CONDITIONS WATER (30,000 gpm) WILL BE DRAWN FROM POND C AND PUMPED INTO POND B TO RESTORE LEVEL.

4. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER (6,000 gpm) MAY BE DRAWN FROM POND B AND PUMPED INTO POND C TO RESTORE WATER LEVEL.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

NPDES Flow Schematic
Sheet 2 of 2

APPENDIX A:

ANTIDEGRADATION/ALTERNATIVES ANALYSIS

ANTIDEGRADATION/ALTERNATIVES ANALYSIS

Pursuant to S.C. Regulation 61-68 (D), an applicant must undertake an antidegradation analysis for a new discharge. To assist with the analysis, SC DHEC issued a July 1998 guidance document titled, Antidegradation Implementation for Water Quality Protection in South Carolina and a NPDES Application Supplement entitled Antidegradation Alternatives Analysis for New or Expanded NPDES Discharges.

A. No Degradation Occurs.

Based on the Mixing Zone Request (Volume 1 Part VI of the NPDES Permit Application), assuming the proposed mixing zone is accepted by the SC DHEC, the outfall pollutants will meet effluent limitations and will not lower water quality by a measurable effect.

The Mixing Zone Request (Reference 8.10) in Part VI concluded that based on the small proportion of the discharge flow to the receiving water body 7Q10 flow (i.e. <4 percent) and the rapid mixing of the discharge provided by the multi-port discharge diffuser there will be no lowering of water quality. Accordingly, Duke Energy does not believe that an alternatives analysis pursuant to S.C. Regulations 61-67.200.D(k)(1) or 61-68(D)(2)(a) is needed for this project.

B. Alternatives Analysis.

In the event SC DHEC believes that an alternatives analysis pursuant to the S.C. Regulations 61-67.200.D(k)(1) or 61-68(D)(2)(a) is required, such analysis is provided below:

(1) Water Recycle or Reuse

The AP1000 design has many features which reduce the use of water and recycle water where possible when the recycling does not create any potential to adversely influence plant reliability or safety. For example, through the use of closed cycle cooling systems, the overall river water withdrawal is reduced by 90 to 95 percent.

As discussed in the Environmental Report of the Lee Nuclear Station Combined License Application (Ref. 8.1, Subsection 5.3.2.2), a driving benefit behind closed-cycle cooling systems is that water is recycled through the plant leading to a 90 to 95% decrease in overall river water withdrawal when compared to a once-through cooling system design. For example, the Circulating Water System is recycling close to 560,050 gpm of water through the system per unit. This reduces the overall maximum water withdrawal from the Broad River to 43,960 gpm (a 96% reduction in water use). A once-through cooling system design would require more than 1,120,100 gpm (total for both units) of water from the Broad River.

The Lee Nuclear Station will utilize three cooling towers per unit. The cooling towers serve to dissipate waste heat from the Circulating Water System primarily by evaporative cooling. The makeup water required replaces the water lost to evaporation, drift, and the

blowdown. The waste heat released to the atmosphere also serves to reduce thermal impacts to the Broad River.

The Service Water System provides cooling water to component cooling (shutdown, spent fuel pool, chemical and volume control system pumps). The Service Water System has a two-cell cooling tower per unit. The Service Water System is an internal cooling system that recycles water rather than using once through cooling. Service Water System cooling tower blowdown is recycled as makeup to the Circulating Water System cooling tower basin.

The Steam Generator Blowdown System controls and maintains the steam generator secondary cycle water chemistry during normal plant operation by removing non-volatile, dissolved impurities and suspended solids. This is accomplished by blowdown of a small fraction of the secondary water from the steam generator. During normal power operation the blowdown is cooled, depressurized, purified, monitored for radioactivity and recovered for reuse within the secondary cycle thereby reducing the required makeup to the system. During normal power operation, the Blowdown System flow ranges between a minimum of 9 gpm and a maximum of 95 gpm per steam generator, there are two steam generators per unit. Normally the Blowdown System is aligned to recycle purified water back to the hot well or main condenser. Depending on the level of impurities the blowdown may also be routed to the Waste Water System or the Liquid Radwaste System.

Raw water from the Broad River is also processed through the clarifier and used in plant water systems. Raw water entering the clarifier is treated with a coagulant and polymer to initiate the formation of settleable solids. After settling, these solids (sludge) are removed from the clarifier. The sludge is then concentrated and dewatered in sludge removal equipment. Liquids from the dewatering process are recycled back to the clarifier inlet such that there is normally no wastewater generated from the clarification process.

The Demineralized Water Treatment System design recycles or reuses waste streams as much as possible and practical. When the Reverse Osmosis units are operating in the double pass mode (the two Reverse Osmosis units operate in a series configuration), the waste stream (brine) from the second Reverse Osmosis unit is recirculated back to upstream of the first Reverse Osmosis unit and the treated water (permeate) is discharged to the downstream electrodeionization treatment. The brine stream from electrodeionization treatment is recirculated through the electrodeionization treatment stacks and electrode compartments. In order to control mineral concentrations and prevent scaling of the membrane stack, a portion of the brine stream (i.e. brine blowdown) is continuously bled off. The brine stream blowdown is normally 5 percent of the total incoming Reverse Osmosis permeate flow and is discharged to waste.

The design of the AP1000 plant allows recycling of most of the major water streams in the various systems wherever it will not compromise safety or plant reliability. Therefore, no additional water saving or reuse strategies are considered technically or economically feasible.

(2) Use of Other Discharge Locations

Duke Energy considered alternative discharge locations in the conceptual design of the project. The discharge must be located downstream of the intake such that the blowdown does not re-circulate back into the intake as this would concentrate constituents, like salts, in the cooling systems. Duke Energy considered an outfall location on the downstream side of the Ninety Nine Islands Dam. Thermal modeling results indicated this configuration would have resulted in an extended plume along one side of the Broad River.

Duke Energy considered a diffuser discharge location on the downstream side of the Ninety-Nine Islands Dam. This could not be accomplished without blasting a trench in the Broad River bedrock and extensive disturbance of the upper reach of the Broad River that has been classified as a South Carolina scenic river.

The present location of the discharge was selected as it afforded the highest potential for rapid and complete mixing of the discharge with the river flows in the hydroelectric generating turbines. The location near the hydroelectric facility helps ensure that the mixing zone is as small as possible and is aided by the high flow rates near the intake of the dam and into the hydroelectric turbines.

Other possible discharge locations within the Ninety-Nine Islands Reservoir would be into other smaller stream channels and backwater areas. These locations have very limited natural flow and discharge to these locations may lead to alterations to the spawning and nursery habitat in terms of temperature and water chemistry preference and abundance of fish and other mobile vertebrates in these regions of the reservoir.

(3) Connection to Other Wastewater Treatment Facilities

The Lee Nuclear Station does not contain any sanitary water treatment facilities. All sanitary water treatment will be provided by the Gaffney Board of Public Works Waste Water Treatment Plant.

There are no other wastewater facilities available in the nearby area that can handle the 18 cfs volume of blowdown wastewater generated by the Lee Nuclear Station. The two wastewater facilities in the county, the Clary Plant and the Broad River Plant have a combined capacity of less than 14 cfs (Reference 8.1, Table 2.5-19). Except for the use of the Gaffney Board of Public Works Waste Water Treatment Plant, no tie-ins to other wastewater facilities are proposed. Additionally, using another facility would require licensing said facility to discharge diluted low level radioactive waste. Therefore no connections to other wastewater facilities are considered technically or economically feasible.

(4) Land Application

Land application of the Lee Nuclear Station discharge is not a practicable alternative because of the high total flows associated with the plant discharge. The normal and

maximum blowdown flows are 8,087 gpm and 28,023 gpm respectively (Reference 8.1, Figure 3.3-1). These flow rates would require a massive infiltration area to disperse to groundwater.

(5) Product or Raw Material Substitution

The selection of chemicals and treatment systems in the AP1000 has been optimized based on the past 30 years experience of the electric utility industry in operating nuclear power plants. Duke Energy further optimized the selection of chemicals and treatment systems in "balance of plant" operations based on experience in operating its fleet of nuclear and fossil-fueled power plants.

Because most of the Lee Nuclear Station discharge water has its source from the Broad River intake, the characteristics of the waste discharge are primarily attributable to the concentrations of the chemical constituents found in the Broad River. Much of the naturally occurring chemicals in the Broad River will be concentrated as much as four fold as a consequence of the operation of the evaporative cooling towers. The use of product or raw material substitution is therefore not considered to be technically or economically feasible.

(6) Other Treatment Options or Alternatives

The normal operation mode (4 cycles of concentration) selected for the cooling towers supports operation of the Circulating Water System by minimizing dissolved and suspended solids. Based on Duke Energy's experience at other facilities, operation at 4 cycles of concentration is anticipated to be possible without use of scale and corrosion inhibitors. This serves to reduce residual chemicals discharged into the environment.

The discharge of blowdown from the cooling towers will be stopped during the application of the biocide. This allows for the dissipation of the residual chlorine without subsequent treatment to remove the residual chlorine. Sodium hypochlorite is an effective biocide and alleviates some of the safety concerns associated with storing and using gaseous chlorine. Alternative biocides such as hydrogen peroxide and ozone were considered but rejected because of personnel safety and cost associated with these alternatives.

The selection of materials in the construction of the Lee Nuclear Station eliminates the generation of metal cleaning waste and the need to consider alternative treatments for this waste.

Duke Energy considered alternative cooling water treatments including the use of once-through discharge, cooling ponds, dry cooling towers and hybrid cooling towers. These alternatives are discussed in the Lee Nuclear Station Combined License Application (submitted and being reviewed by US NRC) and Request for Information No. 128 Response (Appendix G, Part VII, Volume 2, of the NPDES Permit Application). None of the alternatives were considered technically feasible or superior to the selected wet cooling tower alternative.

The water treatment chemicals are designed to be consumed by the system, with residual concentrations remaining in the effluent at trace to non-detectable levels. Once the discharge is mixed back into the Broad River, the constituents will be diluted by the volume of water present in the river at the time of discharge.

Radioactive wastewater meeting the NRC release limits is discharged to the Circulating Water System blowdown through a radiation detector that stops the discharge if a significant level of radiation is detected. During normal operations the liquid effluent treatment systems process and control the release of liquid radioactive effluents to the environment such that the doses to individuals offsite are maintained within the limits of 10 CFR Part 20 and 10 CFR Part 50, Appendix I for pertinent thresholds.

The wastewater system collects non-radioactive wastewater from plant equipment, building floor drains, process fluids, and system flushing wastes. These waste streams are collected in the waste water retention basins for processing and subsequent discharge to the environment. Plant discharges containing concentrations of these chemicals are treated in the wastewater system. Materials used in the wastewater treatment system are compatible with the cooling water chemistry and the chemicals used to control long-term corrosion and organic fouling. Dilutions of these chemicals in the waste water retention basins are expected to reduce concentrations to levels that are environmentally acceptable.

Currently the use of other treatment options or alternatives is therefore not considered to be technically or economically feasible.

C. The Positive Social and Economic Impacts of the Project

The construction and operation of the new nuclear station will have positive impacts to the local and regional economy. South Carolina and particularly the counties surrounding the Lee Nuclear Site will experience an increase in the amount of sales and use taxes collected.

During the construction period, the in-migration of construction workers is likely to create new indirect service jobs in the area. For every construction worker, an estimated additional 0.455 indirect job is created in the Cherokee and York counties, which means that a peak construction workforce of 4512 results in the addition of approximately 1400 indirect jobs in the region (based on 70 percent of the construction workforce in-migrating to the region). Because most indirect jobs are service-related and not highly specialized, it is assumed that most, if not all, indirect jobs are filled by the existing workforce within the 50-mi. region. When comparing the influx of construction workers with the relatively small population of the vicinity, the increase in expenditures and benefits is significant. When comparing the influx of construction workers with the larger population of the region, the increase in expenditures and benefits is proportionally smaller. Expenditures and benefits include the creation of jobs, employee purchasing, and increased tax revenues. Thus the impacts from plant construction employees are considered a moderate to large beneficial impact in the vicinity and a small beneficial impact in the region. (Reference 8.1, Section 4.4.2.2)

During the time period when operational workers are moving into the vicinity and region, the site construction will be concluding. Because construction workers (even those who commute) partake to some degree in vicinity goods and services, certain services will experience loss of economic growth. The influx of operational workers during this period will offset losses from sales, personal income, and tax revenue. Also, an influx of temporary workers to support refueling outages will help alleviate economic loss. Because the overall population in the region and counties is so much larger than the numbers of construction workers leaving, they should not experience the same level of impact. Additional jobs in the region result from the multiplier effect attributable to the new operations workforce. In the multiplier effect, each dollar spent on goods and services by an operational worker becomes income to the recipient who saves some but re-spends the remainder. The recipients' re-spending becomes income to others, who in turn save part and re-spend the remainder. The number of times the final increase in consumption exceeds the initial dollar spent is called the "multiplier." The U.S. Department of Commerce Bureau of Economic Analysis, Economics and Statistics Division provide multipliers for industry jobs and earnings. The economic model, regional input-output modeling system (RIMS II), incorporates buying and selling linkages among regional industries and was used to estimate the impact of new nuclear plant-related expenditure of money in the region of interest. The wages and salaries of the operating workforce have a multiplier effect that could result in an increase in business activity, particularly in the retail and service industries. (Ref. 8.1, Section 5.8.2.2)

For every operations job at the new units, an estimated additional 0.95 jobs is created in the 50-mi. region, which means that 843 direct jobs (957 operation workers minus 114 operation workers present during peak construction) result in an additional 288 indirect jobs (based on 36 percent or 303 of the remaining operational workers of the workforce in-migrating to the region), for a total of approximately 591 new jobs in the region. Because most indirect jobs are service-related and not highly specialized, it is assumed that most, if not all, indirect jobs are filled by the existing workforce within the 50-mi. region. (Ref. 8.1, Section 5.8.2.2)

In the year 2004, there were 2253 people unemployed in Cherokee County and 6735 people unemployed in York County (Ref. 8.1, Section 4.4.2.2). Some or all of the indirect jobs created by the construction and operations workforce could be filled by unemployed workers in these counties. The money spent in the local area by these new workers, their families, and the newly employed persons in the counties also add to the economy of the area.

The impact from plant operation employees in the vicinity is considered a large beneficial impact due to their influence on the local economy. By comparison, because the number of operational workers is small compared to the large regional population, the impact to the regional economy is small and also beneficial.

Several tax revenue categories are affected by the construction and operation of new nuclear units. These include income taxes on wages, salaries, and corporate profits; sales and use taxes on construction- and operations-related purchases and on the purchases made by project-related workers; property taxes related to the operation of new nuclear units; and personal property taxes associated with workers. The increase in

collected taxes is viewed as a benefit to the state and local jurisdictions in the region. It is anticipated that the impacts of construction on the economy of the region would be beneficial and small. Conversely, the impact for host Cherokee County is anticipated to be large and beneficial. Cherokee County is the tax district that is expected to most directly benefit from the construction and operation of Lee Nuclear Station. The anticipated payment in-lieu of tax is greater than 11 million dollars and the anticipated increase in additional property taxes is greater than 21% of the current revenue. (Ref. 8.1, Section 5.8.2.2.1)

Based on existing economic benefits realized from operating nuclear facilities in the region Duke Energy expects an increase of 140 million dollars in economic output and approximately 1000 jobs including direct, indirect, and induced employment. (Nuclear Energy Institute Economic Benefits of the Duke Power-Operated Nuclear Power Plants, Executive Summary, pages 3 and 4.)

Part IV

Location Supplement

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SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL
BUREAU OF WATER

LOCATION SUPPLEMENT FOR ND AND NPDES PERMIT APPLICATIONS

FACILITY: William States Lee III Nuclear Station DATE: 7/28/2011

ITEM 1: Please give a short description of the plant location, if the address is not a specific location. Example: Plant is located at the interchange of Interstate 26 and U.S. Highway #1.

William States Lee III Nuclear Station's address is 1313 McKowns Mountain Road, Gaffney, SC 29349. The station will be located in the eastern portion of Cherokee County. The site is 8.2 miles southeast of Gaffney. The nearest intersection is Highway 329 and McKowns Mountain Road.

ITEM 2: Please give a description of the location of the discharge point into the receiving stream using some landmark as a reference point, i.e., bridge, stream, road junction, the plant itself, etc. Give the direction and the distance in feet from the reference point. Example: Discharge #001 is into Johnny Creek approximately 300 feet directly behind the plant. Discharge #002 is into Doris Creek 150 feet

Treated wastewater will be discharged through a discharge diffuser into the Broad River. The station discharge diffuser will be attached to the upstream face of the Ninety-Nine Islands Dam, running along the dam and ending just before intake structure of the Ninety-Nine Islands Hydroelectric station. The location coordinates for the proposed diffuser are:
Latitude: 35 degrees, 01 minute, 54 seconds
Longitude: -81 degrees, 29 minutes, 39 seconds

ITEM 3: Please locate the discharge on a U.S. Geological Survey 7 1/2 minute quad sheet (or a 15 minute quad if a 7 1/2 quad is not available for the area). The entire quad sheet need not be submitted. An 8 1/2 by 11 inch photocopy of the applicable portion of the map is sufficient. The quad sheet name must be provided on the copy submitted to the Department. USGS Maps are available at the SC Dept. Of Natural Resources/Map Division, 2221 Devine Street, Suite 222, Columbia, SC 29205. Phone number is 734-9108.

RETURN TO: SCDHEC
Bureau of Water
NPDES Administration
2600 Bull Street
Columbia, SC 29201

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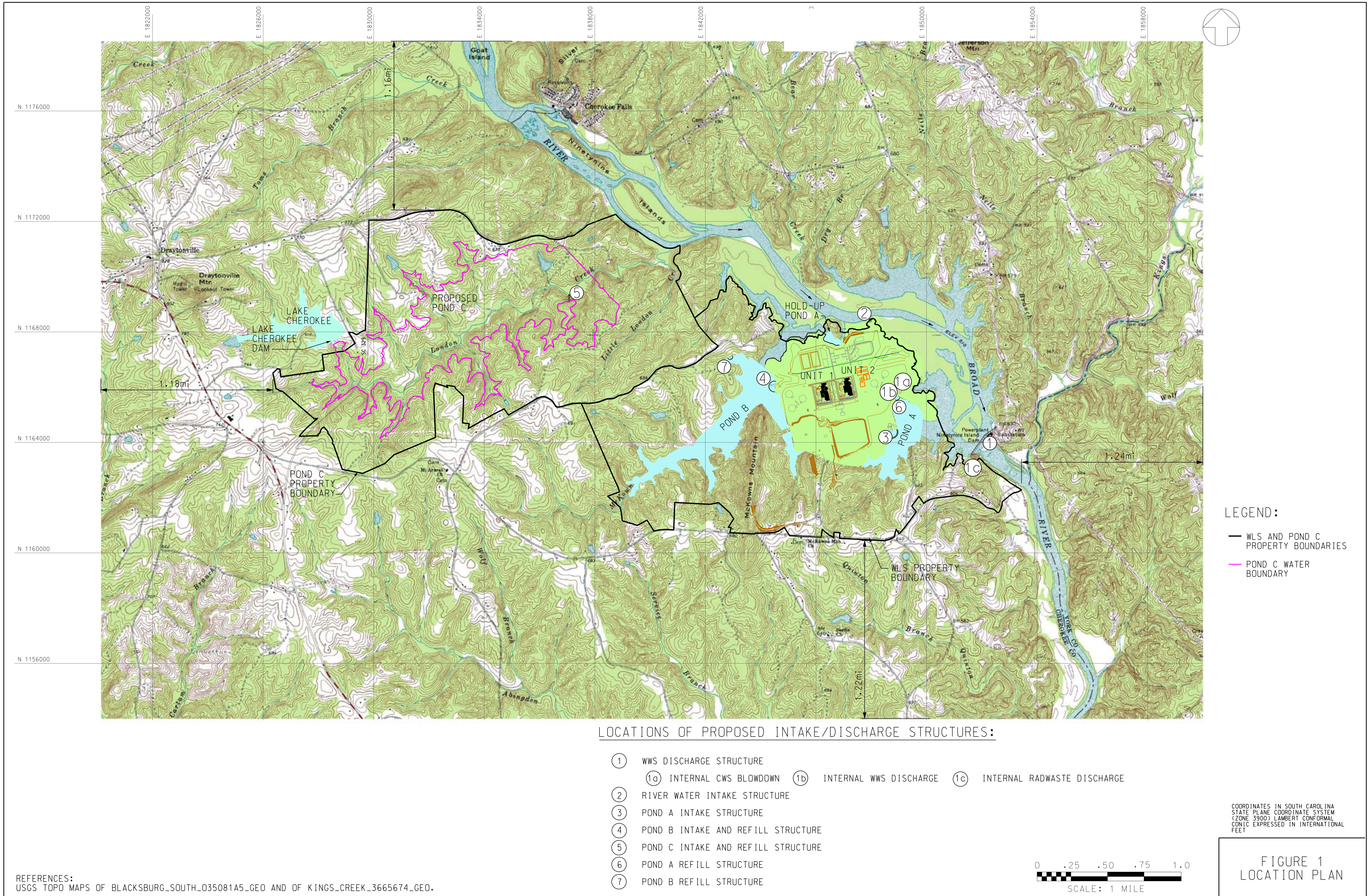
Figure 1: Location Map



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Part V

Sludge Disposal Supplement

D H E C

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

BUREAU OF WATER
SLUDGE DISPOSAL SUPPLEMENT FOR NPDES AND ND PERMIT APPLICATIONS

Facility Name: William States Lee III Nuclear Station ______________________________

Permit Number: SC00______________________ (leave blank for a new facility)

or ND00______________________

Please check your proposed or current sludge disposal procedure:

I. Existing Facilities:

___ Lagoon or other facility with no routine sludge disposal. Please attach a letter that addresses the approximate schedule for sludge removal and address the anticipated disposal method (note that the proposed sludge disposal method must be approved by the Department prior to initiation).

___ Sludge disposal at another wastewater treatment facility. Attached is a recent letter of acceptance dated______________. This letter must include the NPDES or ND number of the treatment facility accepting the sludge for disposal. If no previous SCDHEC approval has been granted on the disposal method, then please include a detailed report on the existing sludge disposal method. See the attached requirements for Sludge Disposal Report A. If a previous SCDHEC approval has been granted, then include a recent analysis that shows the non-hazardous nature of the sludge or a signed statement that the sludge characteristics have not changes since the last analysis.

___ Sludge disposal at a landfill. If the landfill is SWAIP (special waste) approved, an recent acceptance letter from the landfill is acceptable. If the landfill is not SWAIP approved, attached is SCDHEC Solid and Hazardous Waste approval dated ____________, or other SCDHEC approval dated ______________. If no previous approval has been granted on the disposal method, then please include a detailed report on the existing sludge disposal method. See the attached requirements for Sludge Disposal Report B.

___ Sludge disposal by Beneficial Use of Sludge. Attached is SCDHEC approval letter or program approval dated ____________. If no previous approval has been granted on the disposal method, then please include a detailed report on the existing sludge disposal method. See the attached requirements for Sludge Disposal Report C.

II. Proposed Facilities:

_X_ Lagoon or other facility with no routine sludge disposal. Please attach a letter that addresses the approximate schedule for sludge removal and address the anticipated disposal method (note that the proposed sludge disposal method must be approved by the Department prior to initiation).

___ Sludge disposal at another wastewater treatment facility. Please include a detailed report on the proposed sludge disposal method. See the attached requirements for Sludge Disposal Report A.

___ Sludge disposal at a landfill. Please include a detailed report on the proposed sludge disposal method. See the attached requirements for Sludge Disposal Report B.

___ Sludge disposal by Beneficial Use. Please include a detailed report on the proposed sludge disposal method. See the attached requirements for Sludge Disposal Report C.

Send this form and the appropriate disposal report (if applicable) with your NPDES or ND permit application.

ALSO SEE ATTACHED INSTRUCTIONS

Attachment to Sludge Disposal Supplement

Sludge will be generated when Lee Nuclear Station becomes operational. Once the sludge is generated it will be characterized. Once characterized, Duke Energy will provide SCDHEC with identification of the site that has been approved to receive the sludge.

Part VI

Mixing Zone Request

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D H E C

PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control

NPDES APPLICATION SUPPLEMENT

Mixing Zone Request for Surface Water Discharges

NPDES #: A new discharge to Broad River (Ninety-Nine Islands Reservoir)

Facility Name: Lee Nuclear Station

County: Cherokee

Are you requesting a mixing zone for whole effluent toxicity (WET) in accordance with the back of this form?

☐ **No.** No further information is needed. Submit this form. If WET testing is required, a chronic test at 100% will be required, unless the IWC is at least 80%. Proposed IWC ______ %

☑ **Yes.** Check one of the boxes below and submit this form with the appropriate information.

☐ Check this block if you are proposing to perform or have performed a mixing zone demonstration to determine the appropriate zone of initial dilution (ZID) and/or mixing zone size. Complete the remainder of this form and submit a mixing zone demonstration plan as described on the back of this form. The Department recommends the demonstration plan be approved prior to implementation of any demonstration work.

☑ Check this block if you are requesting a mixing zone by providing limited information such as a mixing model like CORMIX to determine mixing in accordance with suggested zone of initial dilution (ZID) and/or mixing zone sizes. Complete the remainder of this form, as applicable, and submit the CORMIX Supplement and modeling results (or other model assumptions, inputs and results).

Please see Section 4.2 of Part VI Narrative → **What is the proposed ZID size (in meters)?** Length: N/A m Width: N/A

What is the proposed acute WET test concentration? 20 %

What is the proposed mixing zone size (in meters)? Length: 66 m Width: 22

What is the proposed chronic WET test concentration? 20 %

Printed Name: Ronald A. Jones **Firm:** Duke Energy Carolinas, LLC

Signature: [signature] **Date:** 8-11-11

Mixing Zone Analysis and Boundary Conditions

Mixing zones must have the qualities of no acutely toxic impact, must allow for safe passage of aquatic organisms, must provide for protection of existing and designated uses of the waterbody, and must not endanger public health and welfare. The Department recognizes different methods for establishing a mixing zone and its boundary conditions and suggests using the following protocol.

The Department has approved the establishment of mixing zones using the following methods of analysis.

- CORMIX modeling or other modeling tools (use the attached information from Chapter 4 of the CORMIX 5.0GT Manual)
- Instream assessments using dyes or conductivity measurements.
- Other appropriate methods.

Boundary conditions of mixing zones may be established as follows.

- *Effluent dominated discharges.* For situations where the instream waste concentration (IWC) using design flow conditions for domestic facilities or long term average flow for industrial facilities and where critical flow conditions (e.g., 7Q10) represent at least 80%, the Department considers that the discharge will be completely mixed within a reasonably minimized area and therefore, test concentrations may utilize 100% of the critical flow condition (e.g., 7Q10). Therefore, use of the complete dilution of the receiving body is appropriate.

- *Other discharges.* For other situations, a demonstration is required to minimize the mixing zone by using the above-mentioned methods to determine chronic mixing permit conditions based on a boundary of one-half the width of the stream (width) and a length downstream of twice the width of the river. Acute mixing conditions are based on a boundary of one-tenth the width of the stream (width) and a length downstream of one-third the width of the river. At the discretion of the permittee (or applicant), an alternative analysis may be prepared for possibly larger mixing zone boundaries, but methods should be used that address a mixing zone analysis consistent with the EPA Technical Support Document for Water Quality-based Toxics Control (TSD) and the water quality standards regulatory mixing zone requirements (e.g., biological, chemical, engineering, hydrological and physical factors).

- *Discharges with Diffusers.* Where a properly installed diffuser provides for a mixing zone that meets the criteria above and addresses biological, chemical, engineering, hydrological and physical factors, a test concentration can be set in a permit at the justified percentage of the critical flow condition (e.g., 7Q10) up to 100% of that critical flow condition. For boundary conditions, please see above.

Prepared for

Duke Energy Carolinas, LLC
526 South Church Street
Charlotte, NC 28201

MIXING ZONE REQUEST
WILLIAM STATES LEE III NUCLEAR STATION
NPDES PERMIT
CHEROKEE COUNTY, SOUTH CAROLINA

Prepared by

Geosyntec consultants

engineers | scientists | innovators

&

MMI

engineers • scientists • innovators

Project Number GK4270

August 10, 2011

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Geosyntec consultants

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1. INTRODUCTION

Duke Energy Carolinas, LLC (Duke Energy) is making application to the South Carolina Department of Health and Environmental Control (SCDHEC) for a National Pollutant Discharge Elimination System (NPDES) permit for its proposed new William States Lee III Nuclear Generating Station (Lee Nuclear Station) to be constructed in Cherokee County near Gaffney, South Carolina.

This document presents background and technical information supporting formal requests to SCDHEC for Thermal and Whole Effluent Toxicity (WET) mixing zones for the Lee Nuclear Station effluent discharge to the Broad River pursuant to Rule 61-68 (Water Classifications and Standards) Section C.10.

1.1 Facility Description

Lee Nuclear Station will be a twin reactor facility with a total electric generating capacity of approximately 2,200 MWe. A Combined Construction and Operating License (COL) application was prepared for the facility in accordance with U.S. Nuclear Regulatory Commission (NRC) regulations, and submitted to NRC at the end of 2007. Plans are for Lee Nuclear Station to be operational by 2021.

Lee Nuclear Station will use as its primary cooling water source waterbody, an existing impoundment on the Broad River created by the Ninety-Nine Islands Hydroelectric Project. The Ninety-Nine Islands impoundment/reservoir (Ninety-Nine Islands) covers about 430 acres and has a total storage capacity of about 2,300 acre-feet (ac-ft) [Reference 1; Chapter 2]. The reservoir is characterized by three hydrographic areas, the main river channel and two backwater areas that have developed because of sedimentation patterns since impoundment of the river. The two backwater regions exhibit very little circulation during non-flood periods. Therefore, the average transit time through the reservoir is conservatively estimated from the volume of the reservoir along the main channel excluding the backwater areas. Consequently, a storage volume of 570 ac-ft along the main channel results in an average hydraulic retention time of about 3 hours under annual average flow conditions [Reference 1; Chapter 2].

As further described below, the Ninety-Nine Islands Hydroelectric project is regulated by the Federal Energy Regulatory Commission (FERC) who has specified certain

minimum water levels to be met in the reservoir and minimum seasonal flows to be released downstream of Ninety-Nine Islands Dam.

1.2 Operational Discharges to the Broad River

As a twin reactor/unit facility, Lee Nuclear Station will require approximately 35,030 gallons per minute (gpm) (78 cubic feet per second (cfs)) of cooling water withdrawal from the Broad River for its closed-cycle cooling system [Reference 1; Chapter 3 – Figure 3.3-1]. An average of approximately 71 percent (24,800 gpm or 55 cfs) of the withdrawal will be consumptive due to evaporative and drift losses from the cooling towers, with 2,000 gpm (5 cfs) returned to the river as screen wash water. In addition to approximately 18 cfs (8,200 gpm) of cooling tower blowdown discharged to the Broad River, other waste streams of much lesser volume include facility process (< 0.28 cfs [< 125 gpm]) and treated radionuclide wastewaters (< 0.009 cfs [<4 gpm]) [Reference 1; Chapter 3 – Figure 3.3-1]. For the purposes of evaluating Lee Nuclear Station discharges to the Broad River, a total average discharge flow from the final outfall 001 of 18.3 cfs (8,216 gpm; as associated with two-unit, normal operation) was used in the current analyses of mixing as reported herein.

The plant will discharge approximately 18.3 cfs of cooling water blowdown and treated process waters to the Broad River more than 95 percent of the time. Less than 5 percent of the time, blowdown discharge could be as low as 9 cfs or as high as 64 cfs. The variation in atypical discharge flows are associated respectively with scheduled unit refueling outages and adjusted (lower) cooling tower cycling rates when necessary to manage high total solids originating from the cooling water source waterbody .

Discharge to the Broad River will be via a submerged multi-port diffuser, designated as NPDES outfall 001, attached to the upstream face of the Ninety-Nine Islands dam spillway in the western portion of Ninety-Nine Islands reservoir forebay (Figure 1). The diffuser design (see Section 2) will consist of an 88-foot (ft)-long pipe, 36 inches inside diameter and having 64 4-inch holes (ports) spaced 1.4 ft apart discharging horizontally [Reference 2]. Extending horizontally from west to east along the dam (and parallel to flow), the diffuser will be positioned approximately 750 ft from the west shore near the Ninety-Nine Islands dam trash sluice structure, and submerged midway in the water column (approximate centerline elevation 505 ft above mean sea level (msl)) [Reference 1; Chapter 5 – Figure 5.3-4]. At normal water elevation of 511 ft msl, the centerline of the pipe will be submerged approximately 6 ft; total depth at this

location is approximately 12 ft. Based on FERC-specified management of the Ninety-Nine Islands impoundment (see next section), depth of the submerged diffuser could range seasonally from 4 to 6 ft (greater during flood flows), with the shallower depth associated with low river flows and pulsed operation of the Ninety-Nine Islands Hydroelectric facility; conditions that occur rarely.

The Lee Nuclear Station cooling water system is designed to achieve a maximum discharge temperature of 91°F during critical summertime conditions of high ambient river and air temperatures, and seasonally low flows. However, as presented later, a discharge temperature of 95°F was also considered in the mixing zone modeling as a rare worst case scenario. Duke Energy is requesting the thermal mixing zone associated with the postulated 95°F discharge temperature as this approach provides added conservatism to the compliance format. Maximum discharge temperatures would be expected to occur during extreme summertime conditions when water temperature and ambient air temperatures are at their seasonal highs.

Additional details about the Lee Nuclear Station cooling water and process wastewater system, including a water balance diagram, have been provided on SCDHEC/U. S. Environmental Protection Agency (EPA) Forms 1 and 2D of the primary NPDES application package.

1.3 Ninety-Nine Islands Dam Operations

Duke Energy's Ninety-Nine Islands Dam is located on the Broad River approximately 4.5 river miles downstream from the Cherokee Falls Dam and is operated under a FERC license (FERC Project No. 2331) [Reference 3]. The Ninety-Nine Islands Dam and associated hydroelectric plant were constructed in 1910, and the dam structure is a concrete gravity dam. The facility operates as a modified peaking plant where the reservoir, augmented by inflow, supports daily operation (i.e., there is no appreciable storage volume).

Although initially designed with six hydroelectric power turbine units, currently only Units 1-4 are operable. Units 5 and 6 are not currently operable. Units are numbered sequentially from the east side of the powerhouse beginning with Unit 1. Thus, the two idled units are those located closest to the proposed Lee Nuclear Station discharge diffuser. Range in approximate distance from the centerline of the proposed discharge diffuser to the turbine units is 130 ft (Unit 6) to 260 ft (Unit 1). Currently, the closest

operable unit (Unit 4) is approximately 175 ft from the proposed diffuser location. At normal water elevation (511 ft. msl), centerline elevation of the turbine inlets is approximately 494.1 ft msl [Reference 3], or about 11 ft deeper than the centerline elevation of the proposed Lee Nuclear Station discharge diffuser (505 ft msl).

During normal river flows, the Ninety-Nine Islands hydroelectric generating units are operated within the FERC license-specified drawdown limits[1] for the reservoir (1 ft below full reservoir (511 ft msl) from March through May and 2 ft below full reservoir from June through February) [Reference 4]. Total hydraulic capacity of the 20 megawatt (MW) Ninety-Nine Islands Dam powerhouse (six units authorized) is 5,220 cfs [Reference 3]. Hydraulic capacity of the four currently operable units (Nos. 1-4; rated at ~14.450 MW total) is 3,510 cfs; thus, as currently configured/operated, the Broad River flows in excess of this amount pass over the dam spillway.

In addition to drawdown limitations, the FERC license for Ninety-Nine Islands Dam also specifies certain seasonally adjusted minimum flows to be maintained below the dam [Reference 4]:

- 966 cfs January through April;
- 725 cfs May, June, and December; and,
- 483 cfs July through November.

If the above-referenced flows cannot be maintained during December through June without dropping below the reservoir level restrictions described above, then at least 483 cfs is required to be released. If there is insufficient water to maintain at least 483 cfs of continuous flow release, the operating license provides that one hydroelectric unit can be operated at its minimum hydraulic output for that portion of every hour that is necessary to release the approximate accumulated inflow, i.e. a pulse flow operational format [Reference 5].

---

[1] Drawdown limits may be temporarily modified in the event of operating emergencies beyond Duke Energy's control.

As indicated above, the FERC-specified July through November minimum flow is 483 cfs. Based on analysis of the Broad River period of record flows (85 years) performed by Duke Energy contractor HDR|DTA, flows were greater than 483 cfs 98.2 percent of the time [Reference 6]. Of the 31,046 days that flows were measured by the U.S. Geological Survey (USGS) for the Broad River since 1926, flows less than 483 cfs were recorded for just 545 days (1.8 percent). Consequently, pulsed flow operations of Ninety-Nine Islands hydroelectric power generation are rare events.

1.4 Chronological Summary of Related Modeling Work

There have been a number of numeric modeling efforts conducted as part of the design and NRC licensing of Lee Nuclear Station. These efforts are summarized in the following sections.

1.4.1 Clemson University Study

The thermal discharge to the Broad River was initially evaluated through limited work performed by Clemson University [Reference 7]. The researchers employed simplifying assumptions and analytical calculation methods, in lieu of a three-dimensional model, to identify any “fatal flaws” in the discharge diffuser concept being developed at that time with regard to thermal gain in the Ninety-Nine Islands forebay and downstream of the dam. The results, not meant to be highly definitive, provided gross insight into the potential thermal effects of the Lee Nuclear Station cooling water discharge in the Broad River above and below Ninety-Nine Islands Dam. The Clemson researchers concluded that, based on conservative assumptions, thermal gain above the dam may range from 1.2 to 3.7°F; with a thermal gain of up to 1.7°F predicted for waters below the dam.

1.4.2 Enercon Study

In support of the COL application, additional modeling was conducted by Duke Energy contractor Enercon, which used a more sophisticated modeling approach employing Cornell Mixing Zone Expert (CORMIX) modeling software (Version 4.3) to simulate the thermal plumes above and below Ninety-Nine Islands Dam [Reference 1]. This effort was coupled with a mass balance analysis to determine expected temperature of water discharged by Lee Nuclear Station after mixing with the Broad River water in the Ninety-Nine Islands hydroelectric station turbines.

Results of the CORMIX simulations predicted a small thermal plume that dissipates quickly. Results of the heat balance calculation indicated that the maximum temperature change downstream of Ninety-Nine Islands Dam is expected to be less than 1.4°F.

1.4.3 Computational Fluid Dynamics Modeling

The results of the CORMIX modeling, though more accurate than the Clemson work, still did not consider the important effects on Lee Nuclear Station thermal discharge mixing characteristics brought about due to variation in reservoir bathymetry, flow velocity, and flow vector (direction) in the Ninety-Nine Islands Dam forebay at the diffuser location. Likewise, the hydraulic influences of the Ninety-Nine Islands Dam hydroelectric generating units on thermal plume characteristics were not considered.

In subsequent discussions with regulatory agencies pertaining to the appropriate permitting approach for Lee Nuclear Station, concerns were raised about the mixing behavior of the thermal discharge from the station in the forebay and the potential effect of this discharge on the aquatic community, particularly on the smallmouth bass (*Micropterus dolomieui*) fishery present downstream of Ninety-Nine Islands Dam.

In order to more definitively characterize the Lee Nuclear Station thermal discharge into the hydrodynamically and spatially complex mixing environment present in the Ninety-Nine Islands Reservoir forebay, a more robust modeling approach was needed. As such, three-dimensional Computational Fluid Dynamics (CFD) modeling technology was conducted [Reference 8].

CFD modeling is based on the Navier-Stokes equations for fluid motion, which are simply an expression of Newton's laws of motion with additional viscous stress terms required to calculate fluid flow [Reference 9]. The equations express the laws of conservation of mass, momentum and energy and are hence a "fundamental" set of equations (i.e., no assumptions are made in forming the basic equation set).

CFD modeling has been used successfully for over 40 years in a variety of industrial and environmental applications. Similar to its use in the current study, the Tennessee Valley Authority (TVA) used CFD modeling to evaluate the multi-port diffused thermal discharge from its Browns Ferry Nuclear Power Plant to Wheeler Reservoir in north Alabama [Reference 10]. The CFD model allowed TVA to determine thermal plume mixing and temperature rise patterns as well as other hydrodynamic features of the

discharge. Notably, TVA found close agreement between CFD model predicted water temperatures and direct temperature measurements at the operating diffusers.

Other examples of CFD environmental applications include the U.S. Department of Energy's Pacific Northwest National Laboratory use of CFD in the hydrodynamic evaluation of the North Fork Dam forebay on the Clackamas River in Oregon and to model the three-dimensional velocity field below Bonneville Dam to enhance fish passage [Reference 11]. CFD has also been used to investigate the increased discharge associated with the re-powering of an existing power plant [Reference 12].

In this initial CFD evaluation of the Lee Nuclear Station thermal discharge, mean annual flow (2,538 cfs[2]), low flow (483 cfs) and extreme low flow (157 cfs) discharge scenarios were conservatively calculated to determine the potential effects of the Lee Nuclear Station cooling water discharge on the Broad River and Ninety-Nine Islands Reservoir environments. Discharge temperatures of 91°F and 95°F were evaluated. In all the cases studied, the maximum temperature rise at the Ninety-Nine Islands hydro turbine intakes was 0.72°F. Therefore, the maximum temperature rise passed through to the Ninety-Nine Islands Dam tailrace would also be 0.72°F. For all other scenarios examined, predicted water temperature rises at the turbines were less than 0.4°F. Based on the minimal temperature rise predicted by the CFD model, the study concluded there would be no substantive changes to the summertime thermal regime that currently exists in the tailrace. Thus, there would be no detrimental impacts to the smallmouth bass fishery.

Modeling of the extreme low flow scenario (157 cfs) also predicted that under certain conditions heat may accumulate in the Ninety-Nine Islands Dam forebay if the pattern of Ninety-Nine Islands hydroelectric station pulsed flow operation is insufficient to fully remove the Lee Nuclear Station heat addition. A pulsed flow operational pattern matched to 322 cfs was predicted through extrapolation to preclude accumulation of heat in the forebay.

[2] At the time that the initial CFD evaluation was performed, 2,538 cfs was the accepted value for mean annual flow. It has since been recalculated based on data from 1926 through 2010 as 2,495 cfs.

1.4.3.1 Presentation of CFD Model Results to SCDHEC

A comprehensive report of the initial CFD thermal modeling, prepared in support of the COL application, was submitted to NRC on 24 September 2009 [Reference 8]. Results were presented directly to SCDHEC on 27 August 2009. Based on SCDHEC feedback regarding apparent accumulation of heat in the Ninety-Nine Islands forebay, additional modeling was performed to further evaluate thermal discharges under critical low flow at times when the Ninety-Nine Islands hydroelectric generating station is operating in pulsed generation mode. The 7Q10 critical low flow of 464 cfs was determined by SCDHEC [Reference 13] to be the appropriate flow value to use for modeling NPDES-permitted discharges to the Broad River from Lee Nuclear Station. The additional CFD modeling was conducted as requested by SCDHEC to: 1) address the issue of heat accumulation in the Ninety-Nine Islands Dam forebay; and 2) to support requests for thermal and whole effluent toxicity (WET) mixing zones in accordance Rule 61-68 (Water Classifications and Standards) Section C.10 [Reference 14].

SCDHEC also requested additional information about the design of the proposed submerged multi-port discharge diffuser; particularly with regard to its efficiency in mixing Lee Nuclear Station discharges with the Broad River receiving waters.

The sections that follow present technical information on optimization of the Lee Nuclear Station discharge diffuser, and supporting information for the Thermal and WET Mixing Zone requests.

2. DISCHARGE DIFFUSER OPTIMIZATION

Duke Energy contracted with Philip J. Roberts, Ph.D. of Georgia Tech's School of Civil and Environmental Engineering to support design optimization for the Lee Nuclear Station submerged multi-port discharge diffuser [Reference 2]. Dr. Roberts has published extensively on such technical topics as environmental fluid mechanics, mixing and dynamics of rivers, lakes, coastal waters, and estuaries; optimization of outfalls for wastewater discharge; and mathematical models of wastewater fate and transport. Dr. Roberts' work is cited multiple times in EPA's *Technical Support Document for Water Quality-Based Toxics Control* (EPA/505/2-90-001), which is the seminal work upon which permitting of potentially toxic discharges to waters of the United States is based.

The following represents a summary of Dr. Roberts' work in optimizing the design of the Lee Nuclear Station discharge diffuser.

2.1 Design Study Objectives

Dr. Roberts' work focused on the optimization of the Lee Nuclear Station diffuser engineering design to satisfy plant operational parameters, promote efficient mixing of the effluent, and limit temperature rise in the receiving waterbody (Broad River). Performance criteria for the discharge design included achievement of a temperature rise in the river at the water surface near the diffuser of no more than 5°F with a maximum temperature not to exceed 90°F (analysis of mixing needed to address chemical constituents in the discharge was not conducted). While water quality criteria for temperature were used to inform the design of the diffuser, it was not the intent of Dr. Roberts' work to directly address an NPDES compliance-based mixing zone. That objective was addressed by the additional CFD modeling reported herein (see Sections 3 and 4).

2.2 Assessment Methodology

The initial multi-port diffuser design proposed by Duke Energy was a submerged 65-ft-long pipe of 36-inch diameter attached to the upstream face of the Ninety-Nine Islands Dam spillway in the western portion of Ninety-Nine Islands Reservoir forebay. The diffuser was to consist of 16 3-inch holes (ports) per square foot. For the optimization study, multiple discharge flow rates (9 cfs [4,039 gpm] to 64 cfs [28,725 gpm]), diffuser

port depth (6 to 8 ft), diffuser nozzle spacings (1 to 10 ft) and nozzle diameters (3 to 4 inches) were modeled by Dr. Roberts using EPA's Visual Plumes model. Modeling targeted two seasons: (i) winter when differential between monthly average ambient river temperature (44.1°F) and cooling tower blowdown (discharge) temperature (70.4°F) is estimated to be greatest (ΔT=26.3°F); and (ii) in summer when maximum monthly average river temperature and blowdown discharge temperature are at their seasonal highs: 82.3°F and 91°F, respectively. The modeling assumed there was no ambient river flow whatsoever in the forebay into which the discharge was made, an attribute reported as conservative by Dr. Roberts [Reference 2].

The Visual Plumes model predicts the buoyant thermal plume to follow a curved trajectory from the submerged diffuser as it rises to the water surface (ports/nozzles are located on the upstream side of the diffuser, away from the face of the dam). As the plume rises, it entrains ambient water that mixes and dilutes the discharge and reduces the temperature rise. The maximum surface temperature occurs where the jet centerline impacts the water surface [Reference 2]. This impact zone represents the maximum spatial extent of model predictability for surface water temperature (i.e., the model domain extends from the point of port/nozzle discharge to impact of the plume with the water surface).

Visual Plumes consists of a suite of models intended for various purposes. In this case, the UM3 model was considered the most appropriate model [Reference 2]. UM3 is a three-dimensional Lagrangian entrainment model for jets and plumes. External fluid is assumed to be entrained into the rising buoyant thermal plume at a rate proportional to the local plume centerline velocity. The local profiles of velocity, density deficiency, and tracer concentrations are assumed to be self-similar and the equations for conservation of mass and momentum, are integrated over the plume cross-section. The equations are solved numerically to predict plume conditions, including dilution and plume width, along the jet trajectory. If the ports are close together, the plumes may merge. The merging of the thermal plumes is considered in the routines of the UM3 model. Entrainment models are widely used in engineering to predict a wide variety of flows related to wastewater and atmospheric discharges.

2.3 Study Findings

It was determined that a minimum mixing dilution ratio of 5.3 to 1 was needed to meet the applicable thermal water quality criteria (ΔT $\leq$ 5°F and 90°F maximum). All

combinations of discharge flow rates, diffuser port spacings and port diameters modeled indicated the needed dilution could be achieved. Based on Dr. Roberts' analysis, the optimally designed submerged, multi-port discharge diffuser (pipe) is approximately 88-ft long with an inside diameter of 36 inches and has 64 4-inch ports spaced 1.4 ft apart. The Visual Plumes model indicates that if the Lee Nuclear Station heated effluent were discharged to the Broad River via a diffuser of this design, the result will be a temperature rise at the water surface (where the buoyant plume emerges) that will always be less than 5°F and have a maximum temperature at the water surface of less than 90°F based on the assumed conditions. The lateral distance from the diffuser port to the point of plume impact with the water surface was estimated to range from 14 ft (9 cfs discharge flow rate) to about 76 ft (64 cfs discharge flow rate).

3. THERMAL MIXING ZONE REQUEST

The Lee Nuclear Station thermal discharge is predicted at times to potentially exceed water quality criteria for temperature (e.g. 90°F). Because the spatial extent of such exceedance in the receiving waterbody is expected to be small, a regulatory mixing zone presents an allowable compliance approach provided requirements specified in Rule 61-68 (Water Classifications and Standards) Section C.10 can be met [Reference 14].

3.1 Background

As indicated previously, Dr. Roberts' work focused on optimizing the design of the submerged multi-port discharge diffuser and not the determination of a regulatory mixing zone. It is important to note, however, that rapid mixing of the Lee Nuclear Station discharge was demonstrated by Dr. Roberts' analysis, with achievement of temperature criteria predicted upon impact of the buoyant plume with the receiving water surface (under the conditions considered).

The limitations of the Visual Plumes model used by Dr. Roberts (as well as the CORMIX model used by Enercon [Reference 1]) to evaluate thermal discharge mixing zones are primarily associated with the orientation of the discharge diffuser parallel to ambient flow along the Ninety-Nine Islands Dam (Figure 1). Typically, a discharge diffuser is oriented perpendicular to flow whereby the discharge from each port/nozzle may be entrained into ambient receiving water unaffected by the discharge. Such orientation provides for efficient mixing of the discharge with the receiving waterbody. The Visual Plumes and CORMIX models are best suited for these conditions.

Constraints imposed by conditions in the Broad River (i.e., heavy debris and sediment accumulation) necessitated placement of the Lee Nuclear Station discharge diffuser along the face of Ninety-Nine Islands Dam, parallel to flow. In the case of diffuser orientation parallel to flow, the discharge from ports located on the "downstream" end of the diffuser entrains the effluent discharged from the "upstream" ports thereby affecting mixing characteristics. This physical phenomena is accounted for in the CFD model, since the parallel flow of the thermal discharges are included automatically (or, more accurately, the parallel flow in the CFD model is due to the influence of the river flow being obstructed by the dam) and allowed to mix according to the fundamental laws of fluid motion. The discharge diffuser is not modeled explicitly as jets emanating

from each port, as this would be too computationally expensive. Rather, the discharge is treated as a mass source at the location of the discharge diffuser, and is allowed to diffuse equally in all directions and mix as the ambient flow dictates.

In the CFD model, a temperature transport model derived from the law of conservation of energy is included. Temperature is transported in the model domain by convection with the water flow, and molecular and turbulent diffusion. It has an influence on the flow profile as the heated water plumes rise – this is included in the calculations via the Boussinesq buoyancy model. As the temperature and flow fields are interdependent it is essential that the flow, turbulence and temperature equations are calculated simultaneously. Heat can also be lost or gained through the model boundaries. For example, heat lost or gained through the free surface will modify the temperature in the reservoir and this can be included in the calculation by selection of appropriate boundary conditions. It is likely that heating and cooling in the forebay is influenced by river temperature, air temperature, cloud cover, sun elevation, shading by vegetation and other effects. In the absence of full knowledge of these variables, heat loss/gain through the free surface cannot be calculated accurately. Instead, adiabatic conditions were specified at the free surface, a conservative modeling approach.

3.2 Current Thermal Modeling Effort

Geosyntec Consultants/MMI Engineering (Geosyntec) was contracted by Duke Energy to conduct the necessary calculations/modeling to determine the Lee Nuclear Station thermal discharge mixing characteristics in the Broad River for the purposes of NPDES permitting of the new facility. Based on SCDHEC feedback received at the 27 August 2009 meeting regarding apparent accumulation of heat in the Ninety-Nine Islands forebay, additional modeling was performed to further evaluate thermal discharges under critical low flow at times when the Ninety-Nine Islands hydroelectric generating station is operating in pulsed generation mode. The 7Q10 critical low flow of 464 cfs was determined by SCDHEC [Reference 13] to be the appropriate flow value to use for modeling NPDES-permitted discharges to the Broad River from Lee Nuclear Station. This modeling scenario (critical conditions and pulsed flow) was used to estimate spatial boundaries for a thermal mixing zone.

The SCDHEC further indicated their focus will be on the size of the Lee Nuclear Station thermal plume relative to the specified acute mixing zone boundary. Duke Energy has assumed SCDHEC is referring to that portion of the plume/mixing zone

where temperatures may potentially exceed 90°F (maximum ambient water quality criterion) as discharge temperatures in excess of 90°F would only be expected to occur during summer - the time when critical low flows in the river (e.g., 7Q10 flows) can also occur. The other component of the state's temperature criteria (adapted from EPA), "*free flowing* [waters] *shall not be increased more than 5°F (2.8°C) above natural temperature conditions*", [Reference 14] is largely based on the objective to "*maintain a well-rounded population of warmwater fishes*" [Reference 15]. In the case of power plant additions, it is further based on the objective to avoid fish lethality resulting from a sudden *drop* in water temperature (should the plant shut down) during winter months when the potential for $\Delta T > 5°F$ to occur is greatest [Reference 2]. As such, the 90°F maximum temperature criterion was selected as the acute condition and the additional CFD modeling was conducted to address this component of the mixing zone request.

Duke Energy is also aware of SCDHEC's interest in temperature differential between the discharge and ambient Broad River as exemplified by the $\Delta T \leq 5°F$ criterion [Reference 14]. The comprehensive CFD thermal modeling report (see Section 1.4.3) speaks directly to this issue and includes several CFD modeling runs that address plume characteristics of $\Delta T \geq 5°F$. In all cases conservatively modeled, plume spatial dimensions associated with temperatures of $\Delta T \geq 5°F$ were very small ranging from 0.002 to 0.01 acre in size. This finding is further supported by Dr. Roberts' additional analysis of the discharge diffuser that indicates the ΔT will always be < 5°F at the point of buoyant plume impact with the water surface [Reference 2].

As is presented in the following text, an approved mixing zone request based upon plume dimensions for the $\geq$ 90°F isotherm associated with a discharge temperature of 95°F will fully encompass the area occupied by that portion of the plume exhibiting $\Delta T \geq 5°F$. Therefore, as the additional modeling requested by SCDHEC (acute, critical summer condition) is most relevant to the Thermal Mixing Zone request, the results thereof are summarized in the following text.

3.3 Critical Conditions Modeling

The Lee Nuclear Station thermal discharge characteristics under critical condition 7Q10 flow of 464 cfs were conservatively calculated using CFD models to determine the potential effects of the Lee Nuclear Station cooling water discharge on the Broad River and Ninety-Nine Islands Reservoir forebay environments, particularly with regard to that portion of the thermal plume where temperatures are $\geq$ 90°F plume. Under 7Q10

flow conditions, the Ninety-Nine Islands Hydroelectric Generating Station is expected to operate in a pulsed mode format whereby a single turbine is pulsed "on" and "off" over an hourly cycle to comply with FERC-specified minimum water levels to be maintained in the impoundment and minimum seasonal flows to be released downstream. The CFD model was configured to address this pulsed mode of operation.

In this specific case, bathymetry data, as well as water column acoustic Doppler velocity and vector data directly for the Ninety-Nine Islands Reservoir forebay measured by Duke Energy, were incorporated into the CFD model. This and other CFD model spatial and temporal features supported a more definitive evaluation of the influences of the Lee Nuclear Station thermal discharge on ambient forebay temperatures and prediction of water temperatures at the Ninety-Nine Islands Dam turbine inlets, and thus, the temperatures that would be discharged to the Broad River below the dam.

The CFD model used in this study is similar to the earlier work [Reference 8] where a more detailed overview of the model is given. The geometry and mesh were slightly changed after this work to reflect the correct position and length of the discharge diffuser (an initial design was used in the previous work), and are shown in Figures 2 through 5 for reference[3].

The model was run in transient mode to capture the pulsed operation of the turbines. As with the previous studies, the diffuser discharge was applied as a mass source at the location of the diffuser and allowed to diffuse equally in all directions. This tends to result in a conservative result for the thermal plume as the momentum induced by the multi-port discharge diffuser will be greater in reality than in the model. This increase in momentum will encourage entrainment of ambient water and enhance cooling of the plume. Therefore, the under-representation of momentum in the CFD model is conservative.

3.3.1 Methodology

Geosyntec/MMI Engineering uses a variety of classical and computational analysis techniques to assess the performance of fluid systems and processes. For detailed CFD analysis, calculations are made with the general purpose, commercial CFD code

[3] Please note that for Figures 4 and 5 the viewer's perspective is from the east bank of Broad River (looking southwesterly), upstream of the dam, and somewhat elevated. This is also true for subsequently-referenced Figures 6-10, 12, 15, 16, 20 and 21.

ANSYS-CFX Version 12 [Reference 16]. This is the CFD model code selected for the current analysis.

The extent (geometry) of the Ninety-Nine Islands Reservoir/Broad River environment in the CFD models included:

- The Ninety-Nine Islands Dam, forebay, turbine intakes, and Lee Nuclear Station diffuser discharge;
- the backwater areas in the locality of the forebay; and,
- a reach of the Broad River extending approximately 0.5 mile upstream of the forebay.

Total surface area of the modeled domain was approximately 61 acres.

Bathymetry data for the reservoir forebay area and river was provided by Duke Energy contractor, DTA [Reference 17] in the form of point-depth measurements in a series of transects. These point data were interpolated to form the river/reservoir bed in the CFD models. The data received did not include the dam or turbine intakes, which were incorporated into the model by reference to the civil engineering drawings of the Ninety-Nine Islands hydropower station [References 18 and 19].

The Lee Nuclear Station cooling water discharge was defined in the CFD models based on reference to the Duke Energy drawings of the discharge [References 19 and 20]. The location of the discharge relative to the turbine intakes is shown in Figure 1. Only the discharge diffuser detail was included in the model; the remainder of the discharge pipe work has no significant effect on plume behavior.

3.3.1.1 CFD Model Relationship to Dr. Roberts' Diffuser Design Study

It is important to acknowledge that at the time the additional CFD modeling (reported herein) was conducted, Dr. Roberts' work in optimizing the discharge diffuser design had not been completed. It should be noted that that Dr. Roberts used a maximum *monthly* average temperature of 82.3°F and normal discharge temperature of 91°F in his discharge diffuser design optimization study; whereas, the CFD model uses a *daily* average maximum temperature of 88.2°F and both 91°F and 95°F discharge temperatures to evaluate worse case conditions of summer in the determination of

mixing zones. These differences are simply the result of independent investigations, conducted at different times, and with differing objectives in mind, and would have no material impact on the CFD model results.

3.3.2 Scenarios Modeled

Two CFD calculations (scenarios or cases) were performed with the following variables common to both cases:

- River flow rate was set to 464 cfs in accordance with the 7Q10 level specified by SCDHEC for the NPDES permitting [Reference 13] ;
- River temperature (background) was set to 88.2°F as determined from Duke Energy continuous water temperature data collected in the Ninety-Nine Islands forebay during June-August 2008 (when 7Q10 flows might be expected to occur) [Reference 21];
- Turbine flow rate was set to 500 cfs when "on" and 53 cfs when "off" (due to leakage through the turbine penstock);
- Ninety-Nine Islands Hydroelectric Station turbine operation:
  - Only 1 turbine unit is in operation.
  - The unit is "off" for the first 4.3 minutes per hour, flow accumulates in the forebay and only leakage flow passes to the tailrace. The unit is "on" for the remaining 55.7 minutes per hour. These timings were calculated by considering the balance of the river and turbine flow rates only.
- Diffuser discharge rate was set to 18.3 cfs.

The scenarios differed in the temperature of the diffuser discharge. In Scenario 1 the discharge temperature was set to 95°F, while in Scenario 2 it was 91°F.

3.3.3 Model Results

For the 7Q10 river flow rate of 464 cfs, the peaks of the average temperatures at the Ninety-Nine Islands Hydroelectric Station turbine inlet calculated from the CFD model are as follows:

- Scenario 1 (95°F discharge temperature): 88.57°F or 0.37°F above ambient river temperature (88.2°F).

- Scenario 2 (91°F discharge temperature): 88.36°F or 0.16°F above ambient river temperature (88.2°F).

It is apparent from the above that the Lee Nuclear Station thermal discharge will have minimal impact on the thermal regime of the Broad River downstream of the Ninety-Nine Islands Hydroelectric Project.

With regard to the Ninety-Nine Islands Dam forebay, the CFD modeling of two consecutive one-hour cycles demonstrated that heat did not accumulate in the forebay beyond initial start-up, and that steady-state conditions were reached by the end of the second hour of pulsed operation. This was determined to be true for both Scenario 1, and is a feature of Scenario 2 as well, although the thermal plumes are much smaller.

For Scenario 1 (95°F discharge temperature), Figure 6 illustrates the 90°F area by the blue iso-surface 20 minutes into the first cycle modeled. At the end of the first cycle, the plume is of a different shape and slightly smaller (see Figure 7). The variation in plume size and shape throughout the cycle is an important consideration in the modeling, and is a feature of Scenario 2 as well, although the thermal plumes are much smaller because the discharge temperature is lower for Scenario 2 (91°F). See Figure 8 and Figure 9 for the thermal plumes for Scenario 2.

The variation in plume volume over two cycles is an important dynamic in the model. As the CFD model uses a uniform temperature throughout the domain of 88.2°F as a starting point (an initial assumption to start the model), the 90°F thermal plume is zero volume, but after the first 15 minutes the volume is approximately constant for the first cycle. Because the turbine is turned off at the start of the second cycle, the thermal plume increases in size, and even increases when the turbine is turned back on for a short period (this lag is to be expected as the turbine does not immediately influence the entire domain as soon as it is turned on), before returning to approximately the steady-

state volume in the first cycle. As the plume volume at the end of the second cycle is approximately the same as at the end of the first cycle, the second cycle can be assumed to be the “repeating” cycle. A similar pattern was also observed for Scenario 2.

Dimensions of the thermal plume were taken at the end of the second cycle in each case, as this is the “steady-state” plume that is the best representation of the plume over the hourly cycle. Figures 10 through Figure 13 show the steady-state plumes for Scenarios 1 and 2, respectively. The plan views (Figure 11 and Figure 13) of the plumes provide a perspective of the size of the plume in comparison to the forebay of the dam. A detailed summary of the plume dimensions for each scenario are shown on the table in the following section. The volume of the thermal plume for Scenario 1 is 0.994 ac-ft (43,339 ft^3), while the surface area is 0.358 acres (15,603 ft^2). The cross-section area (see Figure 15) is 630 ft^2 which constitutes 3.7 percent of the forebay cross-sectional area. The maximum plume length, taken from the end of the discharge diffuser, is 198 ft (approximately 19 percent of the width of the Broad River at the forebay of the dam) while the width of the plume is 63 ft. The maximum and average depths are 7.7 ft and 1.6 ft, respectively. The bar chart showing percent of plume volume against depth for this scenario (Figure 14) indicates that the majority of the plume is less than 7 ft depth – in fact, 97% of the plume volume is less than 5 ft depth for Scenario 1.

For Scenario 2 the thermal plume is significantly smaller, as would be expected, with a volume of 0.087 acre-ft (3,798 ft^3) and a surface area of 0.032 acres (1,389 ft^2). The cross-section area (see Figure 16) is 125 ft^2 which constitutes 0.7 percent of the forebay cross-sectional area. The maximum plume length, calculated from the end of the discharge diffuser, is 30 ft (approximately 3 percent of the forebay length) while the width of the plume is 32 ft. The maximum and average depths are 5.8 ft and 1.6 ft, respectively. The bar chart showing percent of plume volume against depth for this scenario (Figure 17) indicates that the majority of the plume is less than 5 ft depth.

3.3.4 Results Summary

The CFD model inputs and resulting spatial dimensions of the ≥ 90°F plume under each scenario were determined for the steady-state condition and are summarized on the following table:

	Scenario 1	Scenario 2
River Flow	464 cfs 7Q10 Critical Flow	464 cfs 7Q10 Critical Flow
River Temperature	88.2°F	88.2°F
Discharge Flow	18.3 cfs	18.3 cfs
Discharge Temperature	**95°F**	**91°F**
Dimensions of Steady-state ≥ 90°F Thermal Mixing Zone for Repeating Cycle		
	Scenario 1	**Scenario 2**
- **Volume**	0.994 acre-ft 43,339 ft^3	0.087 acre-ft 3,798 ft^3
- **Surface area**	0.358 acre 15,603 ft^2	0.032 acre 1,389 ft^2
- **Cross-Sectional area** o **Percent of forebay**	630 ft^2 3.7 %	125 ft^2 0.7 %
- **Average Depth/Thickness**	1.6 ft	1.6 ft
- **Maximum Depth/Thickness**	7.7 ft	5.8 ft
- **Maximum Width**	63 ft	32 ft
- **Maximum Length**[4]	198 ft	30 ft

It is important to note (as detailed in the next section) that proper interpretation of the model results (i.e. spatial attribute) relative to a regulator mixing zone should consider orientation of the diffuser and buoyant properties of the thermal plume.

[4] Calculated from the end of the discharge diffuser.

Hereafter, discussion of the thermal plume and associated mixing zone for Lee Nuclear Station conservatively assumes the 95°F discharge temperature under critical low flow (7Q10) conditions.

3.4 Relevance to the Thermal Mixing Zone Request

As indicated previously, SCDHEC indicated a significant consideration in its analysis will be on the size of the Lee Nuclear Station thermal plume relative to the specified acute mixing zone boundary. Duke Energy has assumed this to be that portion of the plume/mixing zone where temperatures are in excess of the 90°F criterion. As the discussion hereafter focuses on the plume area characterized by temperatures ≥ 90°F and analogous to the acute mixing zone, the terms "plume" and "mixing zone" are used interchangeably.

Mixing zone boundary conditions set by SCDHEC seek to keep the size of mixing zones to a minimum. According to SCDHEC requirements, acute mixing zones are limited to no more than one-tenth (10 percent) of the width of the stream (width) and a length downstream of one-third (33.3 percent) the width of the stream, although alternatives may be considered for larger mixing zones [Reference 22].

Unlike the conventional configuration where the discharge diffuser extends laterally from shore and is positioned perpendicular to the flow, the Lee Nuclear Station discharge diffuser is attached to a dam and oriented parallel to river flow (i.e., flow is along the dam face toward the hydroelectric turbines). These attributes make the direct application of the SCDHEC acute mixing zone length/width proportional dimensions to the Lee Nuclear Station thermal plume somewhat atypical.

For example, given the placement of the discharge diffuser parallel to flow along the face of the Ninety-Nine Islands Dam, it is necessary to define length of the plume/mixing zone as running parallel to the longitudinal centerline of the diffuser pipe (i.e., easterly), and width as perpendicular to the diffuser (i.e., northerly). As such, the maximum downstream length of the buoyant 90°F plume (acute mixing zone) is conservatively estimated to be 198 ft, which is approximately 19 percent of the width of the Broad River at the forebay of the dam (1,031 ft), while the plume width is conservatively estimated to be 63 ft, or 6 percent the width of the stream. Accordingly, the size of the acute thermal mixing zone for the Lee Nuclear Station discharge as conservatively determined by the CFD model falls well within the maximum spatial

boundary conditions, for the mixing zones established by SCDHEC. In addition, including the enhanced mixing properties afforded by the high-velocity multi-port diffuser, which was not fully considered by the CFD model (see Section 3.3), will further diminish the size of the thermal mixing zone reported herein.

Also, while seasonal temperature data for the Ninety-Nine Islands forebay demonstrate the water column is well mixed and oxygenated all year, the buoyancy of the thermal plume results in an uneven dispersal of heated water vertically in the water column. That is, at the maximum horizontal extent (length) of the ≥ 90°F plume (198 ft), the plume/mixing zone does not extend vertically downward into the water column. Although the maximum depth of the mixing zone (extending from the surface downward) is 7.7 ft, only a very small proportion of the plume is at that depth; 97 percent of the mixing zone volume is found at 5 ft depth or less (Figure 14). The average depth/thickness of the mixing zone is just 1.6 ft. As the average depth is so shallow, there is a significant distance between the mixing zone and the bottom of the forebay where fish may escape or swim around the area.

Given the above discussion, an alternative/analogous approach for evaluating minimization of the size of the Lee Nuclear Station thermal mixing zone relative to the receiving waterbody may be to use percent cross-sectional area of the forebay occupied by the ≥ 90 °F or greater plume/mixing zone. This approach is fully consistent with SCDHEC mixing zone requirements and EPA guidance [Reference 23], which seeks to limit exposure to fish and other organisms to acute conditions. Using this approach, the cross-sectional area of the plume was determined by positioning an east-west oriented line (aligned with the dam and diffuser) through the thickest part of the vertical plane of the plume. This cross-sectional area of the ≥ 90°F plume (associated with a 95°F discharge temperature) measures 630 ft^2 in size; proportionally, this represents just 3.7 percent of the cross-sectional area of the forebay (Figure 15). Thus, under conservative conditions there is very limited potential exposure to the thermal plume for free-swimming fish or benthic organisms and their passive life stages.

EPA guidance provides that the areal extent and concentration isopleths (for toxics) of a mixing zone must be such that the 1-hour average exposure of organisms passing through the mixing zone is less than the acute criteria [Reference 23]. Though maximum temperature criteria are based on experimental studies using longer averaging periods [Reference 15], the 1-hour average exposure period was used as a conservative

means of evaluating, through additional analysis, the potential lethality to passive organisms from exposure to elevated water temperature (> 90°F) in the mixing zone.

The average velocity in the steady-state plume was obtained from the CFD model and divided into the greatest length of the plume (198 ft) to estimate potential travel time through the plume for a passive organism. For Scenario 1, the average velocity was estimated at 0.158 feet per second (ft/s). As such, travel time through the plume was determined to be approximately 21 minutes. For Scenario 2 the average velocity is 0.119 ft/s and the length of the plume is 30 ft, so travel time is 4 minutes. Thus, no passive organisms/life stages will be exposed to water temperatures > 90°F for extended periods of time and any exposures will be well below an hour.

Determination of velocities throughout the plume is a complex exercise given the dynamic conditions in the forebay. However, the analysis is conservative in that the conditions considered (i.e., flow velocities) have been determined for the steady state condition of the plume under rare pulsed-flow conditions. Under typical continuous operation of the Ninety-Nine Islands hydroelectric facility turbines, ambient and turbine-induced flows would be expected to substantially reduce travel time for passive organisms through the mixing zone.

With regard to the downstream extent of the thermal plume, it is important to note that based on the CFD-modeling results (see Section 3.3.3 above), water temperatures greater than 90°F are not predicted to reach the Ninety-Nine Islands hydroelectric turbine inlets and pass downstream to the tailrace under critical conditions. Thus, the acute mixing zone boundary does not extend downstream from the forebay area.

3.5 Thermal Mixing Zone Request

The text provided in this document constitutes Duke Energy's formal request to SCDHEC to authorize a thermal mixing zone for the Lee Nuclear Station thermal discharge to the Broad River. The technical information presented herein fully addresses South Carolina Regulation 61-68 Water Classifications and Standards as they relate to mixing zones for surface waters (Section C.10.); specifically:

- The size of the requested thermal mixing zone has been reasonably minimized based on the proportion of the discharge flow to receiving waterbody critical 7Q10 flow (i.e., < 4 percent). This will be accomplished through the active

design and construction of a closed-cycle re-circulating cooling water system at Lee Nuclear Station as opposed to an open-cycle, once-through cooling water system.

- The size of the requested mixing zone has been further minimized through the use of a submerged multi-port discharge diffuser that provides rapid mixing of the thermal discharge in the receiving waterbody.

- Considering potential acute thermal affects to aquatic life, under a rare worst case discharge temperature of 95°F concurrent with critical 7Q10 low flow conditions, the areal extent of the ≥ 90°F acute mixing zone is predicted by the conservatively applied CFD modeling to be well within SCDHEC's specified spatial boundaries for such mixing zones of no more than one-tenth (10 percent) of the width of the stream (width) and a length downstream of one-third (33.3 percent) the width of the stream [Reference 22]. The Lee Nuclear Station thermal mixing zone width and length are predicted by the model to be 6 and 19 percent, respectively, of the width of the Broad River at the discharge location.

  Under the same discharge scenario, the cross-sectional area of the ≥ 90°F plume is proportionally 3.7 percent of the total cross-sectional area of the Broad River at the discharge location. In addition, the plume is relatively shallow (97% of the plume is at 5 ft depth or less, and the maximum plume depth is 7.7 ft) so that there is a significant distance between the thermal plume and the bottom of the forebay where fish may escape, or swim under the plume.

  Further, the CFD modeling indicates that under the worse case conditions considered, water temperatures ≥ 90°F will not extend to the Ninety-Nine Islands Hydroelectric Station turbine inlets and pass downstream to the tailrace. Notably, maximum temperature rise at the turbine inlets under modeled conditions is predicted to be < 0.4°F.

  Additionally, travel time for passive organisms through the thermal plume/mixing zone was determined to be approximately 21 minutes for Scenario 1 (95°F discharge temperature), and 4 minutes for Scenario 2 (91°F discharge temperature). Thus, exposure of passive organisms/life stages to water temperatures > 90°F for extended periods of time will not occur under critical conditions.

- Given the small size of the thermal discharge area and acute mixing zone ($\geq$ 90°F) relative to the receiving waterbody, there is no reasonable expectation that the thermal discharge and requested mixing zone would "*result in undesirable aquatic organisms or a dominance of nuisance species outside of the mixing zone*".

- Given there are no federally-listed endangered or threatened aquatic species or habitats in the Broad River in the vicinity of the discharge [Reference 1], there is no reasonable expectation that the requested thermal mixing zone "*would adversely affect a federally-listed endangered or threatened aquatic species, its habitat, or a proposed or designated critical habitat*".

- Based on the small proportion of the discharge flow to receiving waterbody critical 7Q10 flow (i.e., < 4 percent), minimization of the thermal mixing zone to meet SCDHEC spatial requirements for mixing zones, and limited travel time through the plume for passive organisms, the requested thermal mixing zone will allow for safe passage of aquatic organisms and the protection and propagation of a balanced indigenous aquatic community in and on the Broad River.

- The requested mixing zone will not endanger public health and welfare.

The CFD modeling was conservatively applied in this study and demonstrates the minimal impact the Lee Nuclear Station thermal discharge is predicted to have on the thermal regime of the Broad River and Ninety-Nine Islands Reservoir forebay, and associated aquatic communities they support.

Based on the above evidence, Duke Energy requests that SCDHEC authorize a thermal mixing zone as defined for a potential daily average discharge temperature of 95°F, as part of the NPDES permit for the Lee Nuclear Station thermal discharge to the Broad River.

4. WHOLE EFFLUENT TOXICITY MIXING ZONE REQUEST

South Carolina water quality regulations allow mixing zones for discharges to state waters [Reference 14]. A mixing zone is defined in the regulations as:

"…*an area where a discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient waterbody. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented (except as defined within a Zone of Initial Dilution) and public health and welfare are not endangered.*"

Zone of Initial Dilution is defined as:

"*that minimal area of a mixing zone immediately surrounding the outfall where water quality criteria are not met, provided there is no acute toxicity to drifting organisms and public health and welfare are not endangered.*"

As an applicant for an NPDES point source discharge permit in South Carolina, SCDHEC provided Duke Energy with procedures for requesting a WET Mixing Zone [Reference 22], including a form to be completed and submitted as part of the NPDES permit application package for Lee Nuclear Station. Completion of the form provides SCDHEC with information needed to determine mixing zone size for chemical constituents potentially present in the Lee Nuclear Station discharge and associated WET requirements.

CORMIX is a common water quality model used by SCDHEC and other regulatory permitting agencies to determine mixing zone size and other attributes to establish WET requirements. In the case of the Lee Nuclear Station submerged multi-port discharge diffuser, the orientation of the discharge diffuser parallel to ambient flow along the Ninety-Nine Islands Dam precluded the use of the more traditional CORMIX model to determine mixing zone size (see discussion in Section 3.1). Consequently, Geosyntec employed CFD modeling to accomplish this task. The results thereof are summarized in the following text.

4.1 Computational Fluid Dynamics Modeling – Approach

4.1.1 Overview

Modeling was conducted to evaluate mixing characteristics of the discharge with the Broad River, and determine spatial dimensions of the mixing zone. The CFD model used was similar to that reported above for the thermal discharge analyses (see Section 3). The geometry and computational mesh were unchanged and are shown in Figure 2 through Figure 5 for reference. To evaluate the mixing of the cooling water with the ambient water of the Broad River, a "passive scalar" approach (physically similar to a dye tracer) was used, as the concentration of constituents was low enough that they would have no significant effect on the overall flow field. A source for this passive scalar was imposed on the volume representing the discharge diffuser. From the concentration of the passive scalar at each point in the flow field, relative to the initial concentration, the dilution of the diffuser discharge could be determined.

The model was run in transient mode to capture the pulsed operation of the turbines. As with the previous effort, the diffuser discharge was applied as a mass source at the location of the diffuser and allowed to diffuse equally in all directions. This will tend to result in conservative results for the mixing zones as the momentum induced by the multi-port discharge diffuser will be greater in reality than in the model. This increase in momentum will encourage entrainment of ambient water and enhance mixing. As a result, the under-representation of momentum in the CFD model is conservative.

4.1.2 Definition of Dilution Ratio

To evaluate mixing, a "dilution ratio" was defined that represented the total number of parts of fluid (background plus discharge) to the number of parts of discharge fluid only. Thus, a dilution ratio of one represents fluid that is purely from the discharge, while a dilution ratio of four indicates three parts background to one part discharge fluid. A useful alternative view is that a dilution ratio of one represents a 100 percent concentration of discharge fluid, while a dilution ratio of four indicates a 25 percent concentration. This is particularly useful as the discharge fluid concentration is a direct output of the CFD model, so that the dilution ratio, *r*, can be calculated using:

$$r = \frac{1}{C_S} \tag{1}$$

where C_s is the concentration of the passive scalar (in the CFD model, the initial passive scalar concentration is 1 so that the above equation holds).

4.1.3 Scenarios Modeled

Similar to modeling of the thermal discharge, the two CFD calculations (scenarios or cases) were performed with the following variables common to both cases:

- River flow rate was set to 464 cfs in accordance with the 7Q10 level specified by SCDHEC for the NPDES permitting [Reference 13];
- River temperature (background) was set to 88.2°F as determined from Duke Energy continuous water temperature data collected in the Ninety-Nine Islands forebay during June-August 2008 (when 7Q10 flows might be expected to occur) [Reference 21];
- Turbine flow rate was set to 500 cfs when “on” and 53 cfs when “off” (due to leakage through the turbine penstock);
- Ninety-Nine Islands Hydroelectric Station turbine operation:
  - Only 1 turbine unit is in operation.
  - The unit is “off” for the first 4.3 minutes per hour, flow accumulates in the forebay and only leakage flow passes to the tailrace. The unit is “on” for the remaining 55.7 minutes per hour. These timings were calculated by considering the balance of the river and turbine flow rates only.
- Lee Nuclear Station discharge rate was set to 18.3 cfs.

The scenarios differed in the temperature of the cooling water discharge which affects water density and associated mixing characteristics. In Scenario 1 the discharge temperature was set to 95°F, while in Scenario 2 it was 91°F.

4.2 Definition of Mixing Zones

Under typical circumstances, SCDHEC requirements [Reference 22] specify that the length of the acute mixing zone (or Zone of Initial Dilution, ZID) extending

downstream should not exceed one-third (33.3 percent) the width of the river and the width of the mixing zone should not exceed one-tenth (10 percent) the width of the river. In addition, the chronic mixing zone should not exceed twice (200 percent) the width of the river in length and should not exceed one-third (33.3 percent) the width of the river in width. However, the nature of the flows in this instance is atypical due to the operation of the nearby hydroelectric power station. For example, under 7Q10 flow conditions, the single operating turbine intake is approximately 175 feet from the end of the discharge diffuser. The flow through the turbine intake must contain discharge fluid at an average concentration of less than 4% (from a simple mass balance calculation of 18 cfs discharge flow and 464 cfs 7Q10 river flow). As the width of the river at this point is approximately 1,031 ft, the turning of the discharge flow into the turbine intake occurs well within the limit of the acute mixing zone length of 344 ft (one-third of 1,031 ft). Downstream of the turbine, the river will maintain a concentration of less than 4% discharge flow.

An alternative definition for the mixing zone is presented that is better suited to the flows in the proximity of the discharge in this case. That is, the volume of fluid with a dilution ratio less than or equal to the lowest value of dilution ratio at the turbine intake. Note that although the average concentration at the turbine intake is around 4%, there is significant spatial variation over intake area. The turbine intake is therefore taken to be the boundary where the highest concentration (or the lowest dilution ratio) is set for the mixing zone.

This approach yields only one value for dilution ratio. It is proposed that this value defines the chronic mixing zone, and the acute mixing zone is not defined.

In both modeling scenarios, an appropriate value of dilution ratio that represented the minimum value at the turbine intake was 5, or 20% concentration. The chronic mixing zone was thus defined as the volume less than, or equal to, a dilution ratio of 5.

4.3 Model Results

Contours of dilution ratio (defined as shown in Equation (1)) for Scenario 1 (95°F discharge temperature) are shown on Figure 18. As expected, the low values of dilution ratio are located close to the discharge diffuser, with the higher values (indicating that the fluid is mostly background) much further away. It should be noted that as the turbine switches on and off during the hourly cycle, the shape of the dilution contours

changes throughout the cycle. However, for the majority of the cycle the plume does not change significantly, and this is referred to as the "steady-state" plume. The results here, and in all other figures, are for this steady-state plume, which is shown after the second hourly cycle in the CFD model. Tests have shown that these results are accurate (in other words the steady-state plume does not increase in size) for subsequent cycles.

Figure 19 shows contours of dilution ratio for Scenario 2 (91°F discharge temperature). The plume in this case is less spread than in Scenario 1. This is due to the difference in discharge temperature in the two scenarios. For Scenario 1 where the discharge temperature is higher, the plume rises to the surface quickly due to its positive buoyancy and then spreads in a relatively thin, shallow layer. The "cooler" discharge in Scenario 2 rises much slower and does not spread as rapidly just below the water surface. Therefore, in general, the cooler plume of Scenario 2 is less spread, but deeper. The differences between the two plumes become greater as the dilution ratio increases.

The volume representing the chronic mixing zone is defined as having a dilution ratio less than or equal to 5 (concentration of 20% or more). A perspective view of the mixing zone looking from above and towards the dam is shown on Figure 20 for Scenario 1 and Figure 21 for Scenario 2. The boundaries of the mixing zone are shown by the solid purple isosurfaces in each figure. Note in particular that the depth of the mixing zones in each case is shallow relative to the depth of the forebay.

4.3.1 Spatial Dimensions of the WET Mixing Zone

Results of the CFD modeling for the chronic mixing zone are summarized in the table below:

	Scenario 1	Scenario 2
River Flow	464 cfs 7Q10 Critical Flow	464 cfs 7Q10 Critical Flow
River Temperature	88.2°F	88.2°F
Discharge Flow	18.3 cfs	18.3 cfs
Discharge Temperature	**95°F**	**91°F**
CHRONIC MIXING ZONE (5:1 dilution, equivalent to 20% concentration)		
- **Volume**	1.25 acre-ft 54,523 ft^3	0.939 acre-ft 40,916 ft^3
- **Surface area**	0.397 acre 17,275 ft^2	0.251 acre 10,936 ft^2
- **Cross-Sectional area**	758 ft^2 4.5% of forebay x-area	932 ft^2 5.5% of forebay x-area
- **Average Depth/Thickness**	1.8 ft	2.0 ft
- **Maximum Depth/Thickness**	12.4 ft	8.5 ft
- **Maximum Width**	72 ft	40 ft
- **Maximum Length**[5]	215 ft	200 ft

[5] Calculated from the end of the discharge diffuser.

There were noted differences in the lateral extent of mixing zones output by the CFD model for the two scenarios considered (Figures 18 and 19). This was the result of changes in density/buoyancy attributable to the two different discharge temperatures modeled. In establishing the mixing zone size for the WET Mixing Zone request, worst case maximum dimensions for length and width were used from each of the scenarios modeled.

Recall from the thermal mixing zone request narrative that the Lee Nuclear Station discharge diffuser is different than the conventional configuration where the discharge diffuser extends laterally from shore and is positioned perpendicular to river flow (see Section 3.1). In this case, plume length runs parallel to the longitudinal centerline of the diffuser pipe (i.e., easterly); and width as perpendicular to the diffuser (i.e., northerly). As determined from the CFD model, the worst case maximum lateral dimensions of the chronic mixing zone are 72 ft in width and 215 ft in length (7% and 21% of the river width respectively).

As for the thermal mixing zone described previously, it is also important to consider the vertical profile of the mixing zone as the lateral dimensions of maximum length and width perhaps overstate the potential impact on aquatic organisms that might be exposed to acute and chronic conditions. Although the maximum depth of the chronic mixing zone (extending from the surface downward) is 12.4 ft, only a small proportion of the mixing zone is at that depth. Specifically, 90 percent of the mixing zone volume is found at 4 ft depth or less for Scenario 1. The same was found for Scenario 2. The average depth/thickness of the chronic mixing zone is just 1.8 ft for Scenario 1 and 2.0 ft to Scenario 2.

The relative profile of the mixing zones is further demonstrated by considering cross-section area, which for the chronic mixing zone is just 4.5 and 5.5 percent of the total forebay cross-sectional area for Scenarios 1 and 2, respectively.

Thus, given the relatively small lateral dimensions and cross-sectional profile of the mixing zone modeled under very conservative conditions, there is limited potential exposure to acute and chronic conditions for free-swimming fish or benthic organisms and their passive life stages.

As presented earlier (Section 3.4), EPA guidance provides that the area extent and concentration isopleths of a mixing zone must be such that the 1-hour average exposure

of organisms passing through the mixing zone is less than the acute criteria [Reference 23]. Based on this guidance, the potential lethality to passive organisms from acute exposure within the chronic mixing zone was determined.

The average velocity in the steady-state plume was obtained from the CFD model and divided into the greatest length of the mixing zone (215 ft) to estimate potential travel time through the zone for a passive organism. For Scenario 1 (95°F discharge), the average velocity was estimated at 0.16 ft/s. As such, travel time through the plume was determined to be approximately 22 minutes. For Scenario 2 (91°F), the average velocity was also 0.16 ft/s. The length of the plume is 200 ft so travel time is 21 minutes. Thus, no passive organisms/life stages will remain in the mixing zone for extended periods of time and certainly not an hour.

Again, determination of velocities throughout the plume is a complex exercise given the dynamic conditions in the forebay. However, the analysis is believed conservative in that the conditions considered (i.e., flow velocities) have been determined for the steady state condition of the plume under rare pulsed-flow conditions. Under typical continuous operation of the Ninety-Nine Islands hydroelectric facility turbines, ambient and turbine-induced flows would be expected to substantially reduce travel time for passive organisms through the mixing zone.

Further, as previously stated, including the enhanced mixing properties afforded by the high-velocity multi-port diffuser not fully considered by the CFD model (see Section 3.3) will further diminish the size of the mixing zones reported herein and lessen exposure for passive organisms.

4.3 Whole Effluent Toxicity Parameters

Duke Energy is requesting a WET mixing zone be authorized for the Lee Nuclear Station discharge to the Broad River and has completed the SCDHEC-provided WET Mixing Zone Request Form. Information requested on the SCDHEC form is repeated here with supporting narrative.

What is the proposed ZID size (in meters)? N/A

Please refer to the site-specific definition of mixing zone given in Section 4.2 of this report.

What is the proposed acute WET test concentration? N/A

Please refer to the site-specific definition of mixing zone given in Section 4.2 of this report.

What is the proposed mixing zone size (in meters)? Length 66 m x Width 22 m

This proposed mixing zone size is deemed necessary to allow for adequate mixing of the discharge to the edge of the mixing zone defined by the turbine intake, and was conservatively determined based on the CFD model output.

What is the proposed chronic WET test concentration? 20.0 percent

A representative value for minimum dilution at the turbine intake was calculated as 5, corresponding to a WET test concentration of 20%.

4.4 WET Mixing Zone Request

In addition to the completed SCDHEC WET Mixing Zone Request Form, this document constitutes Duke Energy's formal request to SCDHEC to authorize a WET mixing zone for the Lee Nuclear Station discharge to the Broad River. The technical information presented herein fully addresses South Carolina Regulation 61-68 Water Classifications and Standards as they relate to mixing zones for surface waters (Section C.10.); specifically:

- The size of the requested mixing zone has been reasonably minimized based on the proportion of the discharge flow to receiving waterbody critical 7Q10 flow (i.e., < 4 percent).

- The size of the requested mixing zone has been further minimized through the use of a submerged, multi-port discharge diffuser that provides rapid mixing of the discharge in the receiving waterbody.

- Initial analysis showed that the spatial dimensions of the acute mixing zone (based on a maximum width of 10% of the width of the river and a maximum length of 33% of the width of the river) almost entirely contained the discharge plume due to the turning of the flow towards the turbine. Thus the turbine intake

was defined as the maximum extent in this case for the chronic mixing zone, while no definition or dimensions were given for the acute mixing zone.

- The spatial dimensions of the chronic mixing zone fall well within SCDHEC's specified spatial boundaries for such mixing zones of no more than one-third (33.3 percent) the width of the river (width) and a length downstream of twice (200 percent) the width of the river [Reference 22]. For the Lee Nuclear Station discharge, the length and width of the chronic mixing zone represent approximately 21 percent and 7 percent respectively of the width of the Broad River at the forebay of the dam.

- The cross-sectional areas of the mixing zones modeled relative to the total forebay cross-sectional area were small, ranging from 4.5 to 5.5 percent. As such, there is limited potential exposure to chronic conditions for free-swimming fish and their passive life stages.

- Travel time through the acute mixing zone under each discharge scenario was determined to be approximately 20 minutes. Thus, no passive organisms/life stages will be exposed remain in the chronic mixing zone for extended periods of time (well less than an hour).

- Given the small size of the discharge area and requested mixing zone relative to the receiving waterbody, there is no reasonable expectation that the Lee Nuclear Station discharge would "*result in undesirable aquatic organisms or a dominance of nuisance species outside of the mixing zone.*"

- Given there are no federally-listed endangered or threatened aquatic species or habitats in the Broad River in the vicinity of the discharge [Reference 1], there is no reasonable expectation that the requested mixing zone "*would adversely affect a federally-listed endangered or threatened aquatic species, its habitat, or a proposed or designated critical habitat.*"

- Based on the small proportion of the discharge flow to receiving waterbody critical 7Q10 flow (i.e., < 4 percent), minimization of the mixing zone to meet SCDHEC spatial requirements for mixing zones, and limited travel time through the plume for passive organisms, the requested mixing zone will allow for safe

passage of aquatic organisms, and allow for the protection and propagation of a balanced indigenous aquatic community in and on the Broad River.

- The requested mixing zone will not endanger public health and welfare.

Based on the above weight of evidence, Duke Energy requests that SCDHEC authorize a WET mixing zone as defined in this request for outfall 001. In summary a WET limit for outfall 001 is requested to be for chronic testing only at a Chronic Test Concentration of 20%.

5. REFERENCES

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FIGURES

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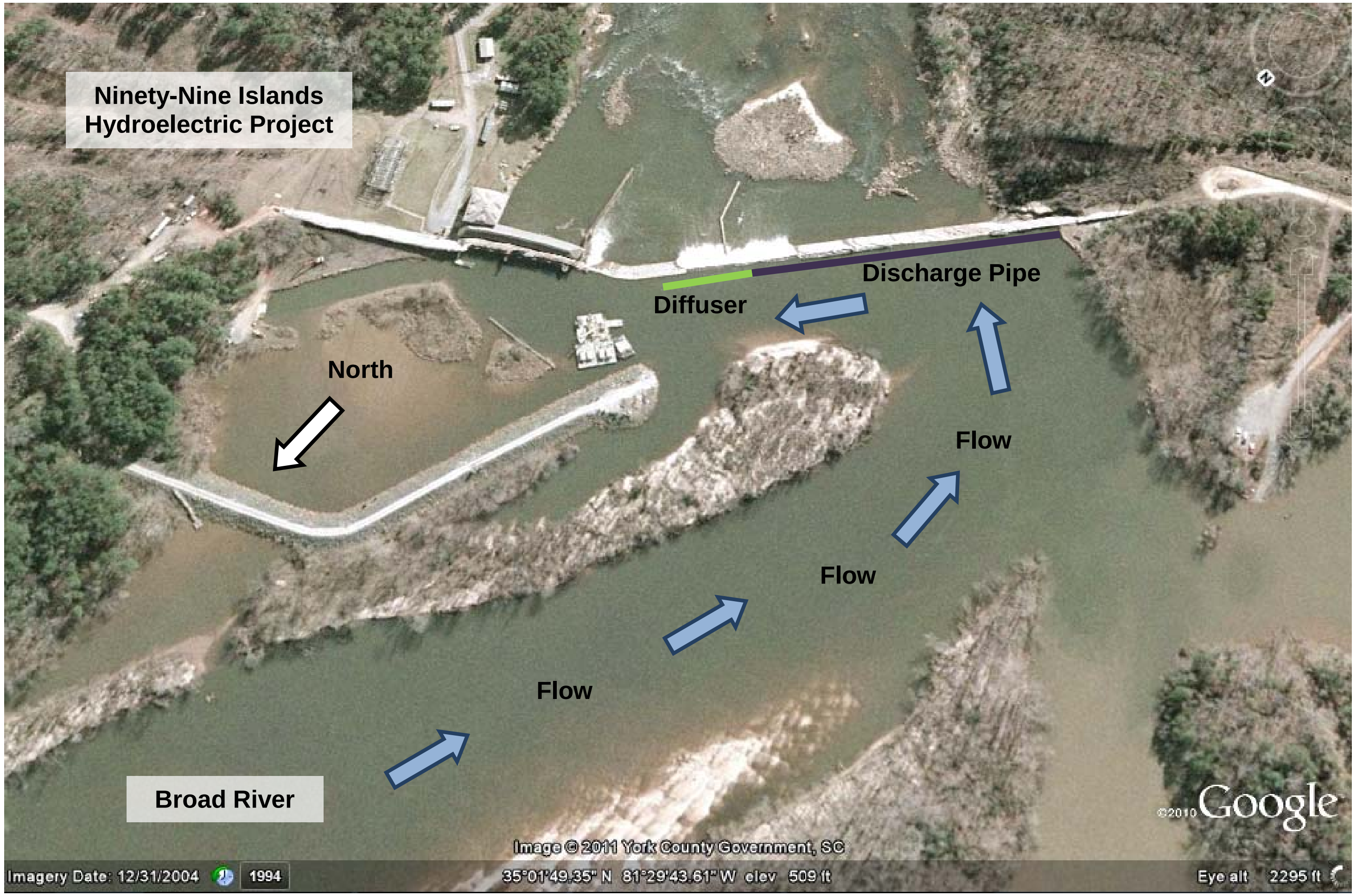

Figure 1 – Plan view of the geometry used in the CFD model

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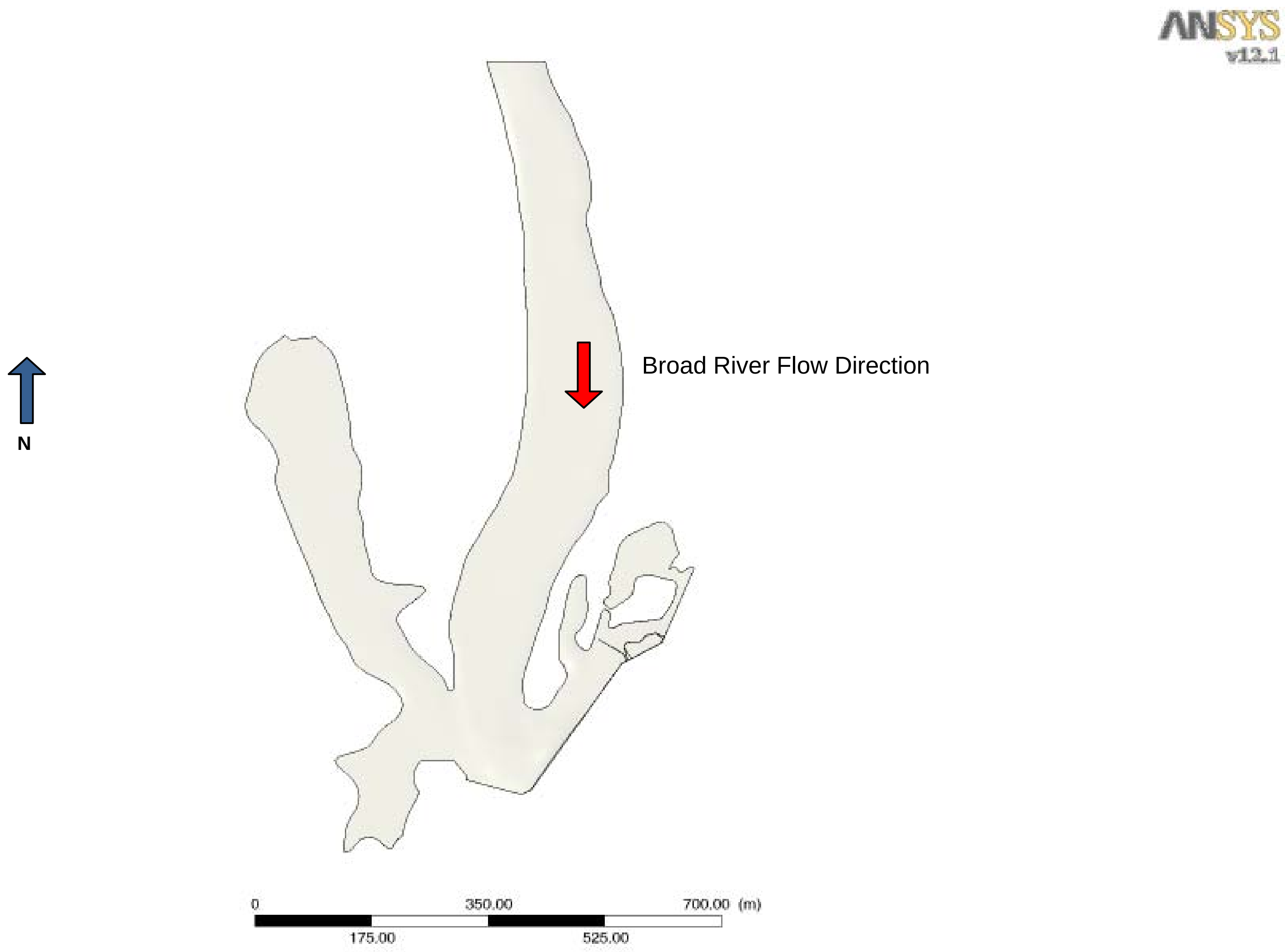

Figure 2 – Plan view of the geometry used in the CFD model

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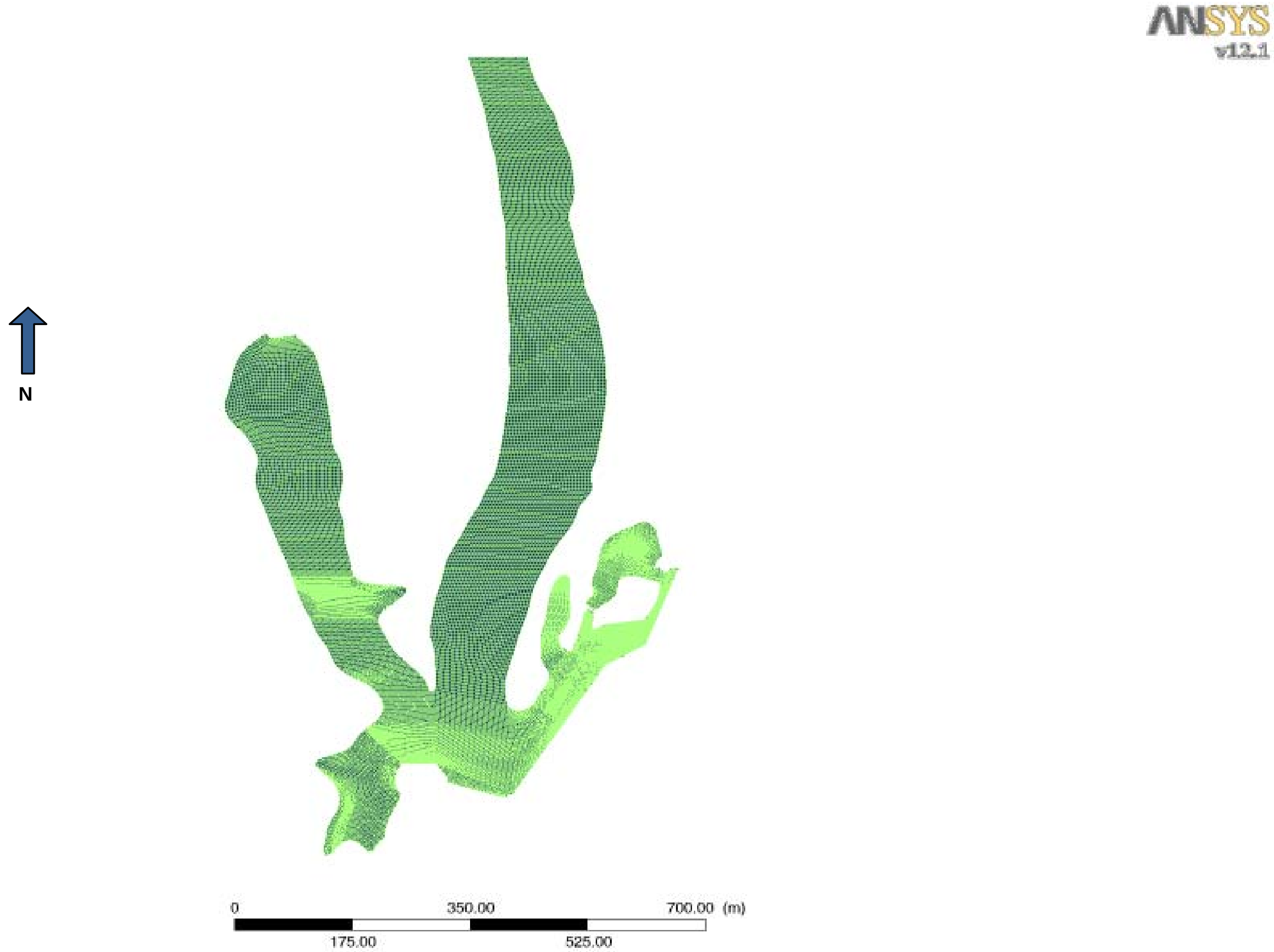

Figure 3 – Computational Mesh

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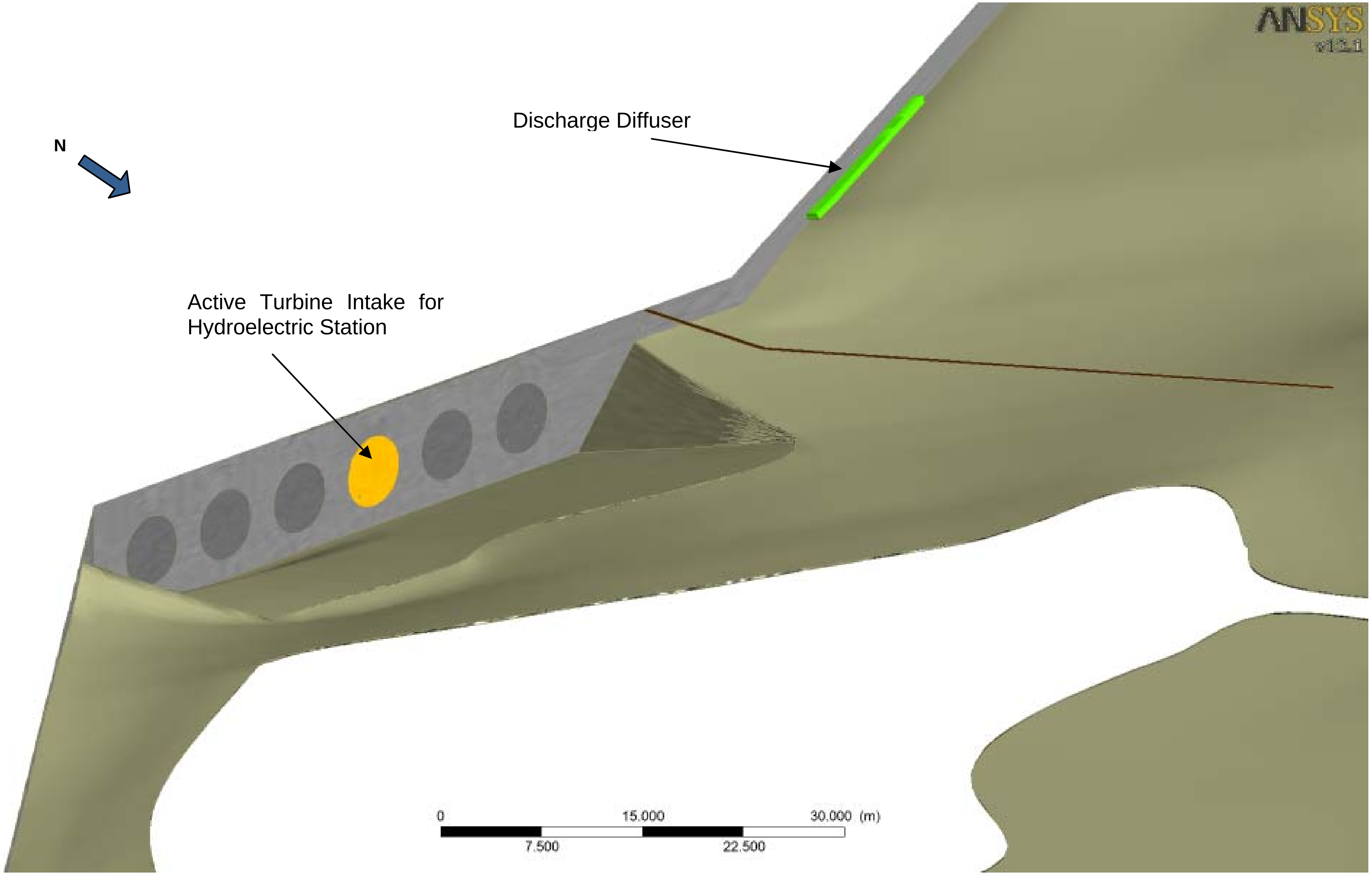

Figure 4 – Close view of geometry, showing forebay, dam, turbine openings
(turbine 4 is colored orange) and volume representing the discharge diffuser (green).

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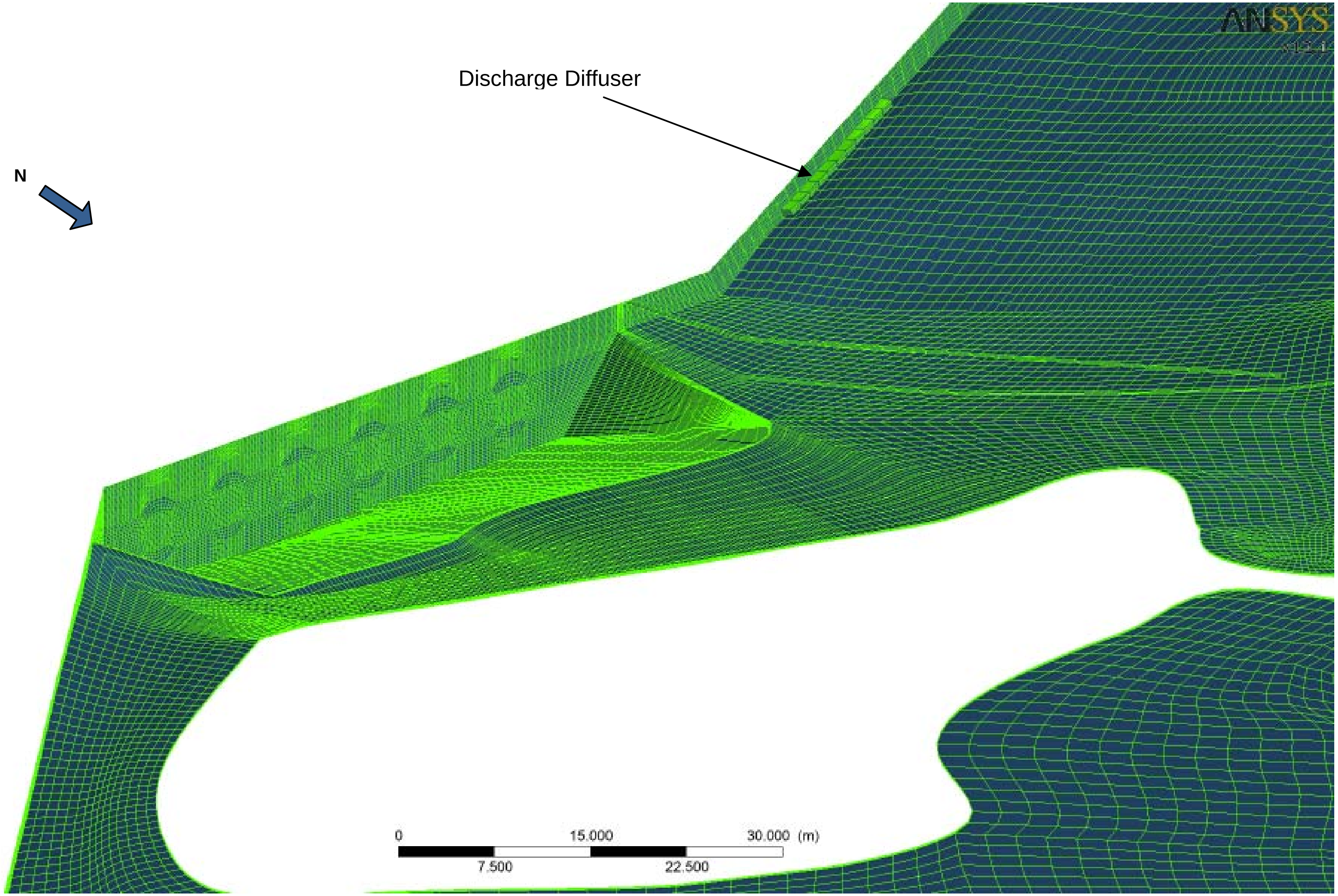

Figure 5 – Close view of the computational surface mesh in the forebay.

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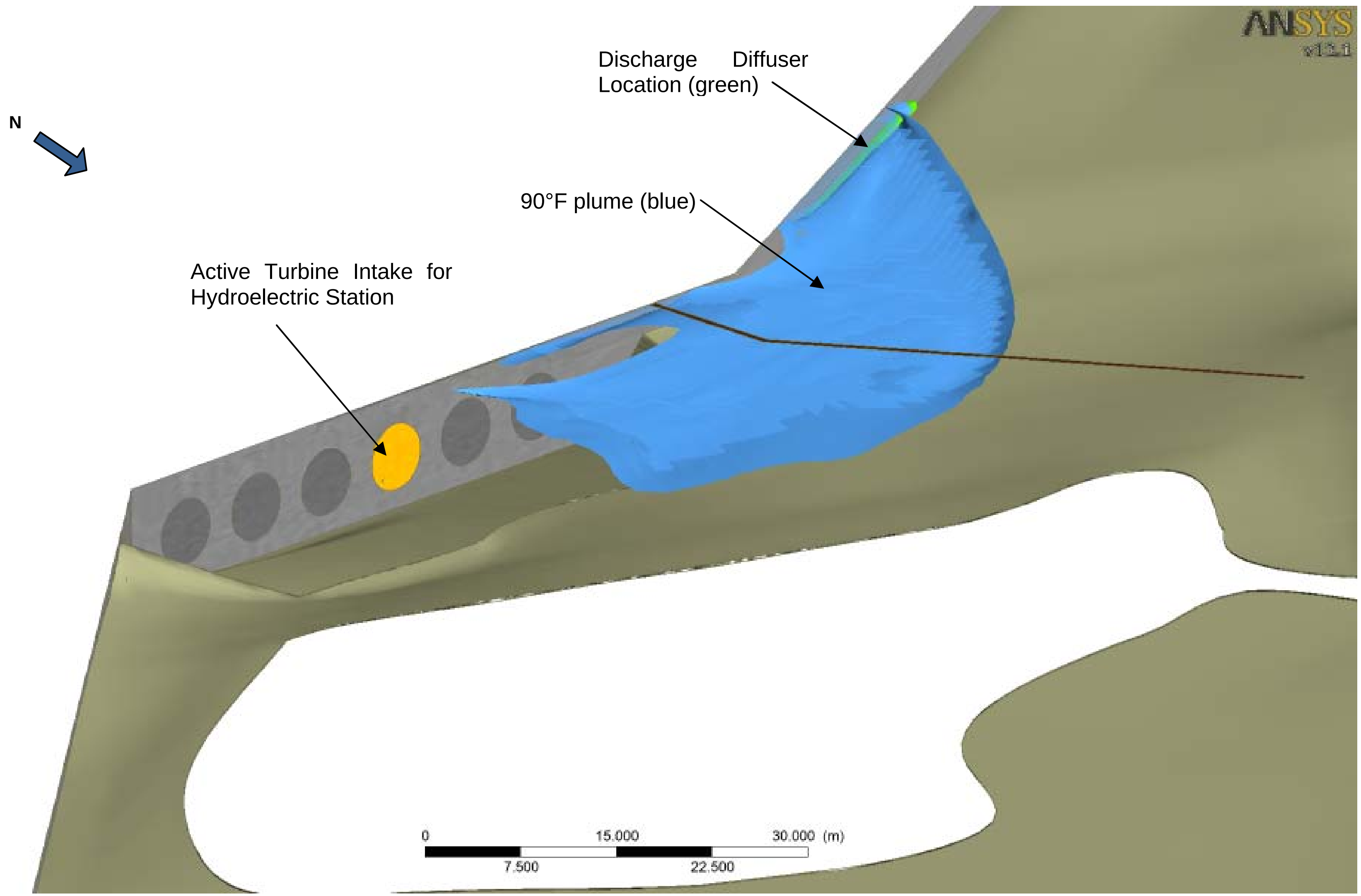

Figure 6 – Blue iso-surface showing 90°F plume for Scenario 1, 20 minutes into cycle 1.

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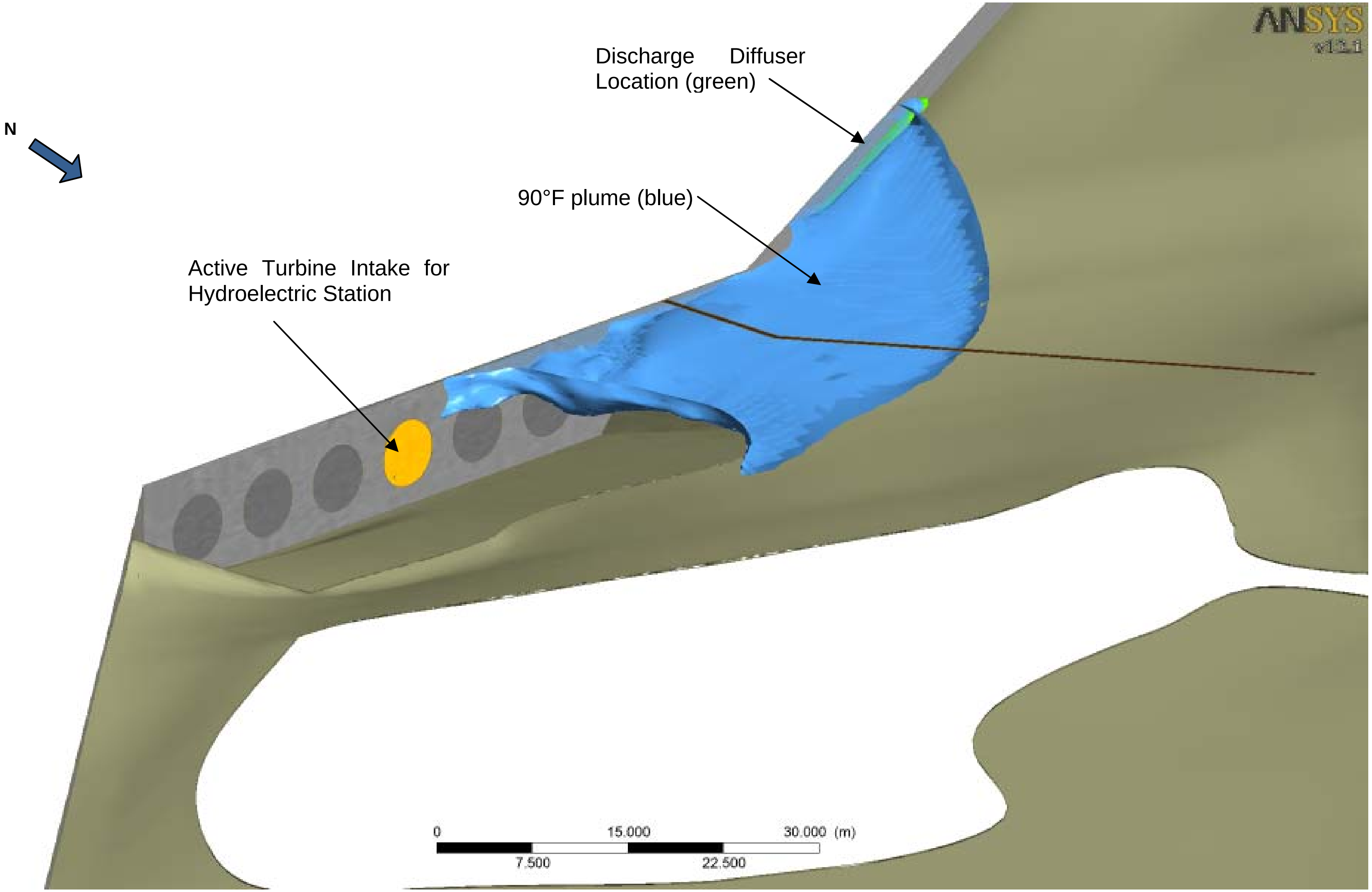

Figure 7 – Blue iso-surface showing 90°F plume for Scenario 1, end of cycle 1.

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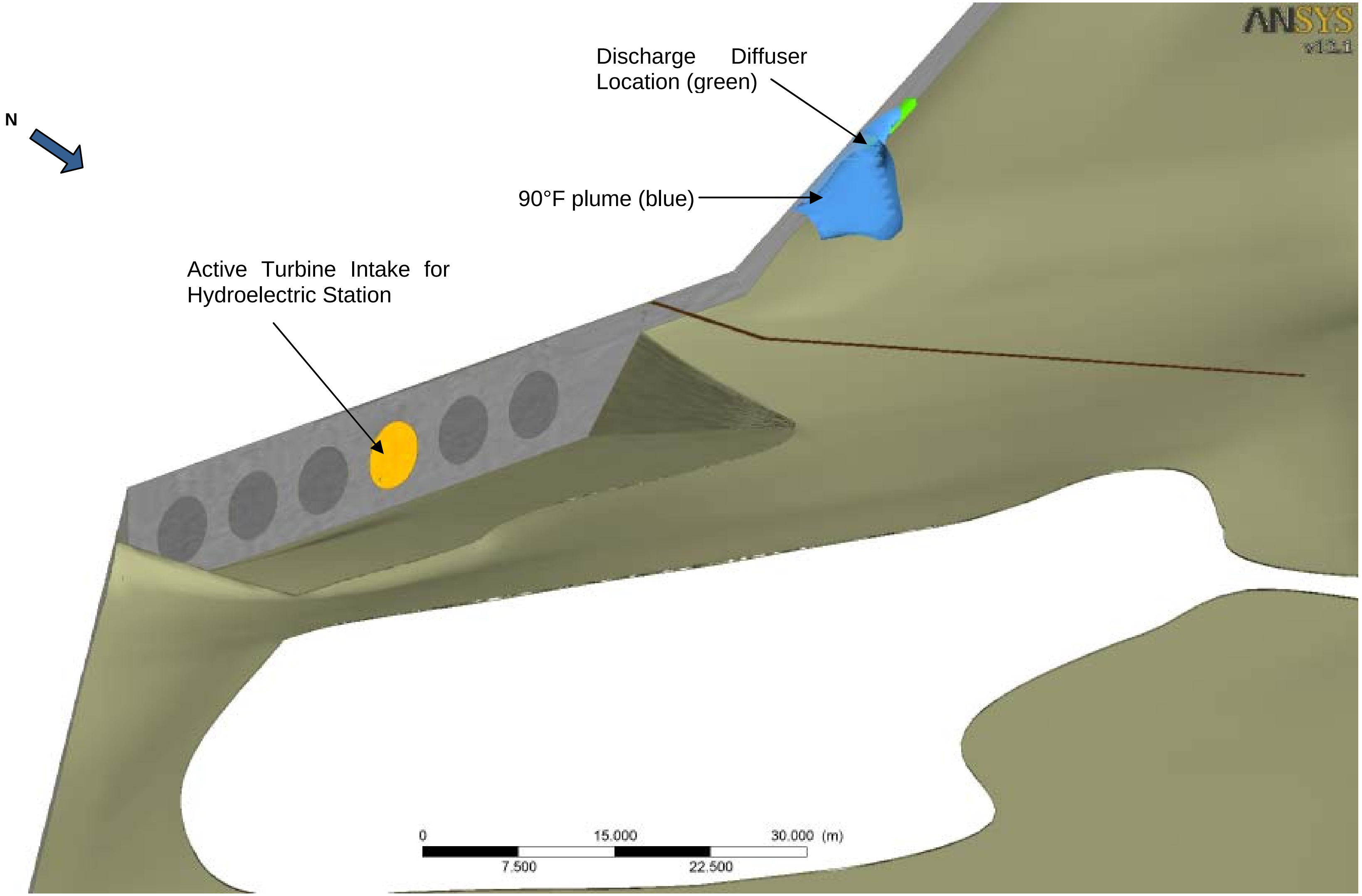

Figure 8 – Blue iso-surface showing 90°F plume for Scenario 2, 20 minutes into cycle 1.

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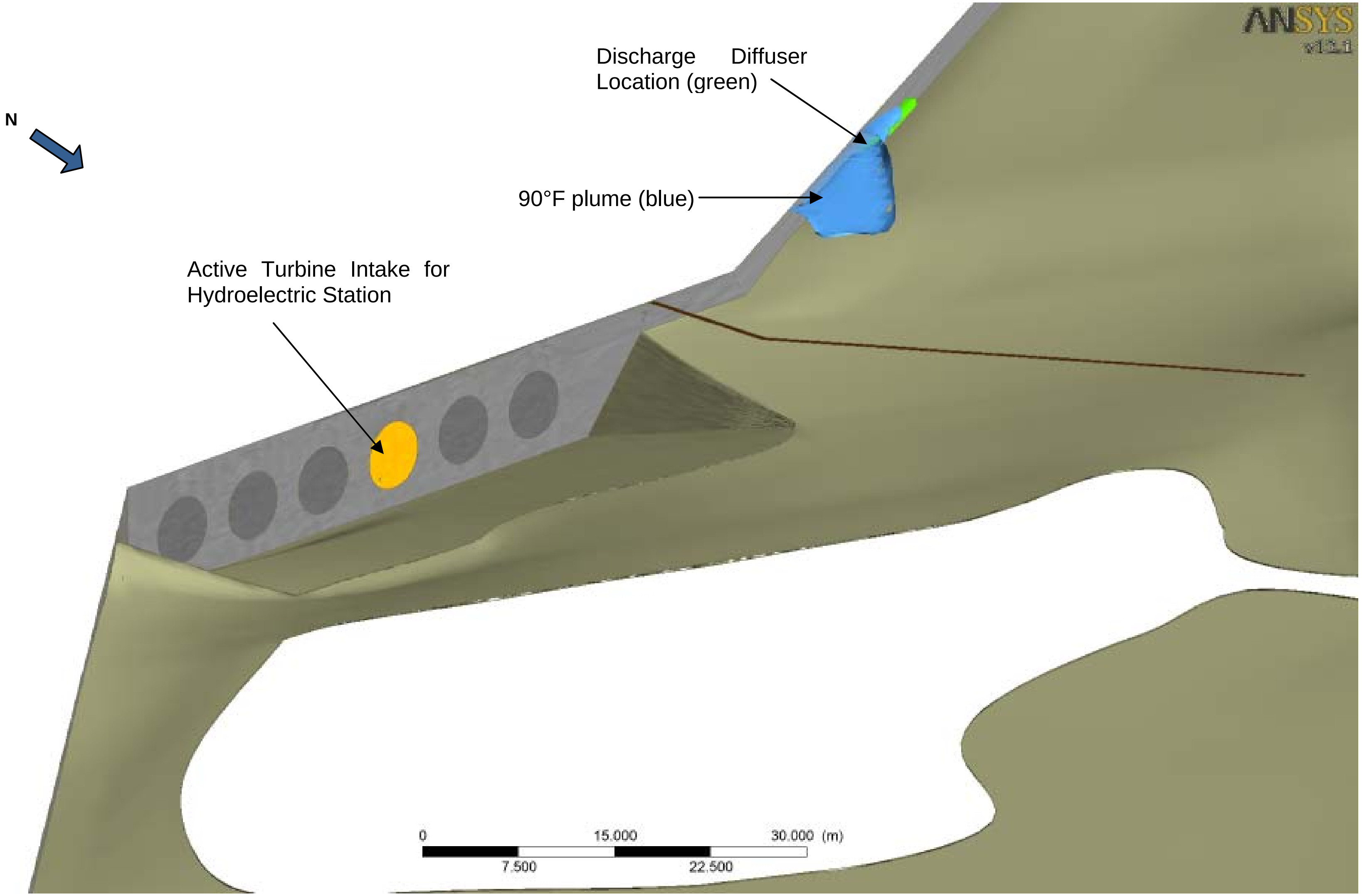

Figure 9 – Blue iso-surface showing 90°F plume for Scenario 2, end of cycle 1.

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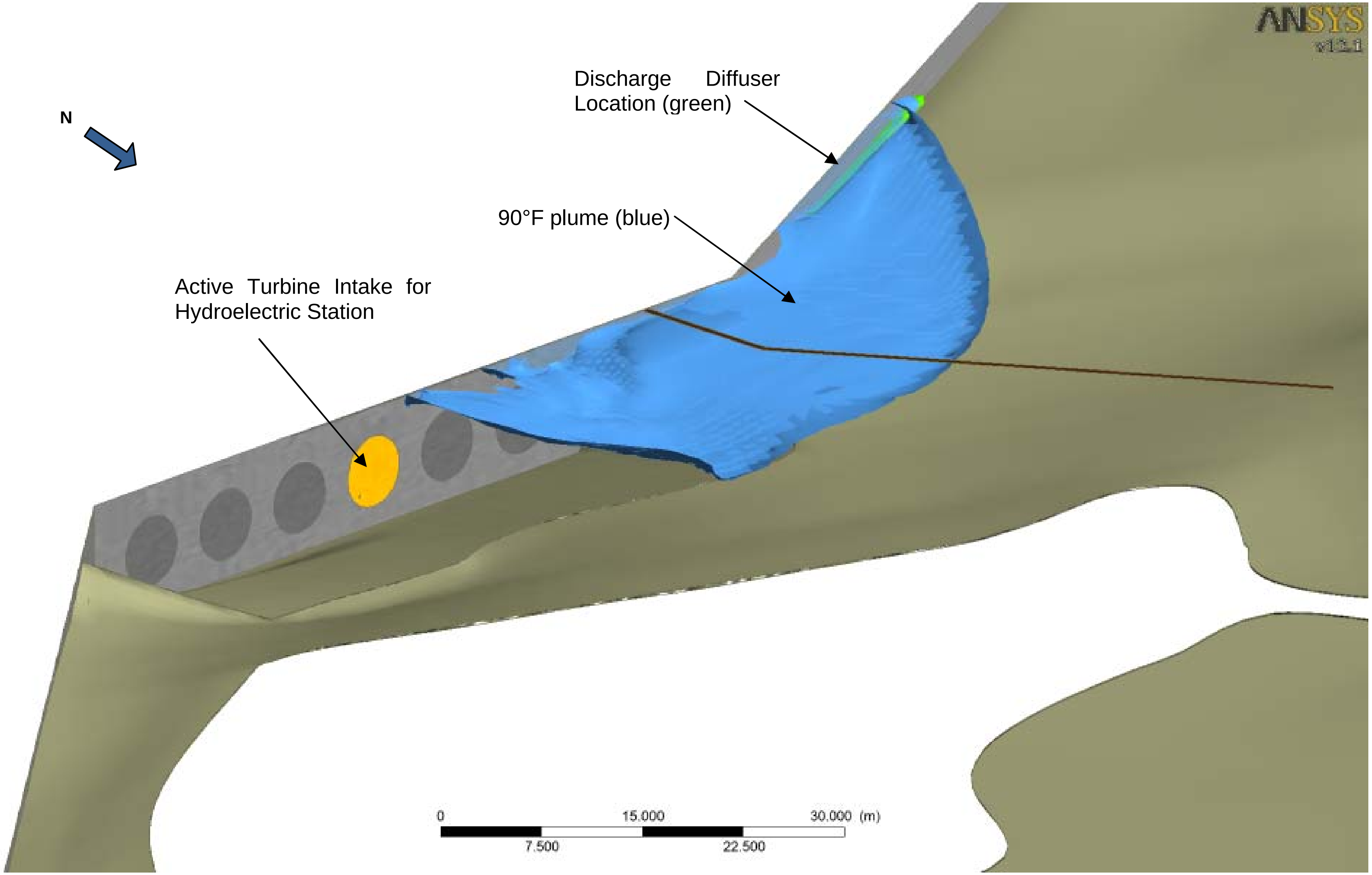

Figure 10 – Blue iso-surface showing steady-state 90°F plume for Scenario 1.

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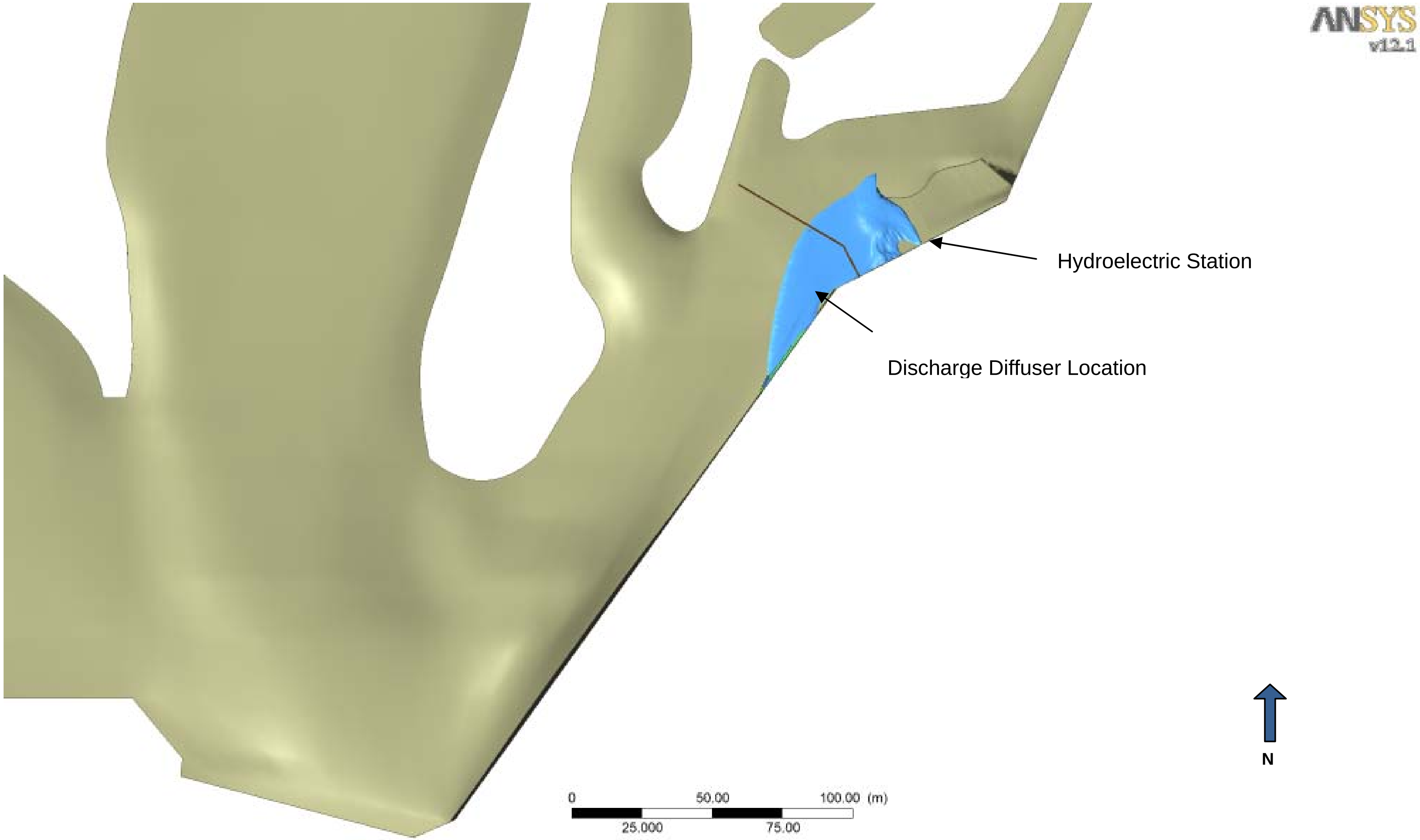

Figure 11 – Blue iso-surface showing steady-state 90°F plume for Scenario 1, plan view

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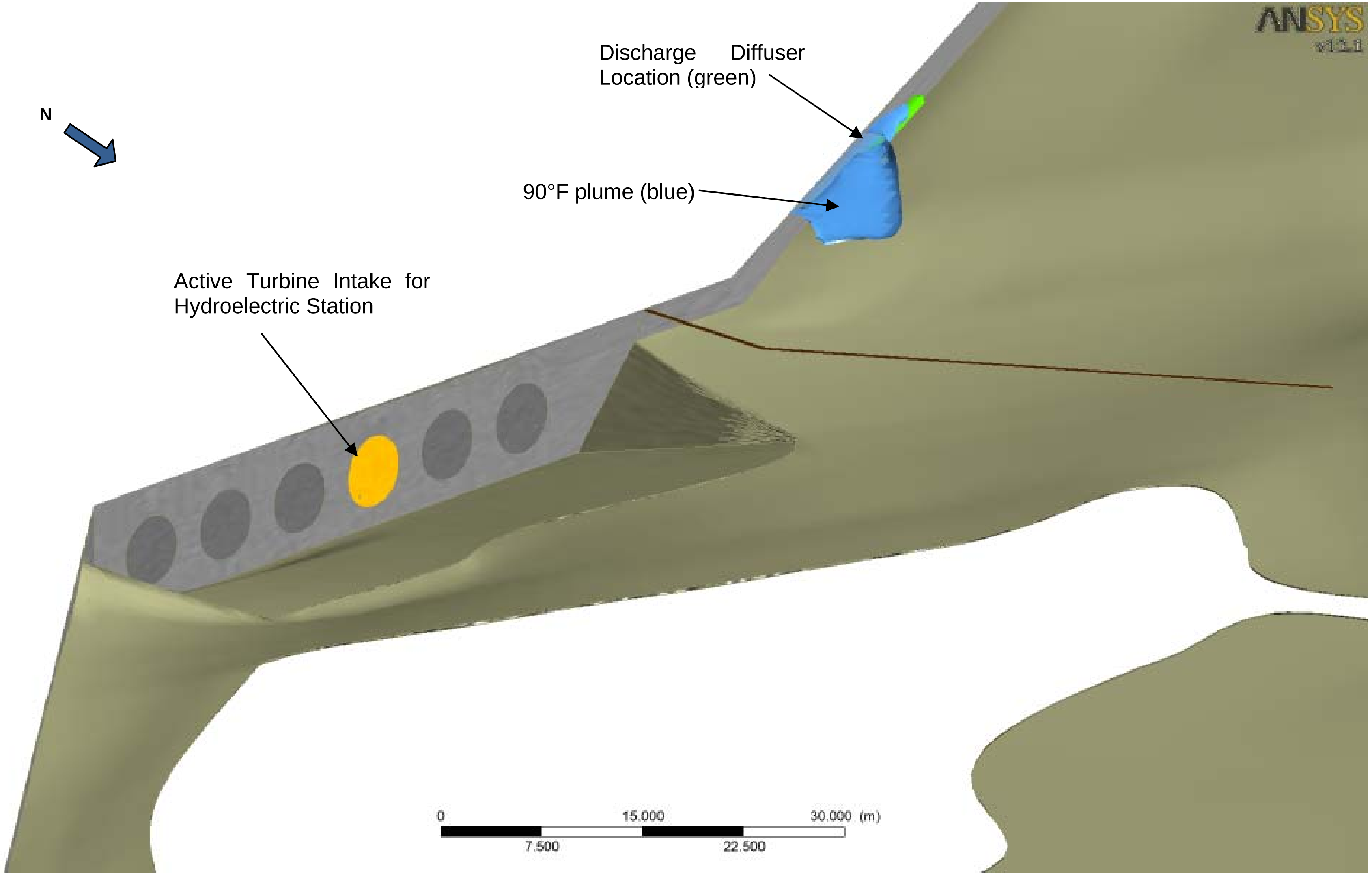

Figure 12 – Blue iso-surface showing steady-state 90°F plume for Scenario 2.

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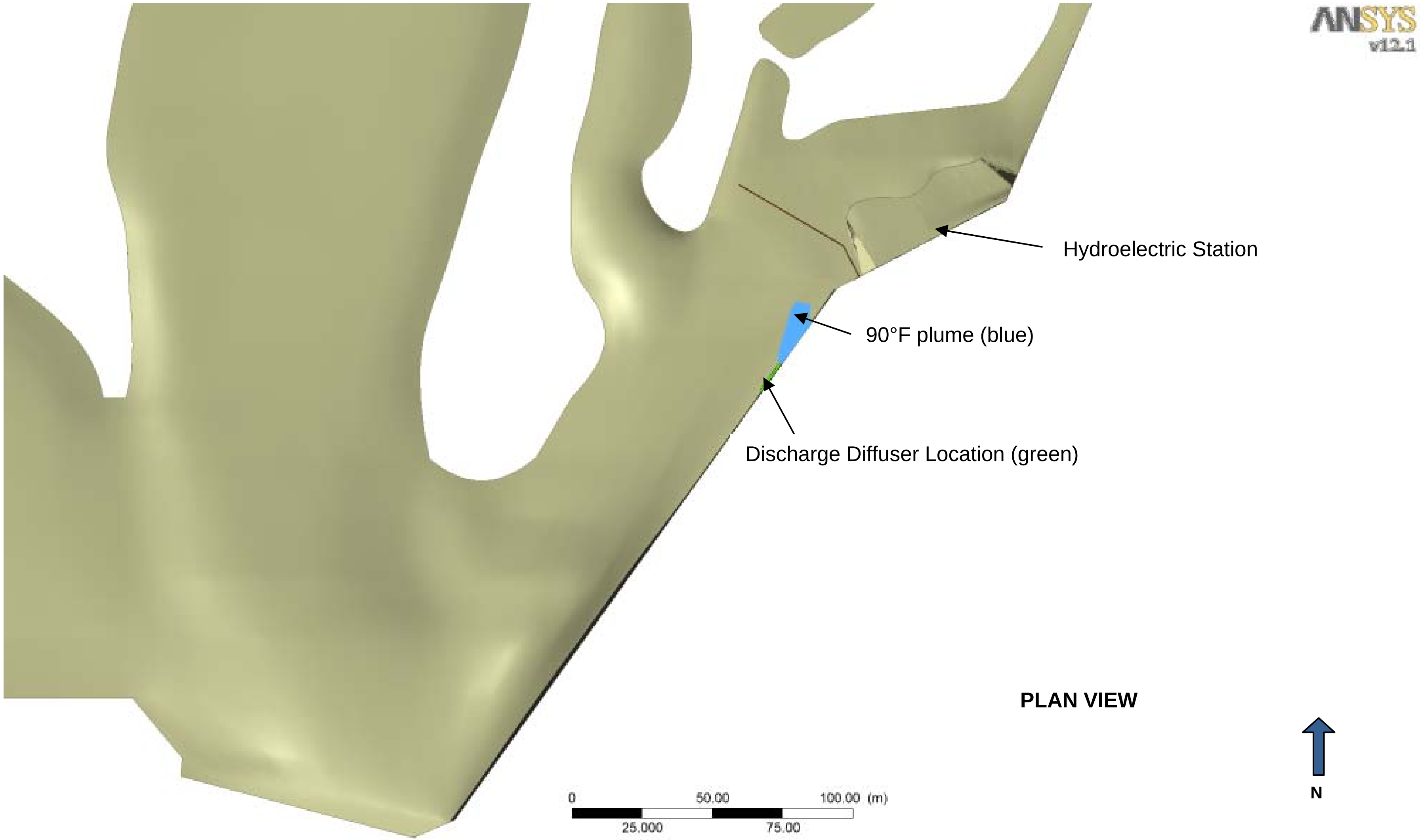

Figure 13 – Blue iso-surface showing steady-state 90°F plume for Scenario 2, plan view

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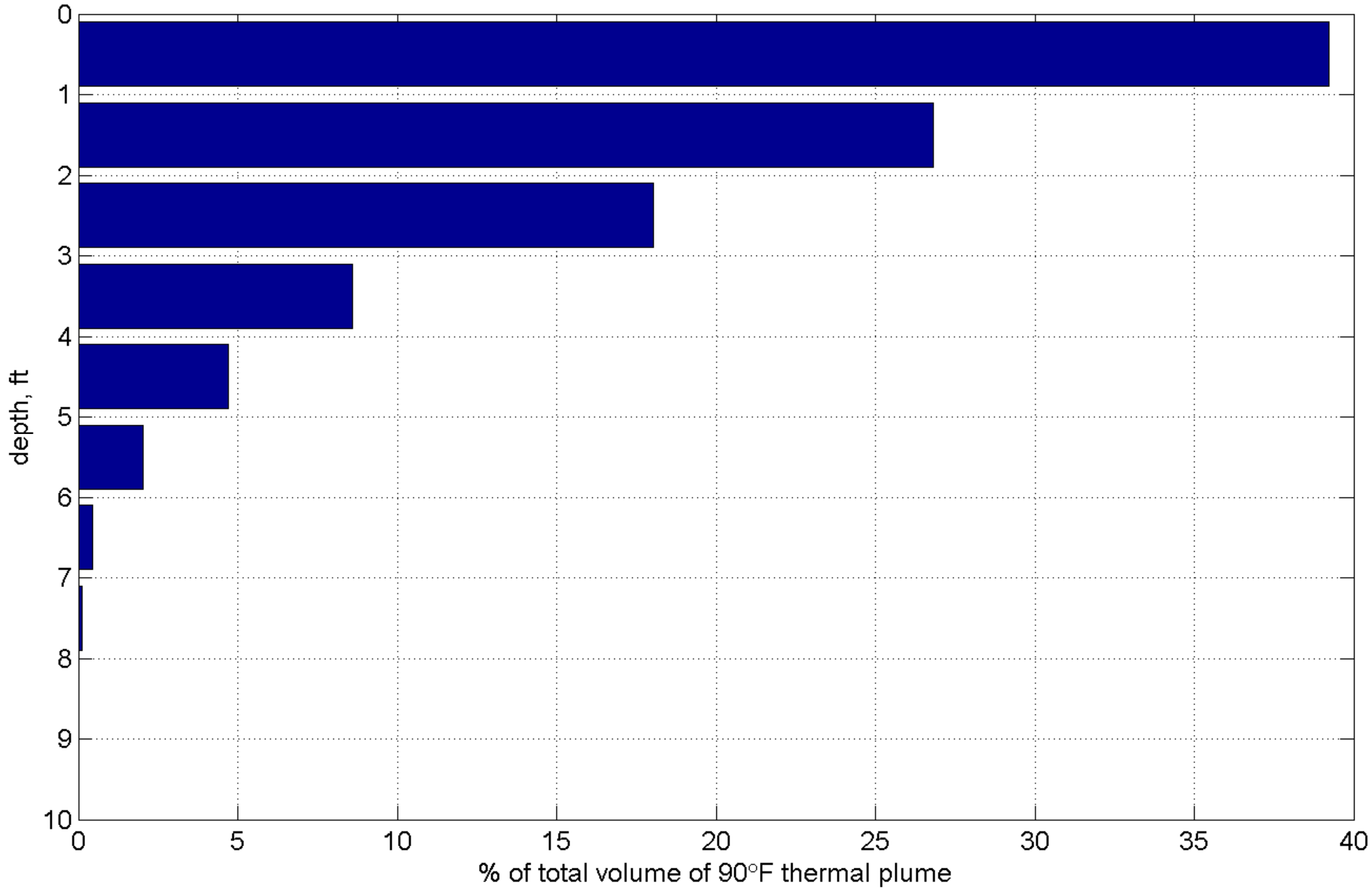

Figure 14 – Bar chart showing percent plume volume against depth for Scenario 1.

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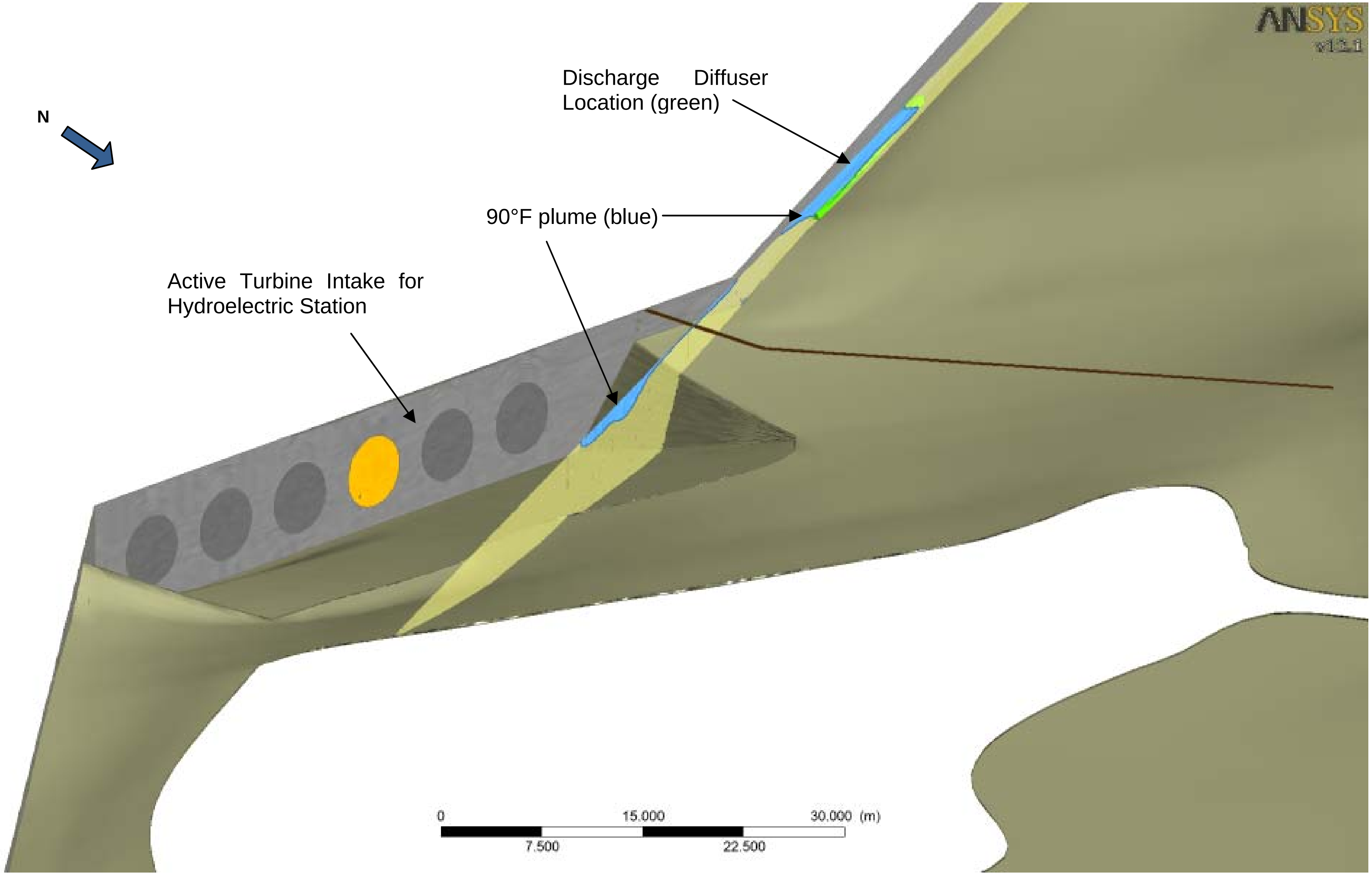

Figure 15 – Blue area showing cross-section of steady-state 90°F plume for Scenario 1.

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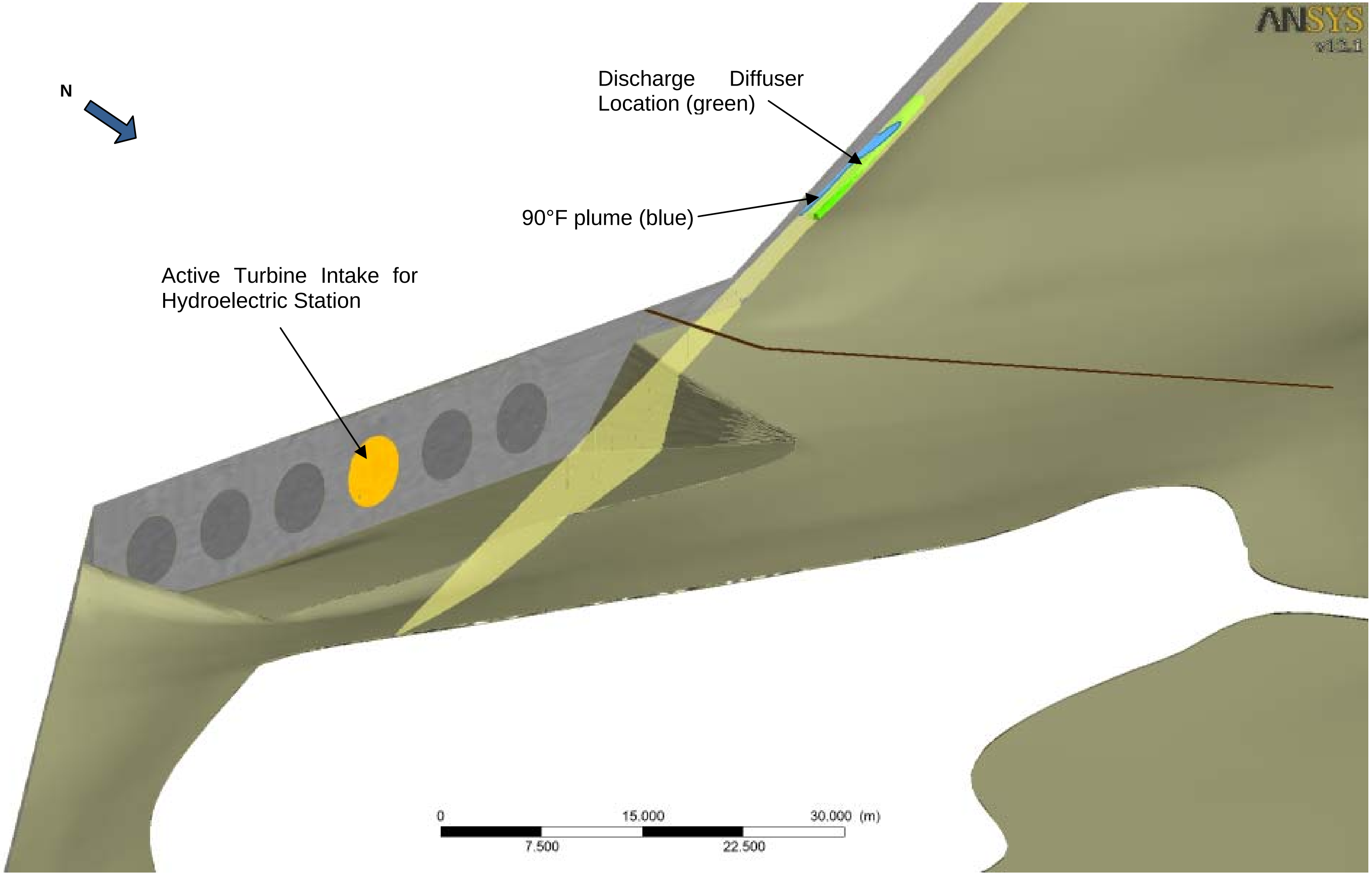

Figure 16 – Blue area showing cross-section of steady-state 90°F plume for Scenario 2.

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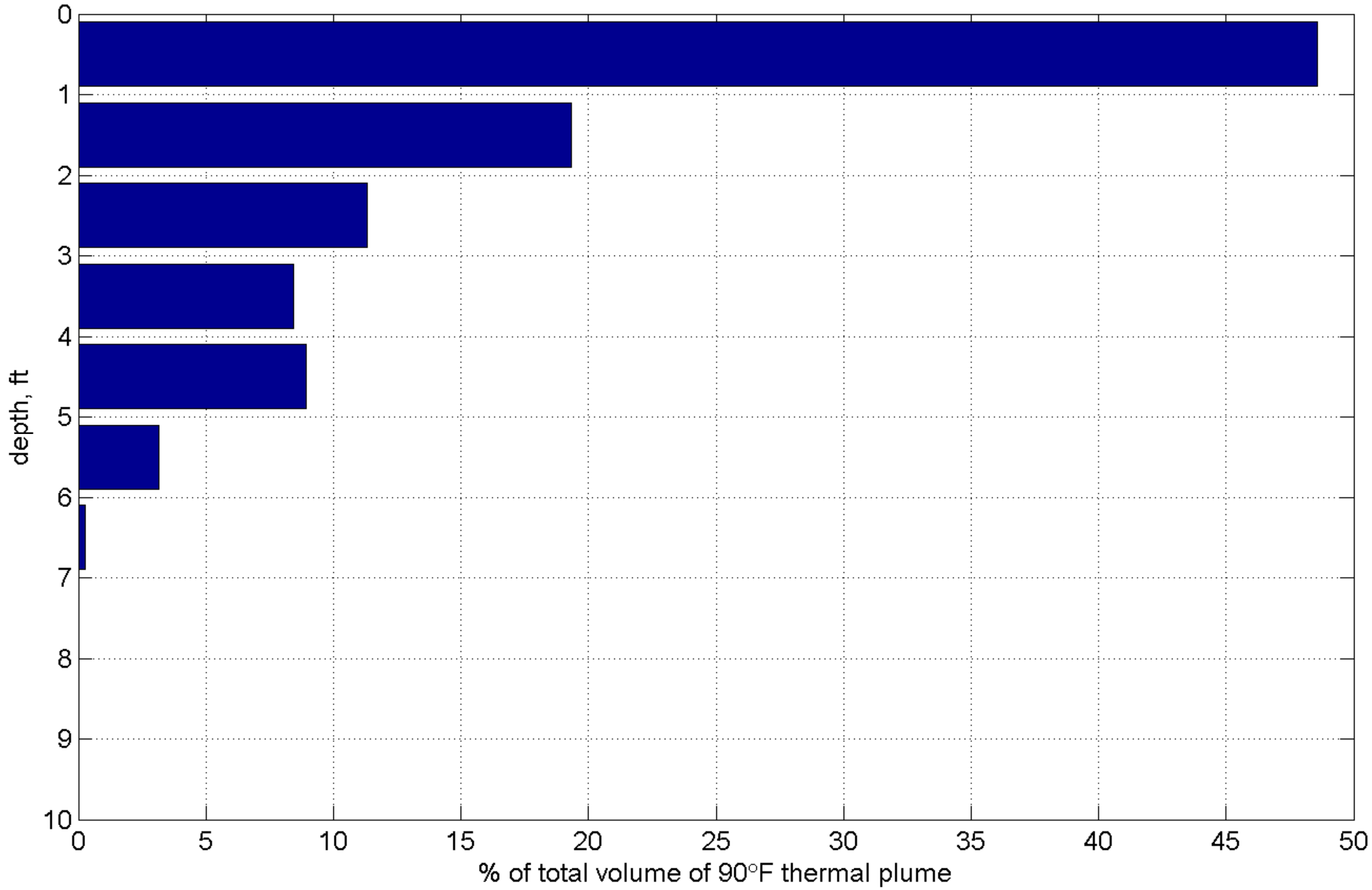

Figure 17 – Bar chart showing percent plume volume against depth for Scenario 2.

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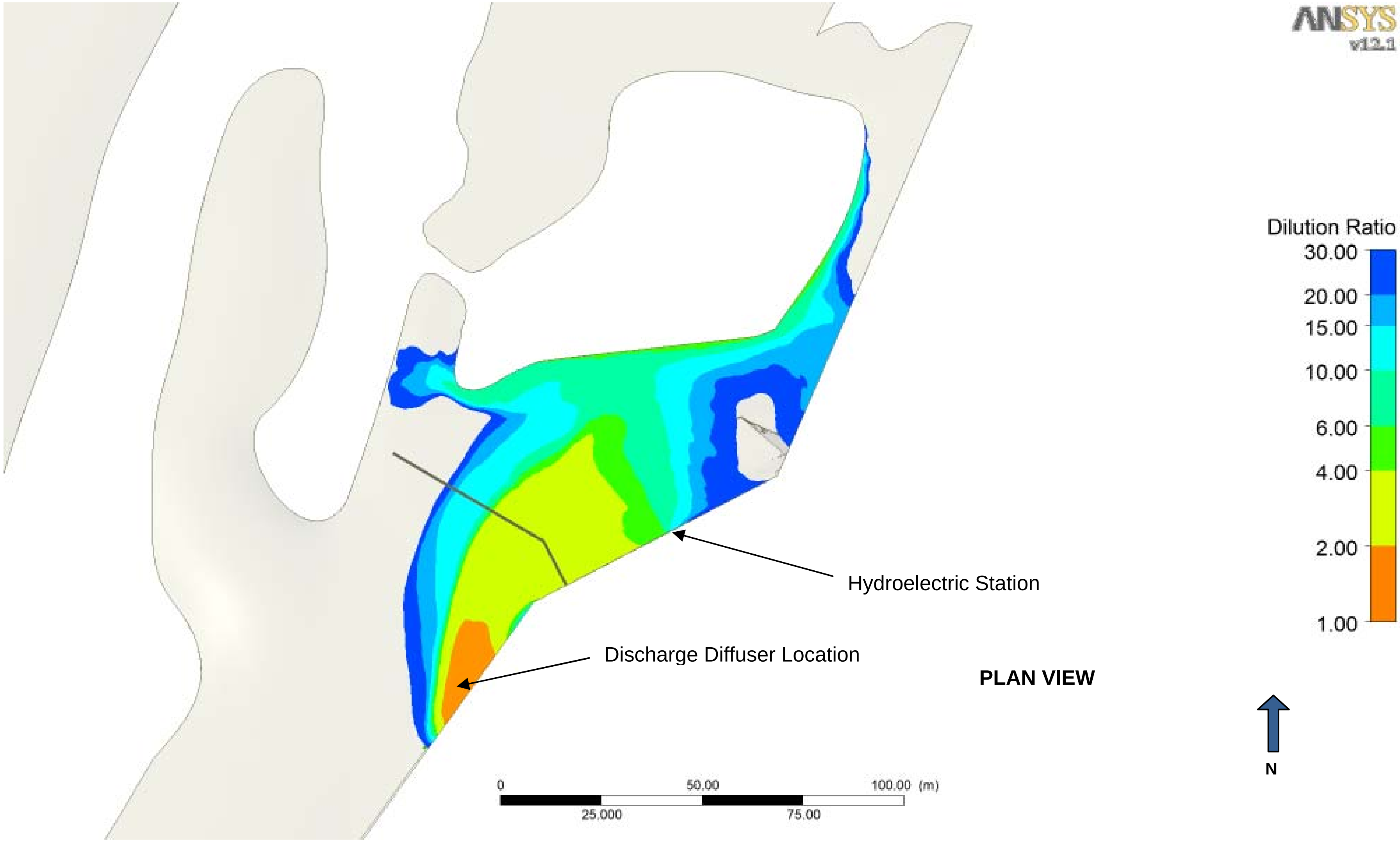

Figure 18 – Contours of dilution ratio for Scenario 1 (95° F discharge).

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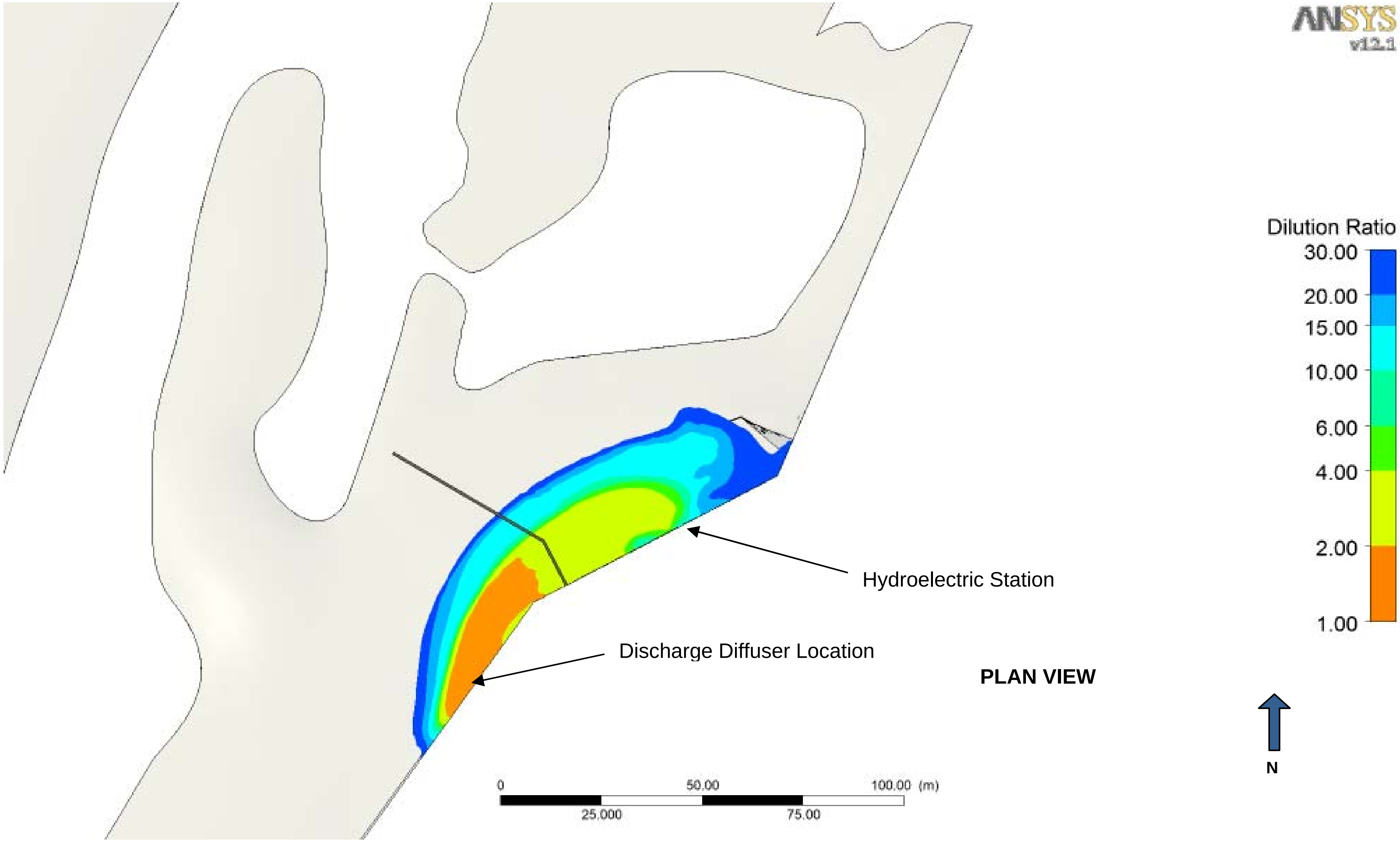

Figure 19 – Contours of dilution ratio for Scenario 2 (91° F discharge).

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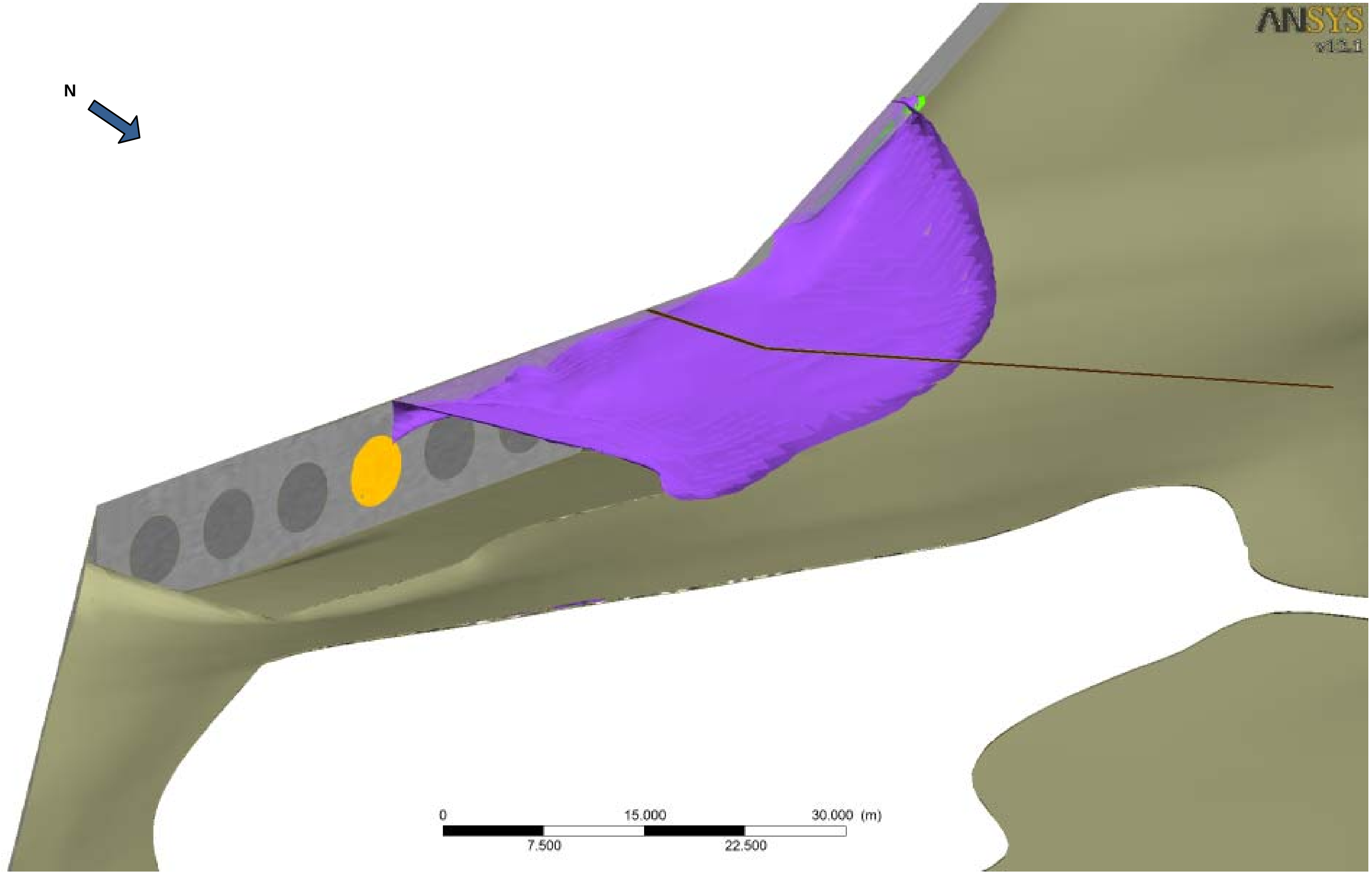

Figure 20 – Chronic mixing zone, 5:1 dilution ratio, for Scenario 1 (95° F discharge).

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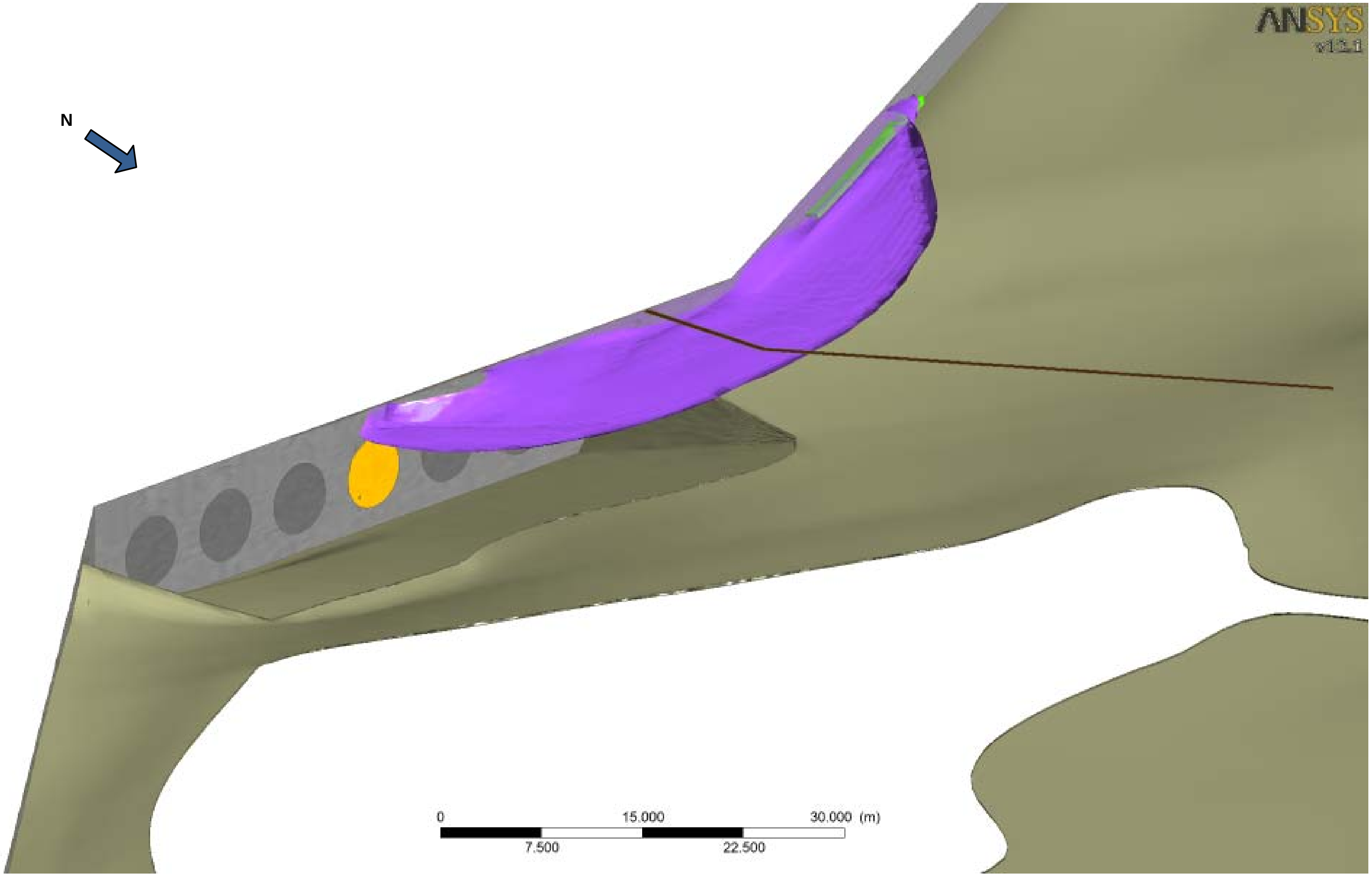

Figure 21 – Chronic mixing zone, 5:1 dilution ratio, for Scenario 2 (91° F discharge).

William S. Lee III Nuclear Station National Pollutant Discharge Elimination System Permit Application

VOLUME II
PART VII
§ 316(b) Compliance Demonstration

Submitted by:

Duke Energy Carolinas, LLC
P.O. Box 1006 Mail Code EC09D
Charlotte, NC 28202

Submitted to:
South Carolina Department of Health and Environmental Control

August 2011

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WILLIAM S. LEE III NUCLEAR STATION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT APPLICATION

Table of Contents

Table of Contents, concluded

WILLIAM S. LEE III NUCLEAR STATION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT APPLICATION

Preface

This National Pollutant Discharge Elimination System (NPDES) Permit Application (Permit Application) for the William States Lee III Nuclear Station (Lee Nuclear Station) is being submitted to the South Carolina Department of Health and Environmental Control (SCDHEC) for review and issuance of an NPDES permit. This preface is intended to provide guidance to the reviewer on contents and structure of this Permit Application.

Structure of the Permit Application

This Permit Application presents a complete package in a two-volume format containing all information necessary for SCDHEC's consideration and issuance of an NPDES Permit, including a Clean Water Act § 316(b) Compliance Demonstration.

Volume 1

PART I EPA FORM 1
PART II EPA FORM 2D
PART III PRELIMINARY ENGINEERING REPORT
Appendix A: Antidegradation Alternatives Evaluation
PART IV LOCATION SUPPLEMENT
PART V SLUDGE DISPOSAL SUPPLEMENT
PART VI MIXING ZONE REQUEST

Volume 2

PART VII CLEAN WATER ACT § 316(b) COMPLIANCE DEMONSTRATION
APPENDICES
A General Application Information Required Under § 125.86(a)(2) and § 122.21(r)
B Cooling Water Intake Structures Hydraulic Zone of Influence
C Engineering Calculations: Standard Raw Water System Traveling Screen Calculation and Standard Raw Water System Passive Screen Calculation
D Thermal Stratification
E EPA's Assumptions and Costing Methodology for the Phase I Rule and Cost Estimates for Lee Nuclear Station
F Air Quality

Preface, cont'd

G Relevant Requests for Additional Information

H Screening Analysis to Eliminate Track I Compliance Options from Detailed Analysis

I Testimony of James W. Cuchens on Behalf of Southern Nuclear Operating Company

J Gray Water Study for the Lee Nuclear Site

K Broad River Downstream of the Ninety-Nine Islands Dam

L Entrainment Assessment

Considerations when Reviewing the Permit Application

Note 1 – Rounding. Rounding of numbers (values) within this document based on significant digits may have produced minor discrepancies between uses.

Note 2 – Terminology. Certain features/components of the proposed Lee Nuclear Station have multiple nomenclatures depending on the context of use. In particular, terminology used in this SCDHEC/EPA compliance document varies from terminology of the same feature/component in the Nuclear Regulatory Commission (NRC) compliance documents. To assist in understanding and consistency, a crosswalk of terminology between contexts is provided in Volume 2, Part VII, Section 1.0, Table 1-2.

Note 3 – Flow Values. This document includes numerous references to various flow values that are germane to this Permit Application. To assist the reviewer a Table of Flow Values (immediately following this preface) is provided as a quick reference tool for understanding flow values and descriptions.

Note 4 – Files Provided on CD. CDs providing the Environmental Report (ER), Environmental Report Supplement (ER-S), and other references are provided.

Table of Flow Values

Broad River Flows	
98 cfs	5% Broad River mean annual flow (2001–2010)
125 cfs	5% Broad River mean annual flow (1926–2010)
464 cfs	Broad River 7Q10 Critical Low Flow
483 cfs	Lowest minimum flow to be released from the dam as specified in the Ninety Nine Islands Dam FERC license; Lee Nuclear Station consumptive water withdrawal from Broad River ceases
538 cfs	Broad River flow at which Lee Nuclear Station begins withdrawal from drought contingency ponds (483 cfs + 55 cfs avg consumptive loss)
1,956 cfs	Broad River mean annual flow (2001–2010)
2,495 cfs	Broad River mean annual flow (1926–2010)
Lee Nuclear Station Operation	
18 cfs	Average blowdown
23 cfs	Average non-consumptive withdrawal (18 cfs blowdown + 5 cfs screen wash)
55 cfs	Average consumptive water loss
63 cfs	Maximum consumptive water loss
78 cfs	Average withdrawal from Broad River (55 cfs consumptive + 18 cfs blowdown + 5 cfs screen wash)
River Intake	
5 cfs	Primary section screen wash
6 cfs	Maximum drought contingency section river intake screen wash
20 cfs	Average drought contingency refill available from primary section of river intake (98 cfs capacity -78 cfs average)
98 cfs	Primary section river intake capacity
200 cfs	Maximum refill capacity of drought contingency section of river intake
206 cfs	Maximum withdrawal drought contingency section river intake (200 cfs + 6 cfs screen wash)
304 cfs	Maximum total withdrawal river intake (98 cfs primary + 206 cfs drought contingency)
Pond A	
5 cfs	Pond A screen wash
139 cfs	Pond A total intake capacity (5 cfs screen wash + 134 cfs intake)
Ponds B and C	
67 cfs	Pond B intake capacity
67 cfs	Pond C intake capacity

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Acronyms and Abbreviations

7Q10	Seven-day, consecutive low flow with a 10-year return frequency; the lowest stream flow for 7 consecutive days that would be expected to occur
ac	acre
ACC	Air Cooled Condensers
ac-ft	acre-feet
AP1000	Westinghouse Advanced Passive Pressurized Water Reactor
BTU	British thermal units
°C	degrees Celsius
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
cells/mL	cells per milliliter
CFR	U.S. Code of Federal Regulations
cfs	cubic feet per second
CO_2	carbon dioxide
COL	Combined Construction and Operating License
CPCN	Certificate of Environmental Compliance and Public Convenience and Necessity
CPUE	Catches Per Unit Effort
CPI	Consumer Price Index
CWA	Federal Water Pollution Control Act
Duke Energy	Duke Energy Carolinas, LLC
Duke Power	Duke Power Company
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
ESA	Endangered Species Act
°F	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
fps	feet per second
FSC	Federal species of concern
ft	feet
GHG	greenhouse gas

Acronyms and Abbreviations, cont'd

gpm	gallons per minute
Hg	mercury
HZI	Hydraulic Zone of Influence
IRP	Integrated Resources Plan
kV	Kilovolt
Lee Nuclear Station	William States Lee III Nuclear Station
m^2	square meters
m^3	cubic meters
MGD	million gallons per day
Moody's	Moody's Analytics, Inc.
MOU	Memorandum of Understanding
msl	mean sea level
MWe	megawatts electric
N	North
NAAQS	National Ambient Air Quality Standard
NCDENR	North Carolina Department of Environment and Natural Resources
ND	Non-Discharge
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NWI	National Wetland Inventory
O&M	Operation and Maintenance
PES	Pacific Environmental Services
Phase I Rule	§316(b) Rule for New Facilities
$PM_{2.5}$	fine particulate matter
ppm	parts per million
PWR	pressurized water reactor
RRCC	Robust Redhorse Conservation Committee
RWS	Raw Water System
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SD	standard deviation
SE	State endangered
Shaw Nuclear	The Shaw Group Inc.

Acronyms and Abbreviations, concluded

SIP	State Implementation Plan
SO_2	sulfur dioxide
SOP	standard operating procedure
sq mi	square miles
ST	State threatened
TDD	Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities
US 29	U.S. Highway 29
USACE	U.S. Army Corps of Engineers
USDOE	U.S. Department of Energy
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compounds
W	West
WMP	Water Management Plan
WWTP	Wastewater Treatment Plant
µg/L	micrograms per liter

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WILLIAM S. LEE III NUCLEAR STATION
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
PERMIT APPLICATION

Checklist of NPDES Permit Application Components

Component	Required Information	Location in Document	Completed & Included
EPA FORM I, GENERAL INFORMATION		Volume 1, Part I	☑
	I. EPA ID Number		☑
	II. Pollutant Characteristics		☑
	III. Facility Name		☑
	IV. Facility Contact		☑
	V. Facility Mailing Address		☑
	VI. Facility Location		☑
	VII. SIC Code		☑
	VIII. Operator Information (A-H)		☑
	IX. Indian Lands		☑
	X. Existing Environmental Permits: SCR100000 General Stormwater Permit for Construction Activities		☑
	XI. Topographic Map		☑
	XII. Nature of Business		☑
	XIII. Certification Signature		☑
EPA FORM 2D, NEW SOURCES AND NEW DISCHARGERS		Volume 1, Part II	☑
	I. Outfall Location (lat and long)		☑
	II. Discharge Date		☑
	III. Flows, Sources of Pollution, and Treatment Technologies		☑
	IV. Production		☑
	V. Effluent Characteristics		☑
	VI. Engineering Report on Wastewater		☑

Checklist of NPDES Permit Application Components, cont'd

Component	Required Information	Location in Document	Completed & Included
	VII. Other Information		☑
	VIII. Certification Signature		☑
PRELIMINARY ENGINEERING REPORT		Volume 1, Part III	☑
	Overview of Station Outfall and Discharges		☑
	Description of Station Waste Streams		☑
	Water Balance		☑
	Antidegradation Alternatives Evaluation	Appendix A	☑
LOCATION SUPPLEMENT FOR NPDES PERMIT APPLICATION		Volume 1, Part IV	☑
	Location Supplement for ND and NPDES Permit Applications Form		☑
	Item 1: Plant Location		☑
	Item 2: Description of Discharge Point Location		☑
	Item 3: USGS Quad Map with Discharge Identified		☑
SLUDGE DISPOSAL SUPPLEMENT		Volume 1, Part V	☑
	Sludge Disposal Supplement Form		☑
MIXING ZONE REQUEST		Volume 1, Part VI	☑
	Mixing Zone Request for Surface Water Discharges Form		☑
	Supporting information for formal requests for Thermal and Whole Effluent Toxicity (WET) mixing zones		☑
CWA 316(b) COMPLIANCE DEMONSTRATION		Volume 2, Part VII	☑
	Source water physical data	Appendix A	☑
	Cooling water intake structure data	Appendix A	☑
	Source water biological data	Appendix A	☑
	Management of Intake Flow at Levels Commensurate with Closed-Cycle Recirculating Cooling Water System	Subsection 2.2.1; Subsection 3.1.1; Appendix A	☑

Checklist of NPDES Permit Application Components, concluded

Component	Required Information	Location in Document	Completed & Included
	Maintaining Through-Screen Design Intake Velocity of 0.5 fps (Velocity Limitation)	Subsection 2.2.2; Subsection 3.1.2; Appendix C	☑
	Design Intake Flow Requirements: Freshwater Rivers or Streams (Proportional Flow Limitation)	Subsection 2.2.3.1; Section 3.2; Appendices E–L	☑
	Design Intake Flow Requirements: Lakes or Reservoirs (Thermal Stratification Limitation)	Subsection 2.2.3.2; Subsection 3.1.3; Appendix D	☑
	Technologies of Operational Measures that Minimize Impingement Mortality and Entrainment of Aquatic Species	Subsection 2.2.4; Subsection 3.1.4; Appendices A and B	☑
	Alternative Requirements Demonstration	Section 2.3; Section 3.2; Appendices E–L	☑

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Part VII

§ 316(b) Compliance Demonstration

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WILLIAM S. LEE III NUCLEAR STATION
CLEAN WATER ACT § 316(b)
COMPLIANCE DEMONSTRATION

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August 2011

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Appendices:

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Acronyms and Abbreviations

ac-ft	acre-feet
BTU	British thermal units
CFR	U.S. Code of Federal Regulations
cfs	cubic feet per second
CO_2	carbon dioxide
COL	Combined Construction and Operating License
CPCN	Certificate of Environmental Compliance and Public Convenience and Necessity
CWA	Federal Water Pollution Control Act
DCD	Design Control Document
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
fps	feet per second
Hg	mercury
HZI	Hydraulic Zone of Influence
MGD	million gallons per day
msl	mean sea level
MWe	megawatts electric
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
O&M	Operation and Maintenance
PWR	pressurized water reactor
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SO_2	sulfur dioxide
TDD	Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities
USACE	U.S. Army Corps of Engineers
USDOE	U.S. Department of Energy
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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1.0 INTRODUCTION

1.1 SUMMARY

Duke Energy Carolinas, LLC (Duke Energy) is applying to the South Carolina Department of Health and Environmental Control (SCDHEC) for a National Pollutant Discharge Elimination System (NPDES) permit for discharges from the proposed William S. Lee III Nuclear Station (Lee Nuclear Station) in Cherokee County, South Carolina. The NPDES permit must include, among other requirements, conditions ensuring that Lee Nuclear Station's cooling water intake structure will meet the requirements of regulations implementing § 316(b) of the Federal Water Pollution Control Act (CWA) and corollary State law. Section 316(b) requires that the "... location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact." State and federal Section 316(b) regulations require new facilities with cooling water intake structures to use technologies and other measures to limit impingement and entrainment related impacts to the aquatic environment associated with water withdrawals by cooling water intake structures.

The United States Environmental Protection Agency (EPA) § 316(b) regulations for new facilities, which SCDHEC has adopted, require that Duke Energy demonstrate compliance by one of two paths, referred to in the rule as Track I or Track II. In addition, an alternative requirement may be established in lieu of any applicable requirements set forth in either Track I or II whenever the State determines that the cost of achieving the otherwise applicable requirement would result in costs wholly disproportionate to the costs EPA considered in establishing that requirement or would result in significant adverse effects on local air quality, water resources (other than impingement and entrainment), or energy markets.

In the case of Lee Nuclear Station, Duke Energy intends to comply with the Track I requirements for new facilities set forth in 40 CFR § 125.84(b) with an alternative requirement for the Proportional Flow Limitation.

1.1.1 Duke Energy's Track I Compliance Demonstration

To satisfy Track I requirements, an applicant must demonstrate compliance with the following four elements:

Closed Cycle Cooling Technology. Intake flow must be reduced to a level commensurate with that which can be attained by a closed cycle recirculating cooling water system.

Velocity Limitation. Each cooling water intake structure must be designed and constructed to achieve a maximum through-screen design intake velocity of ≤0.5 feet per second (fps).

Thermal Stratification Limitation. For cooling water intake structures located in lakes and reservoirs, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water, except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies).

Proportional Flow Limitation. For cooling water intake structures located in freshwater rivers, the total design intake flow may not exceed 5 percent of the source water mean annual flow.

Demonstrating that Lee Nuclear Station will comply with the first three elements of the Track I requirements is straightforward, because those requirements are relatively unambiguous. The Closed Cycle Cooling Technology requirement will be met because Lee Nuclear Station will employ a closed cycle recirculating cooling system with minimized makeup and blowdown. The Velocity Limitation will be satisfied because the cooling water intake structure at the Broad River and each internal pond intake will include screening technology that achieves a design intake velocity of ≤0.5 fps. The Thermal Stratification Limitation will also be met. The withdrawal of water from the sedimentation and drought contingency ponds will not disrupt the natural thermal stratification or turnover pattern of those ponds.

The Proportional Flow Limitation, however, warrants more thorough discussion because that limitation is susceptible to more than one reasonable interpretation. Under the most conservative interpretation, the mean annual flow is calculated using only data from 2001 through 2010 and that flow value is compared to the facility's daily design intake flow.[1] Based on this period of record, the mean annual flow of the Broad River is approximately 1,956 cubic feet per second (cfs). Five percent of this mean annual flow is 98 cfs. Under normal operations, Lee Nuclear Station is designed to operate with an average cooling water make-up flow of approximately 78 cfs, or approximately 4 percent of the mean annual flow. Thus, if no other considerations are taken into account, Lee Nuclear Station could be designed with an intake flow no greater than 5 percent of the mean annual flow, thereby satisfying this requirement.

However, to maintain operations, Lee Nuclear Station would have to continuously withdraw flow at that rate from the Broad River, even when the river is experiencing drought conditions. While this is permissible under §316(b) regulation and would achieve compliance with the Track I

[1] Duke Energy believes the Proportional Flow Limitation, as written, does not mandate such a conservative interpretation, either with respect to which data may be used to calculate the mean annual flow or the time period used for purposes of comparison with the design intake flow. Rather, Duke Energy contends that the § 316(b) mean annual flow calculation provision of the Proportional Flow Limitation should be based on the entire period of record as EPA, itself, did in developing the Phase I Rule. Duke Energy further believes it would be entirely consistent with both the language and the spirit of the Proportional Flow Limitation, as written, to compare the mean annual flow and the design flow on an annual basis. During informal discussions, however, EPA staff were of the view that the Proportional Flow Limitation was more appropriately interpreted as applying on a daily basis and the mean annual flow should be calculated based on the most recent ten years of data. Because this differing interpretation should not be material to the granting of the requested alternative requirement, for the purposes of clarity, convenience of the permitting authority, and as an act of good faith, Duke Energy is applying EPA staff's informal interpretation throughout this demonstration. In doing so, however, should it later be warranted, Duke Energy in no way waives its rights to argue in favor of its interpretation and expressly reserves its right to file additional documentation in support of its interpretation, including without limitation a revised § 316(b) Demonstration based, in part, on this interpretation.

Proportional Flow Limitation, Duke Energy believes such a withdrawal scheme is not adequately protective of the environment. This belief is corroborated by State and Federal drought contingency policies and low flow protocols that are designed to prevent significant adverse impacts to the State's water resources and the environment during these low-flow periods. In particular, these include the instream flow policies embodied in South Carolina's recently enacted South Carolina Water Withdrawal Permitting, Use, and Reporting Act (Water Withdrawal Law) and the Federal Energy Regulatory Commission (FERC) operating license for the Ninety-Nine Islands Hydroelectric Station located on the Broad River. Based on these site-specific considerations, Duke Energy believes that application of the Track I Proportional Flow Limitation, as interpreted by EPA, is not the best technology available for Lee Nuclear Station, and that, at this site, an alternative requirement for this component of Track I is more appropriate.

1.1.2 Duke Energy's Proposed Alternative Requirement

As stated above, an applicant is entitled to an alternative requirement where compliance with a Track I requirement would result in costs wholly disproportionate to the costs EPA considered in establishing the requirement at issue or would result in significant adverse impacts on local air quality, local water resources, or local energy markets. Duke Energy believes that compliance with the Track I Proportional Flow Limitation, with complete disregard to maintaining instream flows during low-flow periods, though permissible under the 316(b) rule, would result in significant adverse impacts to the Broad River. Duke Energy therefore evaluated all reasonably feasible options that might support compliance with the Track I Proportional Flow Limitation while also maintaining adequate instream flows to avoid these adverse environmental effects. Compliance options evaluated included, among others, implementing seasonal shutdowns, using groundwater and reclaimed water as makeup cooling water, and using different cooling tower technologies (both dry and hybrid). In each case, it was ultimately determined that the compliance option was infeasible, would result in costs wholly disproportionate to the costs EPA considered in establishing the Track I requirements, and/or would result in significant adverse effects on local air quality, water resources, or energy markets. Duke Energy has therefore determined that an alternative requirement is appropriate for this site.

Accordingly, Duke Energy has developed, and proposes herein, an alternative requirement for the Track I Proportional Flow Limitation that will support operation of Lee Nuclear Station, yet maintain appropriate instream flows in the Broad River during drought conditions. Specifically, Duke Energy proposes using a Water Management Plan that will utilize drought contingency ponds for its makeup cooling water when the Broad River experiences low flows. Once the Broad River returns to normal flows, makeup cooling water will be withdrawn from the Broad River. The facility also will withdraw additional water to refill the drought contingency ponds.

The operational restrictions described above will be managed under a Water Management Plan, which Duke Energy proposes would be incorporated into its NPDES permit conditions. As

described below, this Water Management Plan imposes strategic water withdrawal limitations designed to ensure instream flows are maintained during droughts. It also imposes seasonal limitations to minimize entrainment. As shown below, compared to the Track I Proportional Flow Limitation, Duke Energy's proposed alternative requirement of operating pursuant to this Water Management Plan would result in less entrainment of aquatic biota and more protection of the local water resource during low-flow periods.

1.1.3 Duke Energy's Water Management Plan

Duke Energy's Water Management Plan is set forth below. Duke Energy believes this plan is the best technology available for minimizing adverse environmental impacts at Lee Nuclear Station, pursuant to the criteria established in SCDHEC's § 316(b) implementing regulations.

- To minimize withdrawal of water during low-flow periods, a drought contingency pond (Pond C) will be built to complement existing drought contingency Pond B.
- During normal flow periods on the Broad River (>538 cfs), Duke Energy will withdraw all of its operational water requirements from Ninety-Nine Islands Reservoir through the primary section of the river intake into existing sedimentation Pond A. The primary section of the river intake will have a design intake flow of 98 cfs. Pond A will provide water for plant processes and cooling tower makeup. Based on the historical Broad River flow conditions, Duke Energy anticipates this will be the normal withdrawal scheme employed greater than 95 percent of the time.
- As the Broad River flow drops below 538 cfs and begins to approach 483 cfs, Duke Energy will proportionally withdraw its consumptive water requirements (≤63 cfs) from Ninety-Nine Islands Reservoir and drought contingency Ponds B and C. Pond B will be drawn down first. If Pond B drawdown reaches 30 feet, drawdown from Pond B will cease and water will be withdrawn from Pond C to a nominal drawdown ≤30 feet.
- When Broad River flow is at or below 483 cfs, only non-consumptive cooling water (approximately 23 cfs) will be withdrawn from the Ninety-Nine Islands Reservoir. That water will be returned to the reservoir immediately after use in order to maintain adequate flows in the Broad River. The remaining water needed to operate Lee Nuclear Station (≤63 cfs) will be drawn from drought contingency Ponds B and C. Pond B will be drawn down first. If Pond B drawdown reaches 30 feet, drawdown from Pond B will cease and water will be withdrawn from Pond C to a nominal drawdown ≤30 feet. Based on modeling using worst case droughts over the 85-year period of record, Duke Energy does not anticipate that any additional drawdown will be needed. However, should it be warranted to support station operations during emergency drought conditions, any additional drawdown or other water management protocols will be performed pursuant to a drought contingency plan to be developed in accordance with the South Carolina Water Withdrawal Law after consultation with appropriate regulatory agencies.
- During the period of July through February, and only when the Broad River flows are above 483 cfs, Ponds B and/or C will be refilled, as needed, by withdrawing water from Ninety-

Nine Islands Reservoir through the drought contingency section of the river intake. During this period, the water necessary to operate the station will also be withdrawn from the Ninety-Nine Islands Reservoir via the primary section of the river intake.

- The drought contingency section of the river intake will have a maximum design intake flow of 206 cfs. However, the actual refill rate will be determined using a flow-sensitive approach to ensure Broad River flows do not fall below 483 cfs due to refill of the drought contingency ponds. Further, regardless of river flows, refilling of Ponds B and C will not occur from March through June, in order to minimize entrainment.

1.1.4 Conclusion

Duke Energy will meet the requirements in SCDHEC's § 316(b) regulations. Lee Nuclear Station will operate with a closed-cycle recirculating water system and intake structures with through-screen, or through-slot, velocity of ≤0.5 fps. Lee Nuclear Station will withdraw from its sedimentation pond and drought contingency ponds without disrupting their natural thermal stratification or turnover pattern. As compared to the Track I Proportional Flow Limitation, Duke Energy believes the Water Management Plan 1) is more protective of users and aquatic biota of the downstream Broad River during low-flow periods; 2) results in lower entrainment of aquatic organisms; and 3) optimizes management of the local water resources of the State. Accordingly, Duke Energy requests that SCDHEC, consistent with its § 316(b) regulatory authority, issue an alternative requirement for the Track I Proportional Flow Limitation, and determine that Duke Energy's proposed use of a closed cycle recirculating cooling water system and intake structures described above, together with the operational restrictions contemplated by Duke Energy's Water Management Plan, constitute the best technology available for minimizing adverse environmental impact at Lee Nuclear site pursuant to § 125.85(a) of SCDHEC's § 316(b) regulations.

1.2 DOCUMENT OVERVIEW

This document is an integral part of the overall NPDES permit application for Lee Nuclear Station. It has been prepared as a clear and complete standalone document in order to facilitate SCDHEC's review. This document has been structured to present Duke Energy's § 316(b) compliance demonstration in an organized fashion to demonstrate compliance with the rule. Following the general introductory discussion in this section, Section 2 provides an overview of all applicable regulations, including a detailed discussion of each of the Track I requirements and the minimum requirements necessary for issuance of an alternative requirement. Duke Energy's demonstration of compliance with each of the Track I elements, with the exception of the Proportional Flow Limitation, is discussed in Section 3.1. Duke Energy's demonstration of an alternative requirement in lieu of the Track I Proportional Flow Limitation is provided in Section 3.2. Section 4 provides an overall summary and conclusion for this Compliance Demonstration for Lee Nuclear Station.

The full citations for documents referenced throughout this document are provided in Section 5. Appendices A through L provide more-detailed information and analyses supporting this demonstration. For ease of reference, Table 1-1 identifies all the requirements that this demonstration must contain under the § 316(b) regulations, with a reference to the section of this document where each requirement is addressed. Also, in some instances, documents associated with Lee Nuclear Station previously filed with the United States Nuclear Regulatory Commission (NRC) or other agencies have used similar but different terms than those used here to describe the same components or systems. These differences generally arise from the NRC's or Westinghouse's use of terms in regulatory or standard design documents that are different than those used in the § 316(b) implementing regulations. Table 1-2 is provided as a cross-reference of synonymous terms to prevent confusion when comparing this document with other filings made by Duke Energy.

1.3 BACKGROUND

1.3.1 Planning for Lee Nuclear Station

Duke Energy Carolinas, LLC[2], a wholly owned subsidiary of Duke Energy Corporation, is a regulated public utility under North Carolina and South Carolina statutes. As such, it has an obligation to provide reliable, economical electric service to its customers. Currently, Duke Energy provides retail electric services to approximately 2.4 million customers within an approximately 24,000-square-mile service area that includes load centers in the largest municipal areas in North Carolina (Charlotte and Greensboro-Winston-Salem); the municipalities of Anderson, Greenville, and Spartanburg in South Carolina; as well as the fast growing industrial corridor stretching along I-85 throughout both states. As a regulated public utility, Duke Energy must ensure minimum capacity requirements for future demand are met (Duke Energy 2010a). The construction of Lee Nuclear Station, which will generate approximately 2,200 megawatts electric (MWe), is a part of Duke Energy's comprehensive plan to meet the forecasted need for additional baseload capacity (Duke Energy 2009a).

Regulatory Coordination for Lee Nuclear Station

Lee Nuclear Station will be developed to meet the demand for power within a 20-year planning horizon for the Duke Energy franchise service area as outlined in the Integrated Resource Plan (IRP) (Duke Energy 2010a) submitted to the appropriate regulatory agencies. Duke Energy is pursuing NRC licensing for Lee Nuclear Station, and has developed an Environmental Report (ER) (Duke Energy 2009a) in support of its license application. The ER addresses the basic components of a National Environmental Policy Act (NEPA) document (e.g., alternatives analysis, existing conditions, environmental consequences), and is ultimately used by the NRC in the development of its Environmental Impact Statement as required by NEPA. An Environmental Report Supplement (ER Supplement) (Duke Energy 2009b) also was developed to describe the environmental impacts

[2] Duke Energy also refers to Duke Energy Carolinas, LLC's predecessor, Duke Power Company.

associated with the proposed drought contingency Pond C. The ER and ER Supplement are referenced throughout this demonstration and have been previously provided to governmental regulatory and resource agencies. The ER and ER Supplement are provided with this demonstration on a compact disc, along with other references noted in Section 5.

The NRC is preparing an Environmental Impact Statement (EIS) for Lee Nuclear Station. Duke Energy will also be applying to the United States Army Corps of Engineers (USACE) for issuance of a CWA § 404 permit authorizing the construction of Pond C and intake structures in waters of the United States. In accordance with the "Memorandum of Understanding Between U.S. Army Corps of Engineers and U.S. Nuclear Regulatory Commission on Environmental Reviews Related to the Issuance of Authorization to Construct and Operate Nuclear Power Plants (September 12, 2008)," the USACE Charleston District is serving as a cooperating agency during preparation of the NRC's EIS (USACE 2009).

1.3.2 Features of Lee Nuclear Station

For Lee Nuclear Station, Duke Energy selected the Westinghouse Standardized Advanced Passive (AP1000) pressurized water reactor (PWR), an NRC-certified design, amendment for which is currently under review with approval through rulemaking anticipated in the near future (WEC 2011)[3]. In choosing a design certified by the NRC through a rulemaking pursuant to 10 CFR Part 52, Duke Energy can incorporate, by reference, the design certification in its license application documents for Lee Nuclear Station (NRC 2010).

Duke Energy anticipates that each AP1000 unit will operate on an approximate 18-month refueling schedule (Duke Energy 2009a). In addition to the standardized components of the AP1000, Lee Nuclear Station also will operate with site-specific components including: a cooling water intake structure on the Broad River comprised of a primary intake section and a drought contingency intake section, mechanical draft wet cooling towers, three ponds [the existing sedimentation pond (Pond A) and the existing and proposed drought contingency ponds (Ponds B and C)] (Figure 1-1), cooling water intake piping, cooling tower blowdown piping, a stormwater collection system, switchyards, transmission facilities, and administrative facilities (Figure 1-2). The site-specific components of Lee Nuclear Station most relevant to this demonstration are discussed in greater detail in the following sections.

1.3.2.1 Lee Nuclear Site

The Lee Nuclear Site is an approximately 1,900-acre facility proposed to support the AP1000 reactors, the water systems, the transmission switchyards, and Ponds A and B. Figure 1-2 illustrates the location of the key features of the Lee Nuclear Site.

[3] AP1000 standard plant design has been certified through revision 15 of the Design Control Document (DCD). Certification of the AP1000 standard plant design through revision 19 of the DCD by the NRC is anticipated by late 2011.

The proposed location for Lee Nuclear Station was chosen as the preferred site following a comprehensive site selection study (Duke Energy 2009a) evaluating a number of different factors set forth in NRC Regulatory Guide 4.7, Revision 2, "General Site Suitability Criteria for Nuclear Power Stations" and the Electric Power Research Institute's (EPRI) Siting Guide (EPRI 2002).

Lee Nuclear Station will be located in the eastern portion of Cherokee County in north-central South Carolina (Figure 1-3). Within Cherokee County, the site is 8.2 miles southeast of Gaffney, 7.5 miles southeast of East Gaffney, 5.8 miles south of Blacksburg, and 2.6 miles southeast of the unincorporated village of Cherokee Falls. The three largest population centers (defined as having more than 25,000 residents) in the region are Charlotte, North Carolina; Spartanburg, South Carolina; and Greenville, South Carolina. The site is 40.1 miles southwest of Charlotte, 24.6 miles northeast of Spartanburg, and 51.6 miles northeast of Greenville. The nearest population center is Gastonia, North Carolina, located 24.0 miles northeast of the site. Gaffney is the largest city within a 10-mile radius of the site (Duke Energy 2009a). The proposed facility will be constructed on the site of the former Cherokee Nuclear Station. The property is owned by Duke Energy.

In the early 1970s, the site was evaluated for construction of three nuclear units. In 1975, the NRC granted a construction permit (NUREG-75/089) to Duke Power Company. Approximately 750 acres of ground on the site were disturbed by the subsequent construction, which began in 1977 and was halted in 1982. The proposed station will be constructed within the large, open, contiguous area of land that was cleared by previous construction activities on the site. The topography in this area ranges from a low elevation of 512 feet above msl along the river bank to a high elevation of 659 feet above msl northwest of the existing excavation. The elevation of McKowns Mountain is 816 feet above msl, the highest point on the Lee Nuclear Site. The terrestrial environs of the site prior to that construction consisted primarily of deciduous hardwood forest and farms. However, the construction resulted in extensive alteration of the site, including vegetation clearing; establishment of on-site construction roads; establishment of a railroad spur to the site; extensive excavation and grading with heavy equipment; building of on-site warehouses, shops, and construction support facilities; and construction of portions of one nuclear unit, including about half of its associated reactor containment/shield building. These construction activities occurred in the large open area that is visible on the Lee Nuclear Site today. As a result, the site consists of open, partially developed industrial land with low groundcover vegetation and scattered areas of sparse tree growth. The Unit 1 basemat and warehouse facilities are the only portions of the original plant construction to be retained. The warehouse facilities will be used during Lee Nuclear Station construction. The basemat will be used as fill since the AP1000 basemat is located at a higher elevation. Many of the original support buildings fell into disrepair. The original Cherokee Nuclear Station construction support buildings that cannot be utilized due to their location or state of disrepair were demolished in 2007–2008, along with demolition of the previously constructed portions of the Cherokee Unit 1 power block.

The Lee Nuclear Site is bounded by the Broad River to the north and east, which is effectively a run-of-the-river impoundment (Ninety-Nine Islands Reservoir) abutting the north and east boundary of the Lee Nuclear Site with a pool elevation of 511 feet above mean sea level (msl) and has an approximate volume of 2,300 ac-ft (Duke Energy 2009a). Immediately adjacent to the easternmost portion of the Lee Nuclear Site is the Ninety-Nine Islands Dam, which was constructed in the early 1900s in connection with Duke Energy's Ninety-Nine Islands Hydroelectric Station (Duke Energy 2009a). Duke Energy operates the Ninety-Nine Islands Hydroelectric Station in accordance with its FERC operating license, which limits the elevation of surface water drawdown and establishes a protocol for flow releases to the Broad River. The requirements of this license satisfy FERC's obligation to consider protection, mitigation of, damage to, and enhancement of fish and wildlife (including spawning grounds and habitat); protection of recreational opportunities; and preservation of other aspects of environmental quality. The proposed river cooling water intake structure is located on the western bank of the Broad River, about 1,000 feet upstream from the Ninety-Nine Islands Hydroelectric Plant, along the north boundary of the Lee Nuclear Site.

1.3.2.2 Ponds

As part of the original construction of the Cherokee Nuclear Station in the 1970s, Duke Energy constructed dams to form the existing on-site Ponds A and B. Pond A serves as a sedimentation pond. Drought contingency Pond B receives water from McKowns Creek and drainage from the McKowns Creek Watershed. The proposed off-site drought contingency Pond C, on London Creek, will drain approximately 2,500 acres [about 3.9 square miles] (Duke Energy 2009b). When the intake flow to Pond A from the primary section of the river intake is reduced, water will be pumped to Pond A either from Pond B, or from Pond C through Pond B, to meet station supply requirements (Duke Energy 2009b). Based on a review of historical flow data, use of these reservoirs over the life of the plant is expected to be infrequent (i.e., less than 5 percent of the time). Figure 1-1 depicts the locations of the existing on-site Ponds A and B and proposed Pond C. The ponds are described in greater detail in Appendix A.

1.3.2.3 Cooling Water Intake Structures

Cooling water intake structures for Lee Nuclear Station will include systems in the Broad River, sedimentation Pond A, and drought contingency Ponds B and C. The cooling water intake structure on the Broad River will be comprised of a primary intake section and a drought contingency intake section. All water withdrawn through the Broad River intake structure will pass through bar screens and dual-flow traveling screens (Duke Energy 2009a). The Pond A intake structure also will be equipped with dual-flow traveling screens (Duke Energy 2010b). The Pond B and C intake structures each will have two cylindrical wedgewire screens fitted to each pump well and located parallel with the intake pump structure causeway. The pond intakes will be located near the bottom of the ponds. Additional information concerning the intake system and its design parameters are included in Appendix A.

1.3.2.4 Recirculating Cooling Water System

The closed-cycle recirculating cooling water system for each unit will consist of: the condenser; three mechanical-draft wet cooling towers; three tower basins (Shaw Nuclear 2008); three pumps, and all associated piping, valves, and instrumentation (Duke Energy 2009a). The heated non-contact cooling water from the station will be piped to the spray headers of the mechanical-draft cooling towers, where the heat in the cooling water will be transferred to the ambient air via evaporative cooling and conduction. The cooling water will then return through the recirculating closed-cycle cooling loop for use in cooling steam in the condenser and other cooling equipment. The recirculating cooling water system will require make-up water from the Broad River to offset losses due to evaporation, drift, and blowdown from the cooling towers. During normal operations, this water will be provided by the Broad River to the recirculating cooling water system (Figure 1-4).

The cooling towers will be designed for an approach temperature (the approach temperature is the difference in temperature between the cold water leaving the tower and the ambient wet bulb temperature) of approximately 10 degrees Fahrenheit (°F) and a maximum inlet temperature of approximately 116°F. Consumptive energy associated with the wet towers for the recirculating cooling water system when both units are in operation is expected to be 13.5 megawatts (MW) (Shaw Nuclear 2007). Most of the heat will be released to the atmosphere via the cooling towers. The cooling towers for both units will dissipate an average of 1.53×10^{10} British thermal units per hour (BTU/hr) of waste heat during normal system operation at full load (Duke Energy 2009a). A small amount of heat will also be discharged during the blowdown process via a diffuser in the Broad River, just upstream of the Ninety-Nine Islands Dam, as discussed in Section 3.0 of the Mixing Zone Request, Part VI of Duke Energy's NPDES application.

1.3.2.5 Recirculating Service Water System

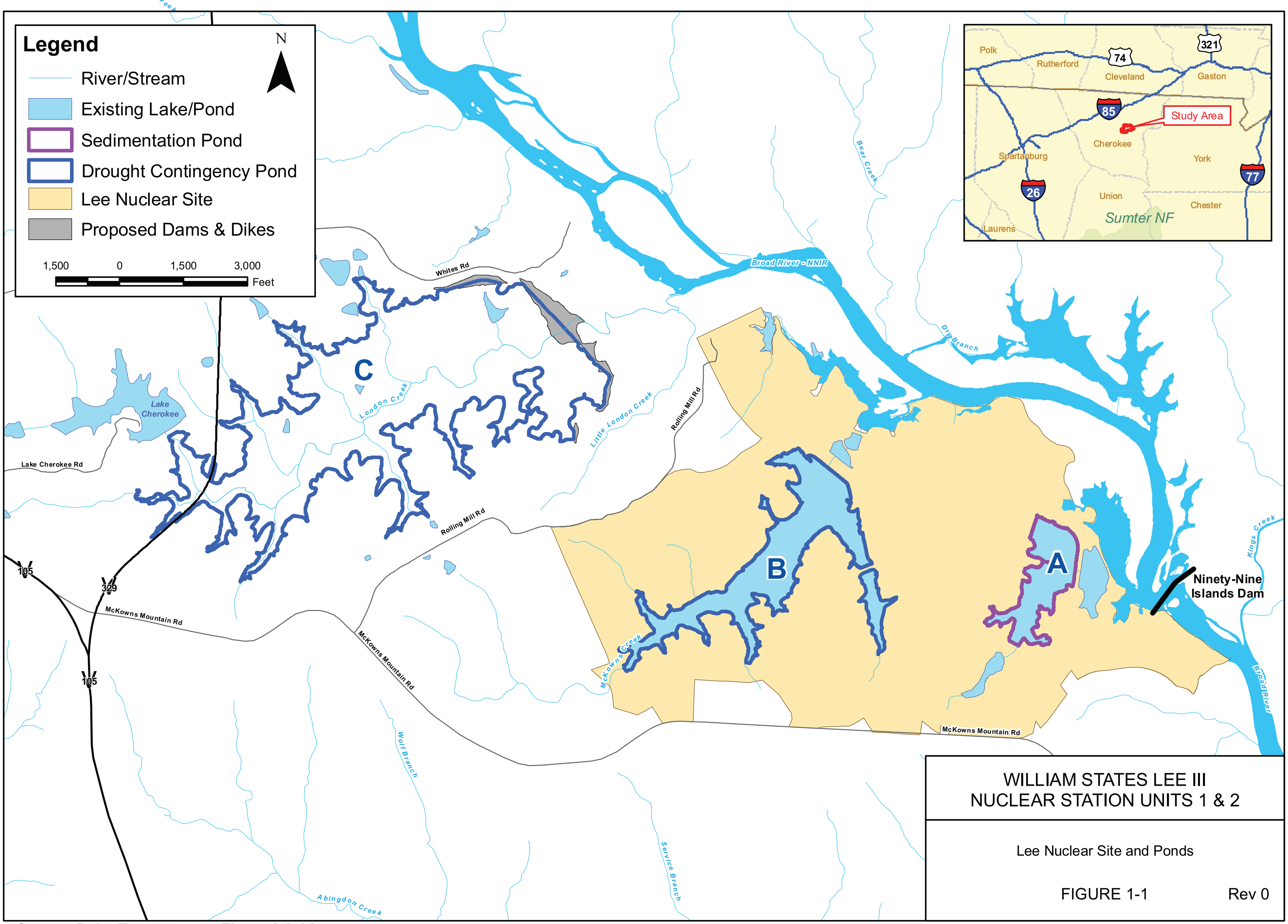
The closed-cycle recirculating service water system (service water system) is a standardized component of the AP1000. At Lee Nuclear Station, the Raw Water Supply Subsystem will withdraw water from sedimentation Pond A, which will be refilled from the Broad River or the drought contingency ponds, depending on the flow within the Broad River. This subsystem provides water to the Clarifier Subsystem for treatment. Once treated, the Clarifier Water Supply Subsystem supplies make-up water to the Service Water Cooling Towers. The service water system will release heat to the atmosphere via evaporation through the cooling tower; a minimal amount of heat also will be discharged as blowdown to either the recirculating cooling water system cooling tower basin or the wastewater retention basin. The discharge of blowdown will control solids concentration within the system (Duke Energy 2009a).

Table 1-1
Regulatory Requirements and Sections of Demonstration

Regulatory Requirement	Section	Appendix
§ 122.21(r)		
§ 122.21(r)(2) Source water physical data	N/A	Appendix A
§ 122.21(r)(3) Cooling water intake structure data	N/A	Appendix A
§ 122.21(r)(4) Source water biological data	N/A	Appendix A
§ 125.85 Alternative requirements		
§ 125.85(b) Demonstration that the alternative requirement should be authorized	2.3 and 3.2	Appendices E–L
§ 125.86(b)(1) Flow reduction information		
§ 125.86(a)(1) Statement of intention to comply	1.1 and 2.1.1	N/A
§ 125.86(a)(2) Section 122.21(r) Information	N/A	Appendix A
§ 125.86(b)(1)(i) Narrative description including documentation demonstrating minimization of make-up and blowdown flows.	3.1.1.1 and 3.1.1.3	N/A
§ 125.86(b)(1)(ii) Documentation showing that the amount of cooling water not reused or recycled has been minimized.	3.1.1.1 and 3.1.1.3	N/A
§ 125.86(b)(2) Velocity information		
§ 125.86(b)(2)(i) Narrative description of the design, structure, equipment and operation used to meet the velocity requirement	3.1.2.1	Appendix C
§ 125.86(b)(2)(ii) Design calculations	3.1.2.2	Appendix C
§ 125.86(b)(3) Source waterbody flow information		
§ 125.86(b)(3)(i) Mean annual flow and engineering calculations	3.1.3.2 and 3.2	Appendices D–L
§ 125.86(b)(3)(iii) Description of thermal stratification	3.1.3.1 and 3.1.3.2	Appendix D
§ 125.86(b)(4) Design and Construction Technology Plan		
§ 125.86(b)(4)(i) Information demonstrating whether or not the criteria in § 125.84(b)(4) and (b)(5) are met	3.1.4.1	Appendix A
§ 125.86(b)(4)(ii) Delineation of hydraulic zone of influence	3.1.4.2	Appendix B

Table 1-2
Terminology Used in Documents Submitted to SCDHEC/EPA and NRC

Terminology in SCDHEC/EPA Submittals	Terminology in NRC Submittals
Pond A	Make-Up Pond A
Drought contingency Pond B	Make-Up Pond B
Proposed drought contingency Pond C	Make-Up Pond C
Cooling water intake structure (i.e., the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the United States [US]). The cooling water intake structures for Lee Nuclear Station will be located on the Broad River, Pond A, and drought contingency Ponds B and C.	Cooling system
River intake	River water intake
Primary section of river intake	River water intake – river water subsystem
Drought contingency section of river intake	River water intake – refill subsystem
Pond A intake	Make-Up Pond A intake
Pond B intake	Make-Up Pond B intake
Pond C intake	Make-Up Pond C intake
Recirculating water system	Circulating water system



WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Lee Nuclear Site and Ponds

FIGURE 1-1

Rev 0

Source: Duke Energy 2009b Figure 2.3-30

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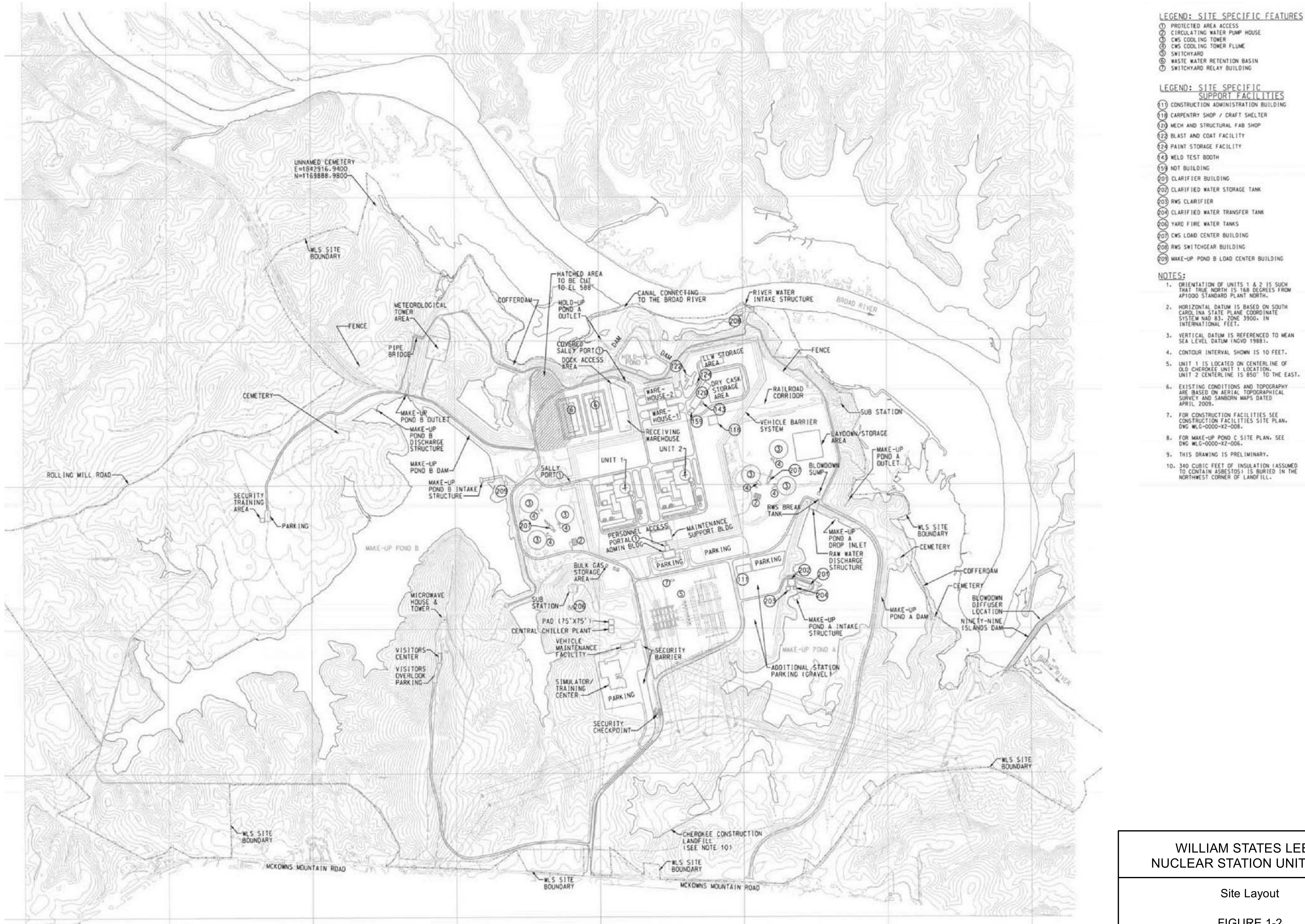

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Site Layout

FIGURE 1-2 Rev 0

Source: Shaw WLG-0000-X2-005; Rev G

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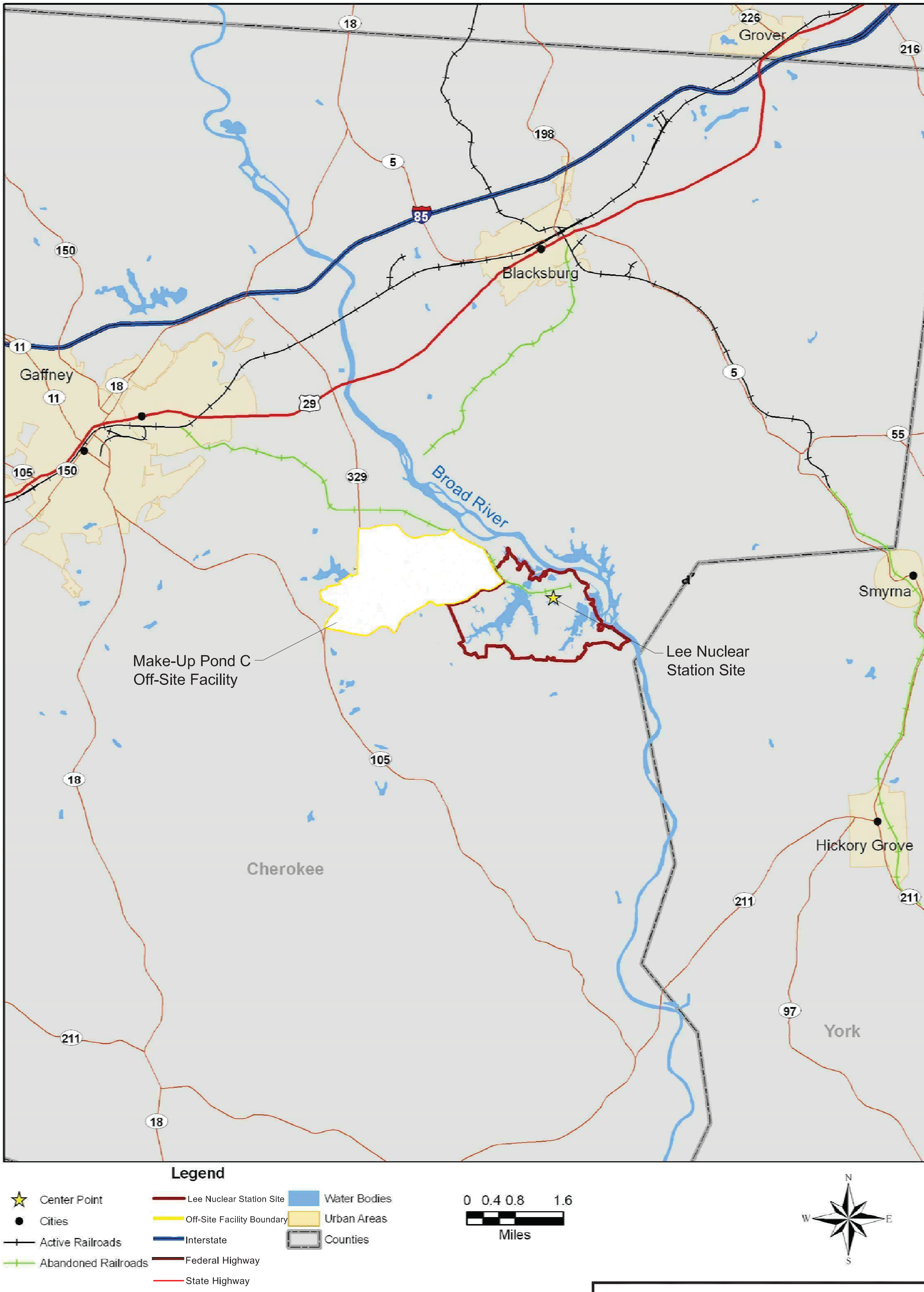

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Site Location Map

FIGURE 1-3 Rev 0

WLS COL 2.1-1

Source: Duke Energy 2010c, Figure 1.1-201

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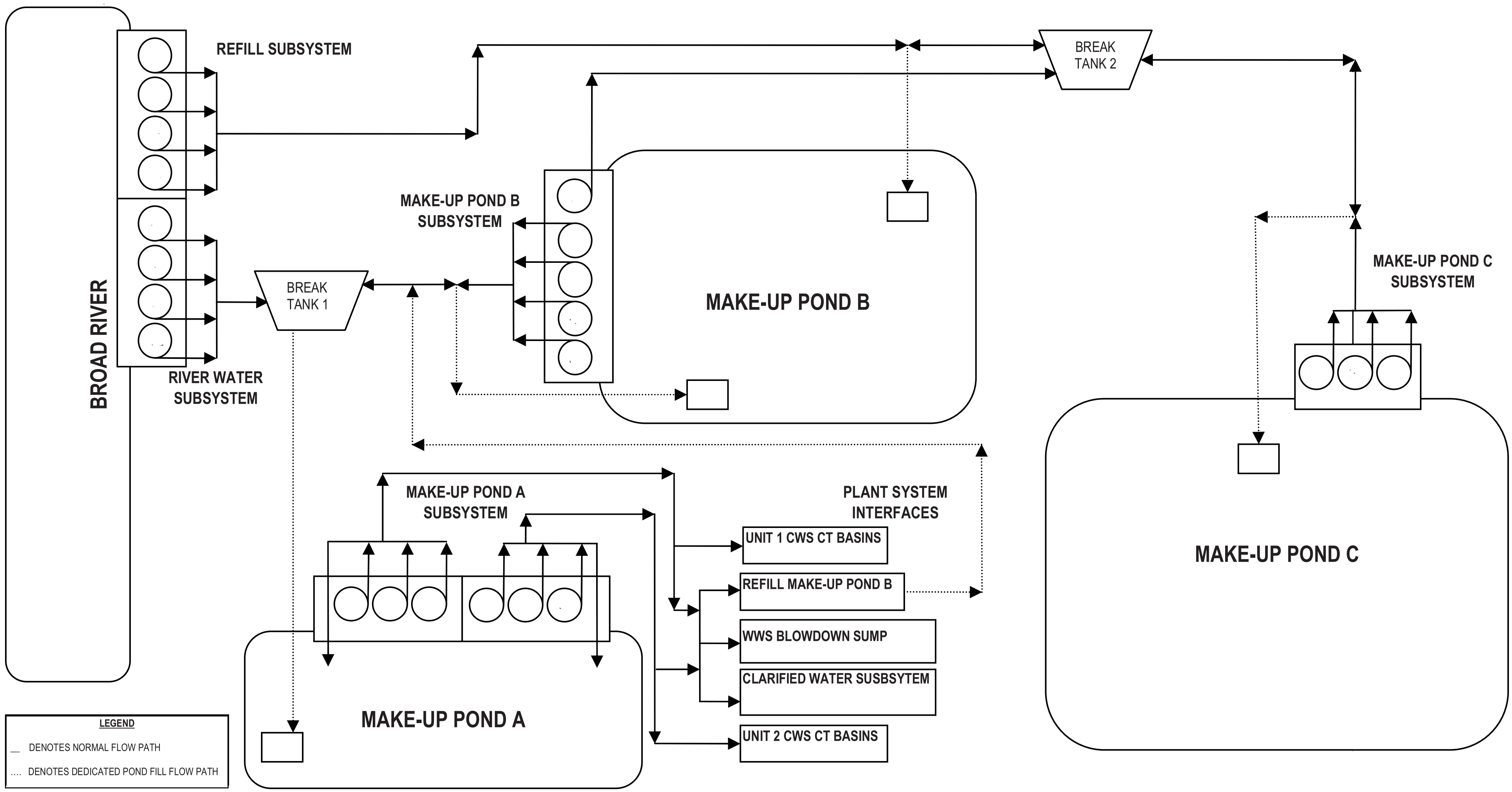
Figure 1-4. Raw Water System-Water Transfer Diagram



Source: Duke Energy 2010b.

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2.0 APPLICABLE REGULATORY REQUIREMENTS

This section describes the applicable laws, rules, and regulations for a demonstration of compliance with § 316(b) under Track I of the Phase I Rule, with consideration of an alternative requirement. This section is organized using a "top down" approach to present the statutory and regulatory requirements in a logical order.

2.1 § 316(b) LAWS AND REGULATIONS

Section 316(b) of the CWA states that:

> [a]ny standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.

The EPA has been developing regulations implementing § 316(b) in phases. In 2001, the EPA promulgated the Phase I Rule that covers new facilities. Lee Nuclear Station meets the definition of a new facility and is therefore subject to the Phase I Rule. SCDHEC, which has been delegated authority by the EPA to manage the NPDES program in South Carolina, has incorporated these federal regulations in full, by reference (SCR 61-9. Water Pollution Control Permits). Under these regulations, the term "cooling water intake structure" refers to the total physical structure and any associated constructed waterways used to withdraw cooling water from waters of the United States (US). The cooling water intake structure extends from the point at which water is withdrawn from the surface water source up to, and including, the intake pumps. The amount of water withdrawn that classifies a structure as a cooling water intake structure is defined in EPA's Phase I Rule at 40 CFR § 125.81. The cooling water intake structures for Lee Nuclear Station will be located on the Broad River, Pond A, and drought contingency Ponds B and C.

2.1.1 § 316(b) Phase I Rulemaking (66 FR 243, 65255–65345)

The Final Phase I Rule establishes national technology-based performance requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new facilities. The national requirements themselves establish that the best technology available for a specific site can be identified using either of two approaches or "tracks." The rule also supports establishment of an alternative requirement for a Track I standard, where appropriate, based on site-specific conditions.

Track I [40 CFR § 125.84(b) or (c)] prescribes performance standards that impose limits on flow and velocity, including proportional flow restrictions for withdrawals from freshwater rivers and thermal stratification limitations for withdrawals from lakes and reservoirs. Track II [40 CFR § 125.84(d)] allows permit applicants to conduct site-specific studies to demonstrate that

alternatives to the Track I requirements will reduce impingement mortality and entrainment for all life stages of fish and shellfish to a level comparable to the level the facility would achieve at the cooling water intake structure under Track I requirements. Track II applies only where a facility seeks to use an alternative to closed-cycle cooling or to use a design requiring a higher design velocity. Since Lee Nuclear Station has been designed to use a closed-cycle recirculating cooling system and low design velocity, Duke Energy intends to comply with the Track I permitting process, with the exception that Duke Energy proposes an alternative requirement in lieu of the Track I Proportional Flow Limitation.

The general permitting standards for § 316(b) compliance are codified at 40 CFR § 122.21(r)(2)-(4) and 40 CFR § 125.86. Since SCDHEC's regulations incorporate the federal regulations by reference, this document provides references to the federal regulations.

2.2 TRACK I STANDARD AND RELEVANT APPLICATION REQUIREMENTS [§§ 125.86(a)(1)(i), 125.84(b)]

Track I requirements vary depending on the volume of water the new facility will withdraw. As proposed, Lee Nuclear Station will withdraw greater than 10 million gallons per day (MGD); therefore, the new facility must comply with all of the following unless an alternative requirement (40 CFR § 125.85) is proposed:

- reduce the intake flow to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system [§ 125.84(b)(1)];
- design and construct each cooling water intake structure to a maximum through-screen design intake velocity of 0.5 fps [§ 125.84(b)(2)];
- design and construct each cooling water intake structure located on a freshwater river to meet proportional flow requirements (e.g., less than 5 percent of the mean annual flow) [§ 125.84(b)(3)];
- design and construct each cooling water intake structure located on a lake or reservoir so that the total design intake flow does not disrupt the natural thermal stratification or turnover pattern (where present) of the source water unless such changes are deemed beneficial by any fisheries management agency [§ 125.84(b)(3)];
- if threatened or endangered or otherwise protected species or habitat exist, implement design and construction technologies or operational measures for minimizing impingement mortality and entrainment of fish and shellfish (not applicable to Lee Nuclear Station) [§ 125.84(b)(4)(5)];
- submit the application information required in 40 § CFR 122.21(r) and § 125.86(b) [§ 125.84(b)(6)];
- implement the monitoring requirements specified in Section 125.87 [§ 125.84(b)(7)]; and
- implement the recordkeeping requirements specified in Section 125.88 [§ 125.84(b)(8)].

A more-detailed discussion of each of the Track I requirements and its associated application requirements follows.

2.2.1 Management of Intake Flow at Levels Commensurate with a Closed-Cycle Recirculating Cooling Water System [§ 125.84(b)(1)]

Section 125.84(b)(1) provides that new facilities:

> . . . must reduce your intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system.

A closed-cycle recirculating system is defined in § 125.83 as a traditional "wet" recirculating cooling system, i.e.:

> . . . a system designed, using minimized makeup and blowdown flows, to withdraw water from a natural or other water source to support contact and/or noncontact cooling uses within a facility. The water is usually sent to a cooling canal or channel, lake, pond, or tower to allow waste heat to be dissipated to the atmosphere and then is returned to the system. (Some facilities divert the waste heat to other process operations.) New source water (make-up water) is added to the system to replenish losses that have occurred due to blowdown, drift, and evaporation.

To demonstrate compliance with this requirement, the applicant must submit a narrative description showing that its system has been designed to reduce intake flow to a level commensurate with that which can be attained by a recirculating cooling water system and any engineering calculations, including documentation demonstrating that its make-up and blowdown flows have been minimized [§ 125.86(b)(1)(i)]. A project-specific demonstration that the proposed Lee Nuclear Station will comply with this requirement is provided in subsection 3.1.1.

2.2.2 Maintaining Through-Screen Design Intake Velocity at Maximum of 0.5 fps [§ 125.84(b)(2)]

Section 125.84(b)(2) states that applicants must:

> . . . design and construct each cooling water intake structure at your facility to a maximum through-screen design intake velocity of 0.5 fps.

The design intake velocity, as defined at § 125.83, means:

> the value assigned (during the design of a cooling water intake structure) to the average speed at which intake water passes through the open area of the intake

> screen (or other device) against which organisms might be impinged or through which they might be entrained.[4]

To demonstrate compliance with the design intake velocity requirements, the applicant must submit a narrative description of the design, structure, equipment, and operation used to meet the velocity requirement [§ 125.86(b)(2)(i)]. The applicant must also submit design calculations showing that the velocity requirement will be met at minimum ambient source water surface elevations (based on best professional judgment using available hydrological data) and maximum head loss across the screens or other device [§ 125.86 (b)(2)(ii)]. A project-specific demonstration that the proposed Lee Nuclear Station will comply with this requirement is provided in subsection 3.1.2.

2.2.3 Design Intake Flow Requirements [§ 125.84(b)(3)]

The Phase I Rule imposes requirements for the design and construction of cooling water intake structures that differ based on the source water type on which the structure resides (freshwater river/stream, lake/reservoir, or estuary/tidal river). A detailed discussion on each of the requirements relevant to Lee Nuclear Station is provided below.

2.2.3.1 Freshwater Rivers or Streams [§ 125.84(b)(3)(i)]

Lee Nuclear Station will withdraw from a freshwater river (the Broad River) as defined in § 125.83:[5]

> Freshwater river or stream means a lotic (free-flowing) system that does not receive significant inflows of water from oceans or bays due to tidal action. For purposes of this rule, a flow-through reservoir with a retention time of 7 days or less will be considered a freshwater river or stream.

Section 125.84 (b)(3)(i) requires that:

> [f]or cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than 5 percent of the source water annual mean flow…

Section 125.83 of the Phase I Rule defines the design intake flow as the "…value assigned (during the facility's design) to the total volume of water withdrawn from a source water body over a specific time period." The Phase I Rule defines "annual mean flow" as "the average of daily flows over a calendar year. Historical data (up to 10 years) must be used where available."

[4] This requirement is equally applicable to the through-slot velocity of cylindrical wedge-wire screens.

[5] The Ninety-Nine Islands reservoir is a FERC-licensed reservoir, but is considered a river under § 316(b) definitions because it has a retention time of less than seven days.

The rule on its face provides no explanation for the internal inconsistency between its definition of "annual mean flow" as the average of daily flow values over a given year and the explicit direction to use multiple years of historical data to calculate that value. Despite the use of "annual mean flow" in the Phase I Rule itself, EPA based its determination of the number of facilities capable of achieving compliance with the requirements at 40 CFR § 125.84(b)(3)(i) on mean annual flow values (Tetra Tech 2001) calculated over a variety of periods of record. The "mean annual flow" is calculated as the average of all annual means during the period of concern (Gordon et al. 2004). EPA used the term "mean annual flow" throughout its record for the Phase I Rule when discussing the requirement to limit the volume of water withdrawn from freshwater rivers and streams, including the proposed Phase I Rule and Preamble collectively (Proposed Rule)[6] (EPA 2000), and the Preamble to the Final Phase I Rule[7] (EPA 2001a). It is reasonable to assume that EPA intended to determine compliance with this requirement based on mean annual flow. Duke Energy, therefore, uses the term "mean annual flow" throughout the remainder of this document in discussing §125.84(b)(3)(i).

In order to demonstrate compliance with the requirement that the total design intake flow must be no greater than 5 percent of the source water mean annual flow (Proportional Flow Limitation), facilities located on freshwater rivers or streams must submit the mean annual flow and any supporting documentation and engineering calculations to show that the cooling water intake structure meets the flow requirements [§ 125.86(b)(3)(i)]. Based on site-specific considerations, Duke Energy believes that application of the Track I Proportional Flow Limitation, as interpreted by EPA, is not the best technology available for Lee Nuclear Station, and that the alternative requirement described in Section 3.2 is more appropriate for this site.

2.2.3.2 Lakes or Reservoirs [§ 125.84(b)(3)(ii)]

Other intake structures for Lee Nuclear Station will withdraw from a lake or reservoir (Pond A and drought contingency Ponds B and C) as defined by Section 125.83:

> Lake or reservoir means any inland body of open water with some minimum surface area free of rooted vegetation and with an average hydraulic retention time of more than 7 days. Lakes or reservoirs might be natural water bodies or impounded streams, usually fresh, surrounded by land or by land and a man-made retainer (e.g., a dam). Lakes or reservoirs might be fed by rivers, streams, springs, and/or local precipitation. Flow-through reservoirs with an average hydraulic retention time of 7 days or less should be considered a freshwater river or stream.

Section 125.84(b)(3)(ii) provides that:

> …in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water

[6] See, for example, 65 Fed. Reg. 49068 and 49085.
[7] See, for example, 66 Fed. Reg. 65260, 65270, 65272, 65273, 65277, 65300 and 65301.

> except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies).

Section 125.83 defines natural thermal stratification to mean: ". . . the naturally occurring division of a waterbody into horizontal layers of differing densities as a result of variations in temperature at different depths." In the preamble to the Phase I Rule, EPA (2001c) explains:

> [t]ypically, this natural thermal stratification will be defined by the thermocline, which may be affected to a certain extent by the withdrawal of cooler water and the discharge of heated water into the system.

EPA defines thermocline at § 125.83 to mean, ". . . the middle layer of a thermally stratified lake or reservoir. In this layer, there is a rapid decrease in temperatures." EPA did not define disrupt within the Phase I Rule. In its response to comments on the proposed rule, EPA provided simply that "EPA expects new facilities located on a lake or reservoir to work in conjunction with the permitting authority to determine what constitutes an unacceptable disruption of any natural thermal stratification or turnover pattern." See Response to Comment 316(b) NFR.068.105. Consistent with the rules of statutory construction, in the absence of a regulatory definition, it is appropriate to look to the "plain meaning" of the term. In this regard, under common usage, disrupt is generally defined to mean "to break apart: rupture," (*Merriam-Webster* 2011, available at http://www.merriam-webster.com/dictionary/disrupt).

To demonstrate compliance with this requirement, § 125.86(b)(3)(ii) requires the applicant to provide a narrative description of the water body thermal stratification, and any supporting documentation and engineering calculations to show that the natural thermal stratification and turnover pattern will not be disrupted by the total design intake flow. Where the disruption is determined to be beneficial to management of fisheries for fish and shellfish, the applicant must "provide supporting documentation and include a written concurrence from any fisheries management agency(ies) with responsibility for fisheries potentially affected" by the cooling water intake structure (EPA 2001b). Heated water will not be discharged from Lee Nuclear Station to the ponds. The majority of the heat will be released to the atmosphere by the cooling towers, with the remainder of the heat loss occurring in the blowdown via a diffuser in the Ninety-Nine Islands Reservoir. Further details demonstrating this project's compliance with this requirement are provided in subsection 3.1.3.

2.2.3.3 Estuaries or Tidal Rivers [§ 125.84(b)(3)(iii)]

Section 125.84(b)(3)(iii) provides that:

> For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than one (1) percent of the volume of the water column within the area centered about the

opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level.

This requirement is not applicable because the cooling water intake structures for Lee Nuclear Station will not withdraw from an estuary or tidal river.

2.2.4 Technologies or Operational Measures that Minimize Impingement Mortality and Entrainment of Aquatic Species [§ 125.84(b)(4) and (5)]

The requirements of Sections 125.84(b)(4) and (5) are not applicable because the aquatic species and habitat covered by the rule are not susceptible to impingement, and will only be susceptible to entrainment in very low numbers at Lee Nuclear Station.

Specifically, additional design and construction technologies are only required if the permit writer or a fisheries management agency determines that:

- threatened or endangered, or otherwise protected species or critical habitat for such species are present in the Hydraulic Zone of Influence (HZI) for the proposed cooling water intake structure [§ 125.84(b)(4)(i)];
- there are migratory and/or sport or commercial species of impingement concern which pass through the HZI [§ 125.84(b)(4)(ii)]; or
- the proposed facility, even after complying with the other technology requirements, would contribute unacceptable stress to the protected species, critical habitat of those species, or species of concern [§ 125.84(b)(4)(iii)].

To allow the permit writer to determine whether or not the applicant is subject to the design and construction technology requirements, § 125.86(b)(4) requires the applicant to submit "(i) [i]nformation to demonstrate whether or not you meet the criteria in § 125.84(b)(4) and (b)(5) …; and (ii) [d]elineation of the HZI for your cooling water intake structure…" Facilities required to implement additional design and construction technologies must develop and submit design and construction technology plans [§ 125.86(b)(4)(iii)]. Although § 125.86(b)(4)(i) does not specify what information is needed to demonstrate whether criteria for imposing additional design and construction technologies are met, the physical and biological information required is encompassed by the additional information submission requirements imposed by § 122.21(r). Those requirements are described in subsection 2.2.8. The information necessary to demonstrate the absence of threatened or endangered, or otherwise protected, species, or critical habitat within source waters of Lee Nuclear Station, is provided in Appendix A. Consistent with this information, Lee Nuclear Station does not require additional design and construction technologies that further minimize impingement and entrainment of aquatic species.

2.2.5 Application Requirements [§ 125.84(b)(6)]

Section § 125.84(b)(6) requires the submittal of application information required in 40 CFR §§ 122.21(r) and 125.86(b). The relevant information required in the application relative to the Track I performance standards is discussed in the previous subsections 2.2.1 through 2.2.4 and 2.2.8, while information relative to § 122.21(r) is provided in Appendix A.

2.2.6 Monitoring Requirements [§ 125.84(b)(7)]

Lee Nuclear Station will comply with the relevant monitoring requirements to be imposed in accordance with § 125.84(b)(7) once the facility is operational.

2.2.7 Record Keeping Requirements [§ 125.84(b)(8)]

Lee Nuclear Station will comply with the record keeping requirements in accordance with § 125.84(b)(8) once the facility is operational.

2.2.8 Additional Information Required Under § 122.21(r)

In addition to the substantive standards and associated application requirements discussed above, the regulations require applicants to provide other information to support a § 316(b) determination for a new facility. Specifically, § 125.86(a)(1) and (2) require, respectively, that applicants identify the compliance option, e.g., Track I with an alternative requirement, chosen for the facility and provide the information required under § 122.21(r)(2) through (4).

Section 122.21(r)(2) requires an applicant to submit a variety of source water physical data, including location maps and documentation used to determine the water body type and the size and location of the HZI.

Section 122.21(r)(3) requires the applicant to submit cooling water intake structure data, including engineering drawings of the cooling water intake structure and narrative, and other information on the intake's location, design, operation, and flows.

Section 122.21(r)(4) requires the applicant to submit source water baseline biological characterization data. The regulation requires applicants to make efforts to obtain a variety of existing biological data to characterize the species, life stage, relative abundance, life history, behavior, and susceptibility to impingement and entrainment of aquatic organisms in the vicinity of the cooling water intake structure. It also requires the applicant to document all threatened, endangered, or other protected species that might be susceptible to impingement and entrainment at the cooling water intake structure, and to document any public participation or consultation with Federal or State agencies. Although the regulation does not require applicants to undertake field studies, applicants that choose to conduct and submit such studies must provide supporting

documentation, including a description of methods and quality assurance procedures for sampling and data analysis.

Information satisfying each of the above requirements is provided in Appendix A.

2.3 ALTERNATIVE REQUIREMENT DEMONSTRATION (§ 125.85)

The regulations authorize permittees to seek, and state agencies to grant, alternative best technology available standards, if the permittee can demonstrate that there are site-specific factors EPA had not considered (EPA 2001b). Section 125.85(a) sets forth the following requirements for requesting an alternative requirement:

- [t]here is an applicable requirement under § 125.84(a) through (e);
- [t]he Director determines that data specific to the facility indicate that compliance with the requirement at issue would result in compliance costs wholly out of proportion to the costs EPA considered in establishing the requirement at issue or would result in significant adverse impacts on local air quality, significant adverse impacts on local water resources other than impingement or entrainment, or significant adverse impacts on local energy markets;
- [t]he alternative requirement requested is no less stringent than justified by the wholly out of proportion cost or the significant adverse impacts on local air quality, significant adverse impacts on local water resources other than impingement or entrainment, or significant adverse impacts on local energy markets; and
- [t]he alternative requirement will ensure compliance with other applicable provisions of the Clean Water Act and any applicable requirement of state law.

Lee Nuclear Station meets all requirements for requesting an alternative requirement under § 125.85(a). Duke Energy's demonstration of compliance with these requirements is provided in subsection 3.2.3.

2.4 OTHER RELEVANT REGULATIONS AND REQUIREMENTS

In addition to the federal regulations established pursuant to § 316(b) of the CWA, Duke Energy must obtain approval from a number of different regulatory entities before initiating construction of Lee Nuclear Station. Those approvals consist of a host of environmental and other permits required by various regulatory agencies including, but not limited to, a Combined Construction and Operating License (COL) from the NRC to construct and operate Lee Nuclear Station, a CWA § 404 permit from the USACE to construct the intake structures and Pond C, a Certificate of Environmental Compliance and Public Convenience and Necessity (CPCN) from the Public Service Commission of South Carolina, approval from FERC to withdraw water from the Ninety-Nine Islands Reservoir, and approval from SCDHEC to withdraw water from the Broad River under South Carolina's newly enacted Water Withdrawal Law. While all the various regulatory requirements

will be addressed by Duke Energy, the requirements of the last two regulatory entities, FERC and SCDHEC, are of particular interest by reason of their correlation with the alternative requirement pursued for Lee Nuclear Station. The following sections summarize the applicable requirements of the South Carolina Water Withdrawal Law and FERC as they relate to maintaining instream flows within the Broad River.

2.4.1 South Carolina Water Withdrawal Law

South Carolina's Water Withdrawal Law will require all facilities with withdrawals of more than 3 million gallons of surface water during any 1 month, from either a single intake or multiple intakes, under common ownership, within a 1-mile radius from any one existing or proposed intake, to obtain a permit from SCDHEC. The intent of the law is to regulate surface water withdrawals to avoid significant impacts to water resources.

The Water Withdrawal Law establishes requirements for minimum instream flow to ensure an adequate supply of water to maintain the biological, chemical, and physical integrity of the stream, taking into account the needs of downstream users, recreation, and navigation. For non-licensed impoundments and rivers, it establishes seasonal minimum instream flow levels, as percentages of the Mean Annual Daily Flow (MADF). For licensed flow-control impoundments such as the Ninety-Nine Islands Reservoir, it establishes instream flow based on the licensed conditions and also establishes requirements for minimum water levels in the impoundment.

As a result of this new law, Duke Energy will be required to apply to SCDHEC for a water withdrawal permit for Lee Nuclear Station. SCDHEC will issue the permit authorizing the withdrawal of cooling water from the Ninety-Nine Islands Reservoir on the Broad River utilizing the criteria in the Water Withdrawal Law. As set forth above, for FERC-licensed reservoirs such as Ninety-Nine Islands, the instream flows necessary to satisfy the Water Withdrawal Law are established during the FERC licensing process. Further discussion regarding the Water Withdrawal Law, as it relates to the § 316(b) Track I Proportional Flow Limitation requirement and Duke Energy's proposed alternative requirement, is presented in Section 3.2.

2.4.2 FERC Low-Flow Protocol

FERC is an independent federal agency that regulates the interstate transmission of electricity, natural gas, and oil. FERC also has jurisdiction over the licensing and environmental matters related to hydroelectric projects like the Ninety-Nine Islands Hydroelectric Station, located on the Broad River. Duke Energy operates the Ninety-Nine Islands Hydroelectric Station in accordance with its FERC operating license, which limits reservoir drawdown and establishes a protocol for releases to the Broad River.

The FERC operating license for the Ninety-Nine Islands Hydroelectric Station includes seasonal limits on reservoir levels to 1 foot below full impoundment (511 feet above msl) from March

through May, and 2 feet below full impoundment from June through February. This allows for a short-term potential of zero outflow (including a measured 53 cfs due to dam leakage) to occur, immediately followed by the required minimum flow release (FERC 1996). Minimum flow requirements below the dam are 966 cfs (January through April); 725 cfs (May, June, and December); and 483 cfs (July through November), when flow is available (FERC 1996). If the above-referenced flows cannot be maintained during December through June without dropping below the reservoir level restrictions described above, then at least 483 cfs is required to be released. If there is insufficient water to maintain at least 483 cfs of continuous flow release, the operating license provides that one hydroelectric unit can be operated at its minimum hydraulic output for that portion of every hour that is necessary to release the approximate accumulated inflow; inflow can be released at the trash gate, or the inflow can be spilled (FERC 1996). Collectively, these limits are referred to as the low-flow protocol. Pursuant to the Water Withdrawal Law, only the *lowest* minimum flow identified above (i.e., 483 cfs) constrains withdrawals by Lee Nuclear Station. See Water Withdrawal Law § 49-4-150(A)(4) (stating in part that water withdrawal from a licensed flow control impoundment is based on the *lowest minimum flow* specified in the license for that impoundment). Further discussion regarding the FERC low-flow protocol as it relates to the § 316(b) Track I Proportional Flow Limitation and Duke Energy's proposed alternative requirement is presented in subsection 3.2.2.2.

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3.0 § 316(b) BEST TECHNOLOGY AVAILABLE COMPLIANCE DEMONSTRATION

Track I requirements were discussed in Section 2.0. This section (3.0) provides facility-specific information required under § 125.86(b) to demonstrate compliance with Track I requirements for closed-cycle cooling, design velocity, and other construction and design technologies under § 125.84(b) and supports Duke Energy's request for an alternative requirement for the Track I Proportional Flow Limitation pursuant to § 125.85. Duke Energy demonstrates compliance with Track I closed-cycle recirculating cooling technology, velocity limitation, and thermal stratification limitation requirements in Section 3.1; Duke Energy presents its alternative requirement demonstration for the Proportional Flow Limitation in Section 3.2.

3.1 TRACK I REQUIREMENTS DEMONSTRATION [§ 125.86(b)]

Lee Nuclear Station meets the requirements for a Track I best technology available determination for closed-cycle recirculating cooling technology, velocity limitation, and thermal stratification limitation requirements. The following subsections present the data, information, and engineering drawings and calculations that support Duke Energy's compliance demonstration.

3.1.1 Closed-Cycle Recirculating Cooling Technology [§ 125.86(b)(1)]

Section 125.86(b)(1) requires Duke Energy to demonstrate that Lee Nuclear Station will meet the Track I performance standard in § 125.84(b)(i). As presented in subsection 2.2.1, § 125.84(b)(i) requires that the system, by design, reduces intake flow to a level commensurate with a closed-cycle recirculating cooling water system. The following subsections provide the narrative description and supporting design calculations to demonstrate compliance with this requirement.

3.1.1.1 Recirculating Cooling Water and Service Water Systems

Lee Nuclear Station's recirculating cooling water and service water systems have been designed to reduce flows commensurate with a closed-cycle recirculating cooling water system since these systems are, in fact, closed-cycle recirculating cooling water systems.

The recirculating cooling water system and recirculating service water system will require make-up water to offset losses due to evaporation, drift, and blowdown from the cooling towers. Duke Energy will normally operate Lee Nuclear Station's cooling towers at four cycles of concentration (Shaw Nuclear 2008), which will minimize the amount of make-up water required for station operations.

A detailed discussion of the function of the recirculating cooling water and service water systems is presented in sections 1.3.2.4 and 1.3.2.5.

3.1.1.2 Engineering Drawings and Calculations

Engineering drawings of the cooling water intake structures and other information required by § 122.21(r) are provided in Appendix A. See subsection 2.2.8 for details on the requirement.

3.1.1.3 Documentation Demonstrating Minimization of Make-Up and Blowdown Flows

The AP1000-certified design has many features that reduce the use of water as well as recycle water where possible. Below is a description of the individual systems that will ensure that make-up and blowdown flows at Lee Nuclear Station will be minimized.

Process water will be minimized by the use of a clarifier system. Raw water from the Broad River will be processed through the clarifier and treated. After settling, sludge will be removed from the clarifier, concentrated, and dewatered. Liquid from the dewatering process will be recycled back to the clarifier inlet for reuse in the system. No wastewater will be generated from the clarification process (Shaw Nuclear 2010).

Lee Nuclear Station will recirculate cooling water to the extent possible, consistent with its NPDES permit. The cycles of concentration for the AP1000 are dependent on the quality of the water. Duke Energy estimates that the water quality will typically support operation with four cycles of concentration, but may need to operate at two cycles of concentration during periods of high turbidity in order to remove the increased levels of dissolved solids from the recirculating cooling system. Operating at four cycles of concentration will reduce the frequency of blowdown, which reduces the amount of make-up water required.

The recirculating cooling water system proposed for Lee Nuclear Station will recycle 90 to 95 percent of water through the system (Shaw Nuclear 2010). Duke Energy anticipates an average withdrawal rate of 78 cfs (35,000 gpm) for Lee Nuclear Station at full operation. In contrast, use of a once-through cooling system at Lee Nuclear Station would require approximately 2,497 cfs (1,120,100 gpm) of water from the Broad River (Shaw Nuclear 2010).

The service water system blowdown will be recycled as make-up water to the recirculating cooling water system cooling tower basins. This will reduce the required make-up water from the raw water system and ultimately the Broad River (Shaw Nuclear 2010).

3.1.1.4 Conclusion: Demonstration of Compliance with § 125.84(b)(i)

As the above descriptions demonstrate, Duke Energy will operate Lee Nuclear Station with recirculating cooling technology, and has taken appropriate measures to minimize the amount of

make-up water withdrawn and blowdown discharged from Lee Nuclear Station. Therefore, Duke Energy has provided the information required under § 125.86(b)(1)(i) and has demonstrated Lee Nuclear Station will be in compliance with the Track I closed-cycle recirculating cooling technology requirements of § 125.84(b)(i).

3.1.2 Velocity Limitation Requirement [§ 125.86(b)(2)]

Section 125.86(b)(2) requires Duke Energy to demonstrate compliance with the performance standard at § 125.84(b)(2). As presented in subsection 2.2.2, § 125.84(b)(2) requires that the system meet a maximum through-screen design intake velocity of no more than 0.5 fps. The following subsections provide the narrative description and supporting design calculations to meet this requirement.

3.1.2.1 Narrative Description of Design, Structure, Equipment and Operation to Meet 0.5 fps Requirement

As described in subsection 1.3.2.3, cooling and other water withdrawn from the Broad River will pass through bar screens and traveling screens (Duke Energy 2009a). The primary and drought contingency sections of the river intake, as well as the Pond A intake at Lee Nuclear Station, will be equipped with fine-mesh, Ristroph, dual-flow traveling screen (Duke Energy 2010b).

The traveling screens for the primary and drought contingency sections of the river intake and the Pond A intake will be sized to ensure a through-screen velocity of less than 0.5 fps, and will be equipped with a fish return system (Appendix C). To be conservative, the minimum screen width will be sized based on the largest pumping capacity of the drought contingency section of the river intake (Appendix A).

The Pond B and C intakes will have cylindrical wedge-wire screens and will be located parallel with the intake pump structure causeway. The passive screens for the pond intakes will be sized to ensure a through-slot velocity of less than 0.5 fps (Appendix C). Margin to account for partial clogging was considered in calculations of through-screen/through-slot velocity for the traveling screens/passive screens. Maximum head loss across these screens will be verified by the supplier when the screens are purchased to ensure that through-screen/through-slot velocity is maintained less than 0.5 fps.

3.1.2.2 Design Calculations

Maximum velocity is established as 0.5 fps. The system design flow is divided by the maximum velocity through the screen to estimate the minimum area of screen required. The minimum total area of the screen must also be adjusted to account for screen slot size opening and for potential clogging.

The following steps were used to calculate a standard traveling screen width:

Minimum area	=	system design flow/maximum velocity
Minimum total area	=	minimum area + A_{slot} + A_{clog}
Traveling screen width	=	minimum total area/1.5* x minimum intake level

* Traveling screen width will be calculated based on 1.5 times the minimum intake level instead of 2 times the minimum intake level to provide additional margin since this will conservatively result in a wider screen and lower through-screen velocity.

The following steps were used to calculate a standard passive screen length:

Minimum area	=	system design flow/maximum velocity
Minimum total area	=	minimum area + A_{slot} + A_{clog}
Minimum passive screen diameter	=	select a screen diameter from a supplier catalog that satisfies the minimum total area required
Minimum passive screen length	=	minimum total area/π x screen diameter

The traveling screen and passive screen calculations and assumptions are included as Appendix C.

3.1.2.3 Conclusion: Demonstration of Compliance with § 125.84(b)(2)

Duke Energy has provided the information required under § 125.86(b)(2) and Lee Nuclear Station will comply with the Track I velocity limitation requirements of § 125.84(b)(2).

3.1.3 Source Waterbody Thermocline Requirements for Lakes or Reservoirs [§ 125.84(b)(3)(ii)]

Section 125.86(b)(3) requires that applicants demonstrate compliance with the performance standard set forth at § 125.84(b)(3). As presented in subsection 2.2.3, § 125.84(b)(3)(ii) requires that total design intake flow of cooling water intake structures located in a lake or reservoir must not disrupt the natural thermal stratification or turnover pattern. The following subsections provide the narrative description and supporting design calculations to meet this requirement.

3.1.3.1 Narrative Description of Thermal Stratification

As described in subsection 1.3.2.3, Lee Nuclear Station will have three ponds with intake structures. The ponds, as manmade structures designed and permitted to provide water to the facility, cannot be said to possess a "natural" stratification pattern, as would be the case for a naturally occurring lake or reservoir. Any consideration of effects on thermal stratification and turnover patterns must be analyzed in light of the design, use, and operation of the ponds for their intended purpose. Duke Energy is, therefore, providing information describing the expected thermal stratification in each pond based on their intended use and the results of a rigorous modeling exercise that demonstrate that the thermal stratification and turnover patterns in Ponds A, B, and C will not be disrupted.

To determine how often low flow conditions in the Broad River would result in Lee Nuclear Station having to rely on drought contingency Ponds B or C for supplemental cooling water, a spreadsheet model was developed to analyze water balance needs to support station operations. The spreadsheet model was based on Broad River daily average flows covering the 85-year period of record (1926–2010). The U.S. Geological Survey (USGS) gauge used was the Broad River at Gaffney, South Carolina (Gauge No. 2153500), chosen due to its proximity to Lee Nuclear Station. Daily average flows for this gauge were compiled using a combination of actual data from the gauge at Gaffney (1938–1971, 1986–1990) and pro-rated flow data from two upstream USGS gauges on the main stem of the Broad River. The two upstream gauges used were the Broad River near Blacksburg, South Carolina (No. 2153200, 3.1 river miles upstream from the Gaffney gauge), and the Broad River near Boiling Springs, North Carolina (No. 2151500, 16.2 river miles upstream from the Gaffney gauge). For periods where data were not available from the Gaffney USGS gauge, the preference was to use pro-rated data from the Blacksburg gauge. If Blacksburg gauge data were not available, the Boiling Springs gauge was used. Pro-rated flows were calculated using drainage area ratios for the two upstream gauges resulting in an 85-year period of record for the Broad River at the Gaffney gauge location (1926–2010).

Figure 3-1 illustrates the number of times drought contingency Pond B or Pond C would have been used during the 85-year period of record and the magnitude of the drawdowns. During the 85-year period of record (1926–2010), these drought contingency Ponds B and/or C were used to support station operations approximately 3 percent of the time.

Using real temperature data and thermal modeling, Duke Energy next evaluated whether a thermocline would be expected to develop in any of the three ponds. The studies also evaluated whether the thermocline would be disrupted from the use of the cooling water intake structure. Temperature studies in existing Ponds A and B showed evidence of thermal stratification (Duke Energy 2009a). Modeling results show that the total design intake flow and use of the cooling water intake structure will not disrupt the stratification in these ponds. Proposed Pond C will likely develop a thermal stratification pattern similar to that observed in Pond B, since the ponds are within close proximity, and subject to the same hydrologic and meteorological conditions (Duke Energy 2009b). Modeling results for Pond C also show that the total design intake flow and use of the cooling water intake structure will not disrupt the thermal stratification that is expected to develop (Appendix D).

3.1.3.2 Engineering Calculations Demonstrating that the Stratification and Turnover Pattern Will Not Be Disrupted

A thermal modeling report is provided in Appendix D. This report concludes that the thermal stratification in the ponds will not be disrupted (refer to Appendix D for a more-detailed discussion).

Pond A is projected to be in continuous use and receives no heated discharge. The withdrawal of water at the total design intake flow of 139 cfs will not disrupt the thermocline or the seasonal turnover pattern as seen in comparing the modeling results for Pond A in Appendix D Figure 2 with no withdrawal to the results of withdrawal shown in Figure 3. Both Ponds B and C have intake structures located near the bottom of each pond and neither pond receives any heated discharge. For Pond B, the comparison of a modeled day 10 on Figure 4 (no withdrawal) and modeled day 10 on Figure 5 (withdrawal at design intake flow) demonstrates that the total design intake flow of 55 (avg)/67 (max) cfs does not disrupt the thermal stratification. For Pond C, a comparison of day 23 on Figure 6 (no withdrawal) and day 23 on Figure 7 (withdrawal at design intake flow) demonstrates that the total design intake flow of 55 (avg)/67 (max) cfs does not disrupt the thermal stratification. Even during extreme drought conditions resulting in maximum drawdowns of Ponds B and C, modeling results in Appendix D demonstrate that although the stratification gradient may be altered, the ponds remain thermally stratified.

Likewise, the turnover pattern will not be disrupted. Appendix D, Figures 2 through 7, demonstrate that the turnover pattern exhibited by existing Ponds A and B will continue, with thermal stratification in the summer and near isothermal conditions in the winter, and that proposed Pond C will exhibit similar turnover patterns whether or not water is being withdrawn. This pattern is present on all of the ponds. The drought contingency ponds are anticipated to be used in flow periods that typically occur in the hotter months when there is thermal stratification. When these ponds are not being used to supply water to the station, the total design intake flow would not be a factor in disruption of the thermal stratification or turnover pattern.

3.1.3.3 Conclusion: Demonstration of Compliance with § 125.84(b)(ii)

Duke Energy has provided all of the information required under § 125.86(b)(3)(iii) and has demonstrated that Lee Nuclear Station will operate in compliance with the Track I source waterbody thermocline requirements applicable for Ponds A, B, and C in § 125.84(b)(3)(ii).

3.1.4 Design and Construction Technology Plan [§ 125.86(b)(4)]

Section 125.86(b)(4) requires Duke Energy to demonstrate that Lee Nuclear Station meets the performance standard in § 125.84(b)(4) and (5), if those standards are applicable.

3.1.4.1 Information Demonstrating that Lee Nuclear Station Does Not Require Additional Measures to Minimize Impingement or Entrainment Under § 125.84(b)(4) and (5)

As described in subsection 1.2.1 of Appendix A, Duke Energy will install technology on all its intakes that will be highly protective of the biota. The river intake will be equipped with fine-mesh, Ristroph dual-flow, traveling screens equipped with a fish return system discharging downstream of the river intake. The Pond A intake will be equipped with the same types of screens as the river intake. The intakes for Pond B and the proposed Pond C will be equipped with narrow-slot,

cylindrical wedge-wire screens. All will operate with through-screen or through-slot velocities less than 0.5 fps, which EPA (2004) has recognized as essentially eliminating impingement of juvenile and adult fish. Moreover, Duke Energy will locate the intakes in areas that are likely to reduce entrainment and impingement of early life stages of organisms. The river intake will be located in a naturally occurring scour hole 30 feet in depth that is upstream of where the shallow backwaters enter the main stem of the Broad River (see Appendix A, Figures A-14 through A-16). The intakes for Ponds B and C will be located in areas characterized with an hypoxic hypolimnion (see Appendix A figures) during biologically relevant periods of time.

As described in Appendix B, the HZI for the primary section of the river intake, which will typically be in operation, will affect only a minute volume of the Broad River, i.e., 0.200 ac-ft of the habitat available to biota potentially susceptible to entrainment and impingement (see figures in Appendix B). When the primary and drought contingency sections of the river intake would be in operation, the HZI would only occupy 0.316 ac-ft of the Broad River. Moreover, the life history strategies of most of the fish species utilizing the Broad River upstream of the Ninety-Nine Islands Dam minimize any likelihood of involvement by the earliest life stage eggs. Most of the fish species build nests and spawn in shallow water and/or produce eggs that are demersal and adhesive. The larval stages of many of these species remain in close proximity to their nests for a period of time and have a preference for shallow water. In Appendix A, Table A-9 shows that most larval fish prefer the shallow backwater regions of the Broad River. While it is possible that some larvae could be susceptible to the primary or drought contingency sections of the river intake, the extremely small HZIs under normal and even under worst-case conditions do not warrant any further measures to protect these species.

The HZIs for the Ponds A, B, and C will also be extremely small, as described in subsection 3.1.4.2. In the ponds, most of the early life stages and smaller fish susceptible to entrainment or impingement inhabit the littoral zones of the ponds. Because the volume of water diverted from each of these waterbodies will be relatively low and their HZIs will be small (Appendix B), larger, healthy fish would be unaffected by the low velocities in the HZI. Since Lee Nuclear Station will employ best technology available by complying with measures to reduce impingement and entrainment, it is unlikely that impingement-related or entrainment-related impacts would result in adverse environmental impacts.

No commercial species are present in the Broad River (Appendix A), so there will be no impingement or entrainment of commercial species. While certain suckers (Catostomidae) that are considered migratory are present in the area (between Ninety-Nine Islands Dam and Cherokee Falls Dam), the migratory life stages (i.e., juveniles or adults) should not be susceptible to entrainment or impingement at the river intake due to the maximum 0.5 fps through-screen velocity and the very small HZI. Although larval suckers were collected in earlier studies, they were present in low densities (see Appendix A). Given the very small HZI of the river intake, impingement and/or entrainment impacts on suckers would be minimal. Therefore, there would be

no significant impacts to migratory species. There will be no measurable impact to any sport species at any of the intakes. The sport species present in the Broad River include largemouth bass (*Micropterus salmoides)* and channel catfish (*Ictalurus punctatus*). Both of these species are nest-building spawners (see Table A-9). While larvae have been present in the river, the vast majority of the largemouth bass larvae (98 percent) and catfish larvae were found in the backwater regions of the Broad River (Appendix A, subsection 1.2.9). Therefore, early life stages of the sport species are not likely to be susceptible to entrainment or impingement in large numbers. Later life stages will be able to avoid the very low velocity (0.5 fps) of the river intake. Finally, as discussed in Appendix A, neither the South Carolina Department of Natural Resources (SCDNR) nor the U.S. Fish and Wildlife Service (USFWS) have identified any threatened or endangered or otherwise protected federal, state, or tribal species, or critical habitat for these species as being present within the HZI of the primary or drought contingency sections of the river intake or the pond intakes. Further, there would be no undesirable cumulative stressors affecting entrainable life stages of species of concern. Lee Nuclear Station, therefore, does not require additional design and construction technologies that minimize impingement and entrainment of aquatic species [§ 125.84(b)(4) and (5)].

3.1.4.2 Delineation of the Hydraulic Zone of Influence of Cooling Water Intake Structure

As discussed in Appendix B, the HZI for the primary section of the river intake was determined for three different scenarios of varying intake flows and surface water elevations. One of the three scenarios also considered the use of the drought contingency section of the river intake. The primary section of the river intake HZI will be 0.200 ac-ft with a surface area of 0.013 acre extending approximately 14.4 feet perpendicular to the primary section of the river intake. When both the primary and drought contingency sections of the river intake are in operation, the volume of the HZI will be 0.316 ac-ft, with a surface area of 0.025 ac extending 15.4 feet from the intake structure (Geosyntec 2011). These HZIs represent extremely small fractions of the volume and surface areas, respectively, of the Broad River in the vicinity of the intake. Figures depicting the HZIs for each of these scenarios are provided in Appendix B.

As discussed in Appendix B, the Pond A HZI was calculated for two different scenarios of varying intake flows. Under the 78 cfs (35,030 gpm) intake flow scenario, the HZI for Pond A will have a volume of 0.054 ac-ft with a surface area of 0.004 ac and extend approximately 3.7 feet into the pond. With an intake flow of 139 cfs (62,000 gpm), the HZI will increase to a volume of 0.150 ac-ft with a surface area of 0.011 ac and extend approximately 9.2 feet into the pond (Geosyntec 2011). Figures depicting the HZIs for Pond A are provided in Appendix B.

The total HZI for Pond B will be 0.039 ac-ft with a surface area of 0.004 acre, extending approximately 7.2 feet outward of the intake structure. Figures depicting the HZI for Pond B are provided in Appendix B.

Similar to Pond B, the HZI for Pond C will remain close to the intake's cylindrical wedge-wire screens. Two different scenarios were used to calculate the HZI for the Pond C intake. The first scenario assumed the proposed 30-foot drawdown. The second scenario evaluated a worst-case 45-foot drawdown. Using the 30-foot drawdown scenario, the total HZI for Pond C is 0.062 ac-ft, with a surface area of 0.005 acre, and extends approximately 9.2 feet into the pond. Using the 45-foot drawdown scenario, the HZI has a volume of 0.061 ac-ft, with a surface area of 0.005 acre, and extends approximately 9.2 feet into the pond (Geosyntec 2011). Figures depicting the HZIs for Pond C are provided in Appendix B.

The HZIs for the sedimentation and drought contingency pond intakes represent extremely small fractions of the volumes and surface areas in their respective ponds.

No threatened or endangered species, otherwise protected federal or state species, and commercial species have been identified as being present in the vicinity of the river intake. Although certain suckers, which are considered migratory, and sport species are present, the cooling water intake structure technologies that Duke Energy will employ will minimize impingement and entrainment to levels that are not expected to be of concern. Therefore, Lee Nuclear Station will not be required to install additional technologies to minimize impingement and entrainment, and Duke Energy is not required to submit a Design and Construction Technology Plan [§ 125.84(b)(4)].

3.2 ALTERNATIVE REQUIREMENT DEMONSTRATION [§ 125.85]: DESIGN INTAKE FLOW REQUIREMENTS FOR FRESHWATER RIVERS OR STREAMS [§ 125.84(b)(3)(i)]

As discussed in subsection 2.2.3.1, § 125.84(b)(3)(i) requires that the total design intake flow of the cooling water intake structure located in the Broad River cannot exceed 5 percent of the mean annual flow. This requirement is referred to in this document as the Proportional Flow Limitation.

3.2.1 Overview of the Alternative Requirement Demonstration

Duke Energy requests an alternative requirement for the Track I Proportional Flow Limitation. Duke Energy believes that application of the Track I Proportional Flow Limitation, as interpreted by EPA, is not the best technology available for Lee Nuclear Station, and proposes use of its Water Management Plan as the best technology available for this requirement.

3.2.2 Alternative Requirement Authority and Applicability

3.2.2.1 SCDHEC Regulatory Authority to Grant an Alternative Requirement

As discussed in Section 2.3, § 316(b) implementing regulations authorize applicants to seek, and state agencies to grant, alternative best technology available standards, if the applicant can demonstrate that there are site-specific factors EPA had not considered (EPA 2001b). Section

125.85(a) provides provisions for establishment of an alternative requirement in lieu of a Track I requirement if certain criteria are met, including:

- there is an applicable requirement under § 125.84(a) through (e);
- compliance with the requirement would result in costs wholly out of proportion to the costs EPA considered in establishing the requirement, or compliance with the requirement would result in significant adverse impacts on local air quality, local water resources (other than impingement or entrainment), or on local energy markets;
- the alternative requirement requested is no less stringent than justified by the wholly out of proportion cost or the significant adverse impacts on local air quality, significant adverse impacts on local water resources other than impingement or entrainment, or significant adverse impacts on local energy markets; and
- the alternative requirement will ensure compliance with other applicable provisions of the Clean Water Act and any applicable requirement of state law.

There are several facility-specific parameters relevant to the proposed Lee Nuclear Station that EPA did not consider in its rule making, including: (1) construction of a nuclear station, and (2) instream flow restrictions, particularly related to the Water Withdrawal Law and FERC operating license.

The Track I requirement at issue for Lee Nuclear Station is the Proportional Flow Limitation, as described in § 125.84(b)(3)(i). Duke Energy evaluated a range of compliance options to meet the Proportional Flow Limitation requirement, but determined that compliance with the requirement would result in costs that are wholly disproportionate to those EPA considered, or would have significant adverse impacts to air quality, local water resources (the Broad River), and/or energy markets. Therefore, Duke Energy has developed a Water Management Plan that will allow Lee Nuclear Station to achieve the result intended by the Track I Proportional Flow Limitation and the instream flow restrictions of the Water Withdrawal Law and the FERC operating license, while providing greater protection during low-flow periods to organisms potentially susceptible to entrainment and to the ecology and the users of the Broad River downstream of the Ninety-Nine Islands Dam. Duke Energy proposes to use this Water Management Plan as the best technology available for the Proportional Flow Limitation requirement. This discussion is expanded in the following subsections.

3.2.2.2 Site-Specific Factors that EPA Did Not Consider Justify an Alternative Requirement

In the Preamble to the Final Rule, EPA (2001a) provided its rationale for including the alternative requirement option; specifically, 40 CFR § 125.85 was included because EPA recognized that it did not fully consider site-specific, local impacts under either Track I or Track II:

> [i]n general, EPA has concluded that at a national level the primary impacts of this rule will be aquatic in nature, and focus on impingement and entrainment effects.

> Nevertheless, at a local level, it is possible that air quality impacts, ***non-impingement and entrainment aquatic affects*** [*sic*], or energy impacts could be significant and potentially justify a different approach to regulating cooling water intake structures. ***Moreover, the cost impact of the rule, under certain local conditions, could be wholly disproportionate to costs anticipated by EPA on a national level. EPA believes that it is prudent to make an alternative regulatory mechanism available to the permitting authority to address such situations, and to be used at the permitting authority's discretion*** [emphasis added].

There are two key factors applicable to Lee Nuclear Station that EPA did not consider in its rulemaking for the Track I Proportional Flow Limitation: (1) construction of new nuclear generation facilities; and (2) considerations for maintaining appropriate instream flows during drought conditions. These are discussed in more detail in the following paragraphs.

Nuclear Generation

The Phase I Rule applies to a diverse array of new facilities, and EPA used data from across industry sectors in developing these requirements. EPA identified the model facilities used to evaluate the economic impact of the Phase I Rule in two documents: the 2001 Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities (TDD) (EPA 2001d) and the 2001 Economic Analysis of the Final Regulations Addressing Cooling Water Intake Structures for New Facilities (EPA 2001c). To conduct its analysis, EPA examined and compared baseline configurations and compliance configurations for model facilities expected to be regulated under the Phase I Rule. The "baseline" configuration represented EPA's estimation of the type of plant, costs, and impacts for the model facility absent EPA's Phase I Rule; the "compliance" configuration represented EPA's estimation of the type of plant, costs, and impacts for the model facility with a circulating water system equipped with redwood wet towers, Ristroph-modified screens, and fish return system to be required under the Phase I Rule.

At the time the Phase I Rule was being developed, the United States Department of Energy (USDOE) and the electric utility industry contemplated that the need for power in the future would primarily be provided by combined cycle and coal-fired facilities (EPA 2001c). EPA (2001d) looked to existing facilities of the type, fuel source, waterbody type, and cooling water intake structure technology that would be used at these facilities, and the cooling systems of the facilities then predicted to come on-line after 2001, to estimate the costs to the utility industry for compliance with the Phase I Rule. EPA made these assumptions based on the USDOE and utility industry information. EPA developed 14 model steam electric facilities. The model facilities were each described by their baseline cooling water system, waterbody type, capacity, baseline intake flow, and baseline cooling flow. EPA used these models when conducting its analysis to assess the likely economic impacts of the Phase I Rule on the projected 121 new steam electric facilities expected to be brought online over the next 20 years.

When EPA developed its suite of 14 model facilities, six of those models represented combined cycle facilities and eight represented coal-fired facilities; none of the 14 model facilities represented nuclear generation (EPA 2001d).[8] In its development of the model facilities, EPA (2001d) concluded that, "[b]ased on all available data in the rulemaking record, EPA projects ***no new additions for nuclear*** and other fossil steam capacity would be constructed between 2001 and 2020." [emphasis added]

The fact that EPA did not consider nuclear generation facilities in the establishment of its policies has direct implications to Duke Energy's proposed Lee Nuclear Station, and substantiates its request for an alternative requirement for the Proportional Flow Limitation requirement. This is discussed in more detail in subsection 3.2.3.1.

Instream Flow Restrictions

As discussed in subsections 2.4.1 and 2.4.2, State and Federal drought contingency policies and low-flow protocols have been developed to prevent significant adverse impacts to the State's water resources and the environment during low flow conditions. These include the policies embodied in South Carolina's Water Withdrawal Law and the FERC operating license for the Ninety-Nine Islands Hydroelectric Station located on the Broad River.

The Water Withdrawal Law establishes instream flow requirements to ensure an adequate supply of water to maintain the biological, chemical, and physical integrity of the stream, taking into account the needs of downstream users, recreation, and navigation.

The FERC operating license for Ninety-Nine Islands Hydroelectric Station limits reservoir drawdown and establishes a protocol for releases to the Broad River. The requirements of this license satisfy FERC's obligation to consider: protection, mitigation of, damage to, and enhancement of fish and wildlife (including spawning grounds and habitat); protection of recreational opportunities; and preservation of other aspects of environmental quality.

Similar to the absence of nuclear generation considerations, the fact that EPA did not consider site-specific instream flow restrictions from other State and Federal entities in the establishment of its policies has direct implications to Duke Energy's proposed Lee Nuclear Station. This further substantiates Duke Energy's request for an alternative requirement for the Track I Proportional Flow Limitation. This is discussed in more detail in subsection 3.2.3.2.

[8] EPA (2001c) did explore the compliance costs of two hypothetical nuclear plants when developing the Phase I Rule; however, no details on this analysis are available in EPA's Phase I Record. Moreover, EPA did not include the costs for nuclear power plants in its overall presentation of national compliance costs used to support the Final Phase I Rule, since nuclear capacity additions were not projected within the 20-year time-span.

3.2.3 Justification of an Alternative Requirement for Lee Nuclear Station

As described in Section 2.3 and subsection 3.2.2.1, an alternative requirement can be established by SCDHEC if the applicant can demonstrate:

- compliance with the requirement would result in costs wholly out of proportion to the costs EPA considered in establishing the requirement, or
- compliance with the requirement would result in significant adverse impacts on local air quality, local water resources (other than impingement or entrainment), or on local energy markets.

In the following subsections, Duke Energy demonstrates that Lee Nuclear Station qualifies for the requested alternative requirement in lieu of the Track I Proportional Flow Limitation as Track I compliance options would result in costs wholly out of proportion to the costs EPA considered and/or significant adverse impacts on local air quality, local water resources, or local energy markets.

3.2.3.1 Compliance Would Result in Costs Wholly Out of Proportion to EPA Cost Considerations

As discussed in subsection 3.2.2.2, EPA did not consider nuclear generation facilities when developing its baseline configurations and compliance configurations for model facilities expected to be regulated under the Phase I Rule. The "baseline" configuration represented EPA's estimation of the type of plant, costs, and impacts for the model facility absent EPA's Phase I Rule; the "compliance" configuration represented EPA's estimation of the type of plant, costs, and impacts for the model facility with a circulating water system equipped with redwood wet towers, Ristroph-modified screens, and fish return system to be required under the Phase I Rule.

In order to evaluate whether the cost of achieving compliance with the Proportional Flow Limitation at Lee Nuclear Station would be wholly out of proportion to those EPA considered in establishing that requirement, Duke Energy first had to determine what EPA's costs would have been for Lee Nuclear Station as the baseline for comparison. Given EPA's decision not to include a nuclear facility as one of its model facilities, Duke Energy used the relevant information in EPA's Phase I Record to develop an appropriate surrogate "model facility" for its alternative requirement demonstration. Duke Energy identified the most appropriate model for estimating impacts and costs for a facility similar to Lee Nuclear Station by selecting a model coal-fired facility with similar design intake and cooling water flow. The design intake and cooling water flow values for Lee Nuclear Station are close to the design values for Model Facility Coal R/FW-3. Therefore, this model was selected as representative of EPA's estimate of costs for Lee Nuclear Station. The analysis Duke Energy used to select and scale the appropriate model facility is presented in Appendix E. This Appendix also includes a discussion of the limitations of this model for use in representing Lee

Nuclear Station. Finally, this Appendix addresses assumptions that EPA used to develop its cost analysis that do not accurately reflect conditions at Lee Nuclear Station. Specific details of the cost estimate, as well as a comparison to costs associated with potential compliance options to meet the proportional flow limit and in-stream flow restrictions, are discussed in the compliance options evaluation in subsection 3.2.4. As is noted in that section, the costs of meeting the proportional flow limit, while complying with in-stream flow restrictions, would be wholly out of proportion to the costs EPA considered in its rulemaking.

3.2.3.2 Compliance Would Result in Significant, Adverse Impacts on Local Air Quality, Local Water Resources (other than impingement or entrainment), or on Local Energy Markets

As discussed in subsection 3.2.2.2, EPA did not consider site-specific state and federally mandated instream flow requirements when developing its Proportional Flow Limitation requirement. As the EPA regulations are written, a 5 percent mean annual flow withdrawal could prevent some waterbodies from maintaining minimum flows during extended drought years. The South Carolina Water Withdrawal Law and FERC operating license for Ninety-Nine Islands Hydroelectric Station both reflect instream flow requirements to protect downstream water uses. To protect these downstream uses, the Water Withdrawal Law limits Lee Nuclear Station's withdrawal from Ninety-Nine Islands Reservoir based on the lowest minimum downstream flow (i.e., 483 cfs) identified in the FERC license. Minimum instream flows provide "an adequate supply of water at the surface water withdrawal point to maintain the biological, chemical, and physical integrity of the stream taking into account the needs of downstream users, recreation, and navigation" (Water Withdrawal Law). In the 2004 South Carolina Water Plan (SCDNR 2004), the SCDNR discussed the importance of maintaining sufficient instream flows to protect water quality, fish and wildlife habitat, navigability, and downstream users. Failure to maintain adequate flows within a particular water body would have significant adverse impacts to these resources.

Additionally, during the development of the policy, EPA understood that compliance with § 125.84(b) may have significant adverse air quality or energy market impacts for some facilities. Compliance under some options evaluated by Duke Energy (see subsection 3.2.4) would result in Lee Nuclear Station not meeting its designed power generation. The decrease in power generation would result from seasonal plant shutdowns or increases in parasitic loads arising from use of alternative cooling sources. During times when Lee Nuclear Station would not meet its base load power projections, Duke Energy would need to replace the power through either purchases or generation from other sources. Since replacement power would come from fossil fuel generating plants, as described in the IRP, such replacement power generation would have associated impacts to air quality through increased emissions. Such air quality impacts include increases in nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon dioxide (CO_2), and mercury (Hg). If the lost power was not replaced and power generation failed to meet forecasted demand, the energy market in Duke Energy's regional service area would suffer significant adverse impacts. Appendix F presents a detailed analysis of the impacts to local air quality associated with these compliance options.

3.2.4 Analysis of Track I Compliance Options

In addition to Duke Energy's proposed alternative to the Proportional Flow Limitation, which will be discussed further below, Duke Energy considered a range of individual compliance options to meet the requirements of § 125.84(b)(3)(i), using Broad River flow data from 2001 through 2010 and projected plant make-up water needs. These compliance options included combinations of technological and operational measures. Duke Energy eliminated a number of these options from further consideration without detailed analysis after determining they were infeasible or failed to meet Track I proportional flow requirements while maintaining adequate instream flows (see subsection 3.2.4.5). Following this initial screening, Duke Energy identified four options that were potentially viable and could potentially meet the requirements of § 125.84(b)(3)(i). Detailed analysis was performed on each of these remaining compliance options to determine whether implementation would result in compliance costs wholly out of proportion to the costs EPA considered, or would result in significant adverse impacts on local air quality, significant adverse impacts on local water resources other than impingement or entrainment, or significant adverse impacts on local energy markets. Table 3-1 identifies each Track I compliance option that Duke Energy considered for detailed analysis and conclusion as to the obstacles to their implementation. Option 1 would result in significant adverse impacts on local water resources. Options 2, 3, and 4 would result in costs wholly out of proportion to EPA-developed costs and significant adverse impacts to air quality. Within the following subsections are assessments of the site-specific factors that EPA had not considered for each compliance option. Further information on costs is provided in Appendix E, while information on impacts to air quality is provided in Appendix F.

3.2.4.1 Option 1 – No Observance of Instream Flow Restrictions

Option 1, No Observance of Instream Flow Restrictions, would involve Lee Nuclear Station withdrawing a maximum daily water rate of 5 percent of the mean annual flow continually without regard to maintaining sufficient instream flows. This option would include: a recirculating cooling water system with wet mechanical draft cooling towers; a daily maximum withdrawal rate of 5 percent or less of the mean annual flow (98 cfs); a cooling water intake structure consisting of fine-mesh, Ristroph dual-flow traveling screens on the river intake with fish return systems; fine-mesh, Ristroph dual-flow traveling screens on the intake for Pond A; and no construction of proposed Pond C. All intakes would have through-screen or through-slot velocities of 0.5 fps or less. The cooling water intake structure would supply the necessary water from the river to the station via Pond A. As is permitted under strict compliance with the Track I Proportional Flow Limitation, 98 cfs would be continuously withdrawn from the Broad River without regard to maintaining adequate instream flow during drought conditions.

Option 1 would have significant adverse impacts to local water resources other than impingement and entrainment.

Although this compliance option would comply with § 125.84 (b)(3)(i), withdrawals of 5 percent of the mean annual flow would have significant impacts to the aquatic environment during low flows as described in subsection 3.2.3.2. Without instream flow restrictions in the Broad River, fish and macroinvertebrate habitat, availability of water for other users, and recreation downstream of the intake and Ninety-Nine Islands Dam would be significantly impacted during drought years. Aquatic resources and water users downstream of the Ninety-Nine Islands Dam are discussed in Appendix K.

As previously discussed, South Carolina, through its enactment of the Water Withdrawal Law and the supporting legislative record, has determined that adequate instream flows are necessary to protect water quality, fish and wildlife habitat, navigability, and downstream users. Since this compliance option would be inconsistent with the above findings and would result in significant adverse impact to local water resources [§ 125.85(a)(2)], particularly biological resources, Duke Energy dismissed this option without further consideration. Therefore, costs were not developed specifically for this compliance option and it is not discussed in detail in Appendix E.

3.2.4.2 Option 2 – Seasonal Shutdowns

Option 2, the Seasonal Shutdowns Option, would include all features of Option 1, but would operate to achieve compatibility with the intent of federal and state instream flow policies. The cooling water intake structure would supply the necessary water from the river to the station via Pond A. During periods of low flow, the cooling water intake structure in Pond B would supply the necessary make-up water from Pond B via Pond A. Under this option, to comply with the 5 percent withdrawal limitation and to maintain adequate instream flows in the Broad River, Duke Energy would shut down Lee Nuclear Station under periods of low flow once the storage volume of Pond B was depleted. Based on a projection of the 9-year period from 2021–2029, using daily flow data from 2001–2009 and projected plant operation make-up water needs, Duke Energy would shut down Lee Nuclear Station for varying lengths of time during four of those years, with shutdowns occurring at two different times in 2028. Table 3-2 and Appendices E and F present the seasonal shutdowns associated with this compliance option. Once flows in the Broad River increased so that adequate flows could be maintained, Pond B would be refilled with the 20 cfs of water beyond the 78 cfs average required for normal plant operations.

This compliance option would present substantial operational difficulties to Lee Nuclear Station. The shutdown schedule would not be compatible with Duke Energy's plans to operate Lee Nuclear Station as a baseload plant. Replacement power purchases required to compensate for lost generation during seasonal shutdowns would lead to costs wholly out of proportion to costs EPA considered and, as compared to the requested alternative requirement, would have significant adverse impacts on local air quality.

Option 2 would have costs wholly out of proportion to EPA cost considerations.

The capital costs associated with the Seasonal Shutdowns Option would be approximately $491 million in 2009 dollars. These costs would be due to the construction of cooling towers, intakes, and related components (Appendix E). Operation and Maintenance (O&M) costs would be approximately $7 million in 2009 dollars (Appendix E). Since Lee Nuclear Station would operate as a baseload plant, it is expected to provide power 24 hours a day, seven days a week, and typically operate more than 8,000 hours per year. If power could not be provided by the plant, power purchases from sources outlined in the IRP would need to provide the necessary power. If Lee Nuclear Station were required to take forced shutdowns, as described above, Duke Energy would incur replacement power costs ranging from $123,277,000 in 2021 to $921,733,000 in 2028. Comparison of Option 2 costs to EPA costs are provided in Appendix E. Total capital costs are more than 4.7 times the costs considered by the EPA ($103,366,294) in the Phase I Rule for a facility the size of Lee Nuclear Station. O&M costs are projected to be $12.4 million less than EPA costs ($19,168,934) based on Duke Energy's operating experience. EPA (2001a) did not consider replacement power costs associated with forced shutdowns in developing the Phase I Rule. While capital costs for compliance are already wholly out of proportion with costs EPA considered and O&M costs are less, the additional costs incurred due to the seasonal shutdowns, when added to the wholly-out-of-proportion capital costs, cumulatively make the cost of this compliance option exponentially out of proportion to what EPA considered. Table 3-5 provides cost comparisons of Option 2 to the costs that EPA considered.

Option 2 impacts to local air quality.

To meet statutory obligations as a regulated utility providing power to the public, Duke Energy would likely be required to generate electricity from fossil fuel-fired power plants and/or purchase replacement power from other local and regional facilities to make up for the energy lost during the forced shutdowns. This would result in increased air emissions for NO_x, SO_2, and Hg (Appendix F). In addition, increased operation of the fossil fuel-fired power plants would result in a significant increase in the release of CO_2 emissions. These increases in air emissions are summarized in Table 3-6.[9]

3.2.4.3 Option 3 – Pond C and Seasonal Shutdowns

Option 3, Pond C and Seasonal Shutdowns, is similar to Option 2, the Seasonal Shutdowns Option, in that it would include all of the technological measures proposed under Option 2 (recirculating

[9] Although not directly relevant to the current § 316(b) analysis, it is worth noting that other fuel types such as natural gas combined cycle would not meet Track I proportional flow requirements without the addition of Pond C to maintain flows in the Broad River during drought conditions and would result in greater air impacts than those discussed here. See Letter from R.A. Jones (Duke Energy) to USNRC Document Control Desk, Supplemental Responses to Requests for Additional Information, Ltr. # WLG2011.07-04, July 8, 2011, Enclosure 4 (Available in Appendix G). In addition, combined cycle and other fuels are not Duke Energy's preferred alternative (Duke Energy 2009b; RAI response above) at this site and are inconsistent with Duke Energy's strategy for this station to provide a reliable, diverse, environmentally sound, and reasonably priced portfolio of resources over time (Duke Energy 2010a).

cooling and service water system with wet towers, cooling water intake structure with Ponds A and B) plus Pond C and its attendant cylindrical wedge-wire screens for the single intake/refill structure and associated piping. However, because of the additional supplemental water supply available in the additional drought contingency pond, Duke Energy would take less frequent and shorter seasonal shutdowns than under Option 2 to comply with § 125.84(b)(3)(i), while maintaining sufficient instream flows within the Broad River. For the 9-year period between 2021–2029, it is predicted that Duke Energy would be required to take a forced shutdown at Lee Nuclear Station during one year (2028).[10] Table 3-3 and Appendices E and F present the seasonal shutdown associated with this compliance option. Once flows in the Broad River increased so that sufficient flows could be maintained, the drought contingency ponds would be refilled with the 20 cfs of water beyond the 78 cfs average required for normal plant operations.

Although the forced shutdowns would be shorter and less frequent than Option 2, the shutdown schedule would not be compatible with Duke Energy's plans to operate Lee Nuclear Station as a baseload plant. Replacement power purchases required to compensate for lost generation during seasonal shutdowns would lead to costs wholly out of proportion to costs EPA considered and, as compared to the requested alternative, would have significant adverse impacts on local air quality.

Option 3 would have costs wholly out of proportion to EPA cost considerations.

The capital costs associated with this compliance option—wet towers and cooling water intake structure with Ponds A, B, and C—would be approximately $721 million in 2009 dollars. The increase in capital costs from Option 2 would be due to the construction of intake and piping associated with Pond C, and the construction of Pond C. Duke Energy would incur O&M costs, including costs associated with pumping between Ponds A, B, and C and the drought contingency section of the river intake, of approximately $8 million in 2009 dollars (Appendix E). A forced shutdown to maintain sufficient flows would result in a replacement power cost of $350,630,000 in 2028. Comparison of Option 3 costs to EPA costs are provided in Appendix E. Capital costs for the Seasonal Shutdowns with Pond C compliance option are more than 6.9 times the costs considered by EPA in the Phase I Rule for a facility the size of Lee Nuclear Station, while the O&M costs are less than what EPA considered. EPA (2001a) did not consider replacement power costs associated with forced shutdowns in developing the Phase I Rule. The cost of constructing Pond C represents a substantial increase in capital cost over Option 2, yet seasonal shutdowns are not avoided. Therefore, replacement power purchase costs, when added to the wholly-out-of-proportion capital costs, cumulatively make the cost of this compliance option exponentially out of proportion to what EPA considered. Table 3-5 provides cost comparisons of Option 3 to the costs that EPA considered.

[10] As described above, these projections are based on actual flow data for the river from 2001 through 2009. The Prosym model was limited to projections through the year 2029 at the time the analysis was performed.

Option 3 would have significant adverse impacts to local air quality.

To meet statutory obligations as a regulated utility providing power to the public, Duke Energy would likely be required to generate electricity from fossil fuel-fired power plants and/or purchase replacement power from other local and regional facilities to make up for the energy lost during the forced shutdowns. Although the increase in air emissions would be lower than the increase associated with Option 2, the Seasonal Shutdowns Option, the shutdowns associated with Option 3, the Pond C and Seasonal Shutdowns Option, would result in increased air emissions for NO_x, SO_2, and Hg pollutants (Appendix F). In addition, increased operation of the fossil fuel-fired power plants would result in a significant increase in the release of CO_2 emissions. These increases in emissions are summarized in Table 3-6.

3.2.4.4 Option 4 – Hybrid Towers

Duke Energy considered a Hybrid Tower compliance option, consisting of a hybrid cooling technology design utilizing 50 percent indirect dry cooling towers in series with 100 percent wet mechanical-draft cooling towers, to decrease water consumption (Appendix G) in conjunction with the cooling water intake structures with Ponds A, B, and C. The dry cooling towers would be sized to reject 50 percent of the heat load at the design dry bulb temperature for Lee Nuclear Site of 92°F (1 percent exceedance). These dry cooling towers (three per unit) would be very large (100 feet wide by 935 feet long by 100 feet high), owing to the significant surface area required for heat transfer to support the required range of heat dissipation. The wet cooling towers would be sized to reject 100 percent of the heat load.

Duke Energy considered two operational strategies: a maximum “water savings” control strategy, and a “power savings” strategy (Appendix G). Since the water savings strategy utilizes the dry towers more often, Lee Nuclear Station would have an increased parasitic load and associated replacement power costs under this scenario. Therefore, for the purposes of conservatively demonstrating that the Hybrid Tower compliance option would result in costs wholly disproportionate to costs considered by EPA, the less costly “energy savings” scenario is used in this discussion. In the “energy savings” strategy, circulating water would normally be routed to the wet cooling towers. When a decrease in consumptive water use would be required to maintain sufficient instream flows, the dry component of the hybrid system would be used in conjunction with the dry towers to reduce water consumption. Appendix G provides a more-detailed description of this technology.

Consumptive water savings from the hybrid design would be achieved through the decreased heat load on the wet towers due to sensible heat rejection in the dry cooling towers. However, sensible heat rejection is dependent on the temperature of the ambient air, and during summer conditions, the heat rejection (and therefore consumptive water savings) would decrease substantially. The wet tower would be required to reject most of the heat load; therefore, only a limited decrease in consumptive water usage would be realized.

The evaluated hybrid system utilized the largest indirect dry cooling towers that could be feasibly accommodated by the site layout. However, the hybrid tower configuration sized to conserve enough water to preclude shutdown during all historical low-flow river conditions would result in a loss of generation output from the station due to higher parasitic loads, would require an additional 100 acres of clearing and grading to site the dry towers, and still would require the construction of Pond C as a drought contingency pond (Appendix G).

Although this compliance option may be technically feasible, the dry cooling towers would be twice as large as any similar towers currently installed worldwide and would be "first of a kind" technology. This leads to uncertainties and questions about the system's operational capability, which creates a substantial risk to both generating performance and capital assets of the system not operating adequately. Additionally, EPA rejected dry cooling as best technology available as a national standard because the costs of the technology are sufficient to pose a barrier to some proposed facilities' entry to the marketplace (EPA 2001b). Implementation of the Hybrid Towers Option would lead to costs wholly out of proportion to the costs EPA considered as well as impacts to local air quality.

Option 4 would have costs wholly out of proportion to EPA cost considerations.

The capital costs estimated for a hybrid tower system would be approximately $1.8 billion in 2009 dollars (Appendix E). These capital costs would be associated with construction of the wet and dry cooling towers and Pond C, as well as the intakes and piping. The O&M costs associated with a hybrid tower system, as well as costs associated with pumping between Ponds A, B, and C, would be estimated at approximately $9 million in 2009 dollars (Appendix E). As shown in Appendix G, a hybrid system at Lee Nuclear Station would lower each unit's net output by approximately 24 megawatts (MW) due to additional fan loads. The cost to replace the loss in megawatts for the first year of two-unit operation (projected as year 2021) was estimated to be approximately $30,000,000. Replacement power costs are estimated to range from $22,154,000 in 2023 to $53,432,000 in 2026 (Appendix E). Comparison of Option 4 costs to EPA costs are provided in Appendix E. Total capital costs for the Hybrid Towers Option are more than 17 times the costs considered by EPA in the Phase I Rule for a facility the size of Lee Nuclear Station. The capital costs alone make the cost of this compliance option wholly out of proportion to costs that EPA considered, as EPA did not evaluate hybrid cooling tower technology for compliance with the Phase I Rule. The cost of replacement power for parasitic loads even further increases the cost of the Hybrid Cooling Tower Option. Table 3-5 provides cost comparisons of Option 4 to the costs that EPA considered.

Option 4 would have impacts to local air quality.

To meet statutory obligations as a regulated utility providing power to the public, Duke Energy would likely be required to generate electricity from fossil fuel-fired power plants and/or purchase replacement power from other local and regional facilities to make up for the energy lost from

parasitic loads of the dry cooling tower fans. This would result in increased air emissions for NO_x, SO_2, and Hg (Appendix F). In addition, increased operation of the fossil fuel-fired power plants would result in a significant increase in the release of CO_2 emissions. These increases in air emissions are summarized in Table 3-6.

3.2.4.5 Track I Compliance Options Eliminated From Detailed Evaluation

Other compliance options were evaluated to determine their ability to meet the requirements of § 125.84(b)(3)(i), but were eliminated from detailed evaluation based on the following criteria:

- feasibility of application at the proposed site for Lee Nuclear Station, considering Duke Energy's experience with the technology and its having been demonstrated at the appropriate scale;
- ability to meet the requirements of § 125.84(b)(3)(i);
- ability to provide sufficient make-up water to avoid seasonal shutdowns;
- ability to meet the load requirements forecasted by Duke Energy;
- ability to obtain required permits, licenses; and/or agreements;
- ability to meet other federally mandated regulatory requirements; and
- whether impacts to wetlands and other waters of the U.S. would be greater than impacts associated with the proposed alternative requirement.

As summarized in Table 3-4, the following compliance options were ultimately determined not viable for Lee Nuclear Station:

- using an alternative reactor design (see Duke Energy 2009a);
- using indirect dry towers (see Duke Energy 2009a);
- using air cooled condensers (ACC) (see Appendix I)
- increasing the capacity of existing drought contingency pond (see Duke Energy 2009b);
- raising the height of Ninety-Nine Islands Dam (see Duke Energy 2009b);
- relocating the river intake (see Duke Energy 2009a);
- releasing additional water from upstream reservoirs (see Duke Energy 2009b);
- impounding Kings Creek (see Duke Energy 2009b);
- using groundwater as the source of make-up water (see Duke Energy 2009b);
- using reclaimed water as the source of make-up water (see Appendix J); and
- using municipal water as the source of make-up water.

These compliance options and the reason(s) that they were not considered feasible for implementation at Lee Nuclear Station are more fully described in Appendix H.

3.2.5 Recommendation for Alternative Requirement: Water Management Plan as Best Technology Available for Proportional Flow Limitation

As discussed, an applicant is entitled to an alternative requirement where compliance with a Track I requirement would result in costs wholly out of proportion to the costs EPA considered in establishing the requirement at issue or would result in significant adverse impacts on local air quality, local water resources, or local energy markets. For this project, because of its consideration for maintenance of instream flows, strict compliance with the Track I Proportional Flow Limitation would result in significant adverse effects on the Broad River. Duke Energy evaluated all reasonably feasible options that might support compliance with the Track I Proportional Flow Limitation, and in each case it was ultimately determined that the option would be infeasible, would result in costs wholly disproportionate to the costs EPA considered in establishing the Track I Requirements, and/or would result in significant adverse effects on local air quality, water resources, or energy markets. Duke Energy has demonstrated that an alternative requirement is appropriate for Lee Nuclear Station. Therefore, Duke Energy proposes a Water Management Plan, described below, that is consistent with the State and Federal site-specific drought contingency considerations and policies and, as compared to the Track I Proportional Flow Limitation, results in less entrainment of aquatic biota and more protection of the local water resource during low-flow periods.

3.2.5.1 Duke Energy's Water Management Plan as Best Technology Available

Duke Energy proposes the following Water Management Plan that reflects the best technology available at Lee Nuclear Station pursuant to the criteria established in the § 316(b) implementing regulations and is highly protective of local water resources.

- To minimize withdrawal of water during low-flow periods, a drought contingency pond (Pond C) will be built to complement existing drought contingency Pond B.
- During normal flow periods on the Broad River (>538 cfs), Duke Energy will withdraw all of its operational water requirements from the Broad River through the primary section of the river intake into existing sedimentation Pond A. The primary section of the river intake will have a design intake flow of 98 cfs. Pond A will provide water for plant processes and cooling tower makeup. Based on the historical Broad River flow conditions, Duke Energy anticipates this will be the normal withdrawal scheme employed greater than 95 percent of the time.
- As the Broad River flow drops below 538 cfs and begins to approach 483 cfs, Duke Energy will proportionally withdraw its consumptive water requirements (≤63 cfs) from the Broad River and drought contingency Ponds B and C. Pond B will be drawn down first. If Pond B drawdown reaches 30 feet, drawdown from Pond B will cease and water will be withdrawn from Pond C to a nominal drawdown ≤30 feet.

- When Broad River flow is at or below 483 cfs, only non-consumptive cooling water used (approximately 23 cfs) will be withdrawn from the Broad River. That water will be returned to the Reservoir after use in order to maintain adequate flows in the Broad River. The remaining water needed to operate Lee Nuclear Station (≤63 cfs) will be drawn from drought contingency Ponds B and C. Pond B will be drawn down first. If Pond B drawdown reaches 30 feet, drawdown from Pond B will cease and water will be withdrawn from Pond C to a nominal drawdown ≤30 feet. Based on modeling using worst-case droughts over the 85-year period of record, Duke Energy does not anticipate that any additional drawdown will be needed. However, should it be warranted to support station operations during emergency drought conditions, any additional drawdown or other water management protocols will be performed pursuant to a drought contingency plan to be developed in accordance with the South Carolina Water Withdrawal Law after consultation with appropriate regulatory agencies.
- During the period of July through February, and only when the Broad River flows return above 483 cfs, Pond B and/or C will be refilled, as needed, by withdrawing water from the Broad River through the drought contingency section of the river intake. During this period, the water necessary to operate the station will also be withdrawn from the Broad River via the primary section of the river intake.
- The drought contingency section of the river intake will have a maximum design intake flow of 206 cfs. However, the actual refill rate will be determined using a flow-sensitive approach to ensure Broad River flows do not fall below 483 cfs due to refill of the drought contingency ponds. Further, regardless of river flows, refilling of Pond B and/or C will not occur from March through June in order to minimize entrainment.

3.2.5.2 Alternative Requirement is No Less Stringent Than Track I Requirement

As compared to the Track I Proportional Flow Limitation, the alternative requirement proposed by Duke Energy will be more protective of local water resources of the Broad River and will be more protective of the ecology of the downstream Broad River and its users. The Water Management Plan encompasses use of drought contingency ponds and instream flow restrictions. Based on the historical period of record, it is expected that the Water Management Plan will operate consistent with the Track I Proportional Flow Limitation greater than 95 percent of the time. The proposed alternative requirement is designed to maintain instream flows during the remainder of the time when the Broad River is experiencing low flows.

The expressed purpose of the Track I Proportional Flow Limitation is to limit entrainment of aquatic biota. To ensure the proposed alternative requirement is adequately protective of entrainable biota and consistent with the intent of the Track I Proportional Flow Limitation, Duke Energy conducted an Entrainment Assessment (Appendix L) to compare levels of entrainment that would be likely to occur at the proposed Lee Nuclear Station under two water withdrawal scenarios:

- **EPA Track I Scenario**: Constant daily water withdrawal rate, year-round, equal to 5 percent of the 10-year mean annual flow of the Broad River in the vicinity of Lee Nuclear Station (i.e., 98 cfs), as allowed by EPA's Phase I Rule.
- **Proposed Alternative Scenario**: Maximum daily water withdrawal rate, March through June, equal to 98 cfs, maximum daily water withdrawal rate, July through February, equal to 304 cfs, and no withdrawals that would cause the Broad River flow to drop below 483 cfs.

As discussed in detail in Appendix L, and exemplified by Figure 3-2, for all years (2001–2010), the likely entrainment under the alternative scenario is substantially lower than the entrainment that would be permitted under the EPA Track I option. The likely level of entrainment under this scenario is lower than the level of entrainment that would be allowed under the EPA Track I option because the daily proportion of river flow that would be withdrawn is lower during periods when larvae most likely to be vulnerable to entrainment would be present. During periods of the year when entrainable life stages are less likely to be present in significant numbers, higher withdrawal rates would not result in higher entrainment. The water withdrawal schedule for the alternative scenario is specifically intended to minimize withdrawals during periods of higher entrainment vulnerability and low river flows, and make up for those periods of lower withdrawals by withdrawing additional volumes during periods of low entrainment vulnerability and higher river flows.

The Water Management Plan that Duke Energy is proposing will allow Lee Nuclear Station to address both the intent of the Track I Proportional Flow Limitation and the instream flow restrictions of the Water Withdrawal Law and the FERC operating license, while providing greater protection to organisms potentially susceptible to entrainment as well as to the ecology and users of the downstream Broad River. Since the Water Management Plan will be even more protective of aquatic organisms during low flow situations in the Broad River, the use of an alternative requirement is no less stringent than necessary to address the wholly disproportionate costs and significant adverse energy, water resources, and air impacts created by the Track I Proportional Flow Limitations.

3.2.5.3 Alternative Requirement Will Ensure Compliance with Other Applicable Provisions of the Clean Water Act and Any Applicable Requirement of State Law

The proposed alternative requirement will ensure that Lee Nuclear Station is in full compliance with all other sections of the CWA, including §§ 208, 303, 306, 402, and 404, as well as South Carolina's Pollution Control Act §§ 48-1-10 *et seq*. It will also ensure compliance with South Carolina's Water Withdrawal Law by maintaining instream flow to ensure an adequate supply of water to maintain the biological, chemical, and physical integrity of the stream. Specifically, the Water Management Plan restricts withdrawals based on the lowest minimum flow identified in the FERC operating license for the Ninety-Nine Islands Reservoir. In addition, as a result of this new law, Duke Energy will be required to apply to SCDHEC for a water withdrawal permit for Lee

Nuclear Station. The permit that SCDHEC will issue will require that Duke Energy prepare an operational and contingency plan to promote an adequate water supply from the surface water during low-flow periods. The plan must address actions to address low flow conditions such as water conservation, supplemental water supplies, or off-stream water storage. Duke Energy's plan to use water from the drought contingency Ponds B and/or C during low-flow periods to minimize withdrawals from the river and its proposed refill schedule during higher flow/lower biological activity periods is fully consistent with this law.

Table 3-1
Factors Affecting Ability to Implement
Track I Compliance Options Considered by Duke Energy

Alternative	Infeasible	Costs Wholly Out of Proportion	Impacts to Local Air Quality	Impacts to Local Water Resources	Impacts to Local Energy Markets
Option 1 – No Observance of Instream Flow Restrictions		NO	NO	YES	NO
Option 2 – Seasonal Shutdowns		YES	YES	NO	YES
Option 3 – Pond C and Seasonal Shutdowns		YES	YES	NO	YES
Option 4 – Hybrid Towers		YES	YES	NO	YES
Alternative reactor design	YES	Not Evaluated			
Dry cooling – indirect dry cooling	YES				
Air Cooled Condensers	YES				
Increase capacity of existing drought contingency pond	YES				
Raise height of Ninety-Nine Islands Dam	YES				
Relocate River intake	YES				
Release additional water from upstream reservoirs	YES				
Impound Kings Creek	YES				
Use groundwater as source of make-up water	YES				
Use reclaimed water as source of make-up water	YES				
Use municipal water supplies as source of make-up water	YES				

Table 3-2
Option 2 Seasonal Shutdown (Assumes Drought Contingency Pond B only)

Model Year	Historical Year	Start Day	Stop Day	Total Offline Days
2021	2001	October 9	November 10	32
2022	2002	July 8	October 14	98
2023	2003	—	—	—
2024	2004	—	—	—
2025	2005	—	—	—
2026	2006	—	—	—
2027	2007	August 22	November 30	100
2028	2008	July 1	September 15	76
2028	2008	November 5	December 15	40
2029	2009	—	—	—

Source: Duke Energy, Lee Nuclear Seasonal Shutdown Study, July 2011.

Table 3-3
Option 3 Seasonal Shutdown (Assumes Drought Contingency Pond B and C)

Model Year	Historical Year	Start Day	Stop Day	Total Offline Days
2021	2001	—	—	—
2022	2002	—	—	—
2023	2003	—	—	—
2024	2004	—	—	—
2025	2005	—	—	—
2026	2006	—	—	—
2027	2007	—	—	—
2028	2008	October 21	December 4	44
2029	2009	—	—	—

Source: Duke Energy, Lee Nuclear Seasonal Shutdown Study, July 2011.

Table 3-4
Compliance Options Eliminated from Detailed Evaluation

Alternative	Reason for Elimination from Analysis						
	Demonstrated at Appropriate Scale or Feasible for Site Conditions	Meets Requirements of §125.84(b)(3)	Provides Sufficient Make-Up Water	Meets Load Requirements Forecasted by Duke Energy	Obtain Required Permits, Licenses, or Agreements	Meets Other Federally Mandated Regulatory Requirements	Environmental Impacts Greater than Proposed Alternative
Alternative reactor design		NO					
Dry cooling – indirect dry cooling	NO			NO			
Air Cooled Condensers	NO			NO			
Increase capacity of existing drought contingency pond			NO				
Raise height of Ninety-Nine Islands Dam		NO			NO	NO	YES
Relocate River intake		NO					
Release additional water from upstream reservoirs			NO		NO		
Impound Kings Creek							YES
Use groundwater as source of make-up water			NO				
Use reclaimed (i.e., gray) water as source of make-up water			NO				
Use municipal water supplies as source of make-up water		NO	NO				

Table 3-5
Comparison of EPA's Costs for Lee Nuclear Station with Costs for Options 2, 3, and 4

	EPA's cost for Lee Nuclear Station	Option 2	Option 3	Option 4
Compliance Capital Cost				
Wet Cooling Towers				
Dry Cooling Towers				
Piping				
Intakes and related components				
Pond C structures				
Total Capital Cost	**$103,366,294**	**$490,628,892**	**$721,007,178**	**$1,761,806,339**
Compliance O&M Cost				
Wet Cooling Towers				
Dry Cooling Towers				
Intake pumping energy				
Intake Traveling Screens				
Additional costs				
Total O&M Cost	**$19,168,934**	**$6,867,028**	**$7,980,617**	**$9,432,592**
Replacement Power Costs				
Total Replacement Power Cost	**$0**	**$694,225,000**	**$91,929,000**	**$148,393,000**
Total Costs - Capital, O&M, and Replacement Power				
Total Cost	***$122,535,228***	***$1,191,720,920***	***$820,916,795***	***$1,919,631,931***

COST INFORMATION REDACTED

Table 3-6
Peak Emission Estimates for Replacement Power for All Compliance Options

Pollutant	Peak Projected Annual Emissions Increase (tons per year)				
	No Minimum Flows Option 1	Seasonal Shutdowns Scenarios		Hybrid Towers Option 4	Water Management Plan Alternative Requirement
		Option 2	Option 3		
Nitrogen Oxides	0	1,900	900	200	0
Carbon Dioxide	0	3,800,000	1,500,000	300,000	0
Sulfur Dioxide	0	900	400	180	0
Mercury	0 (pounds)	35 (pounds)	16 (pounds)	7 (pounds)	0 (pounds)

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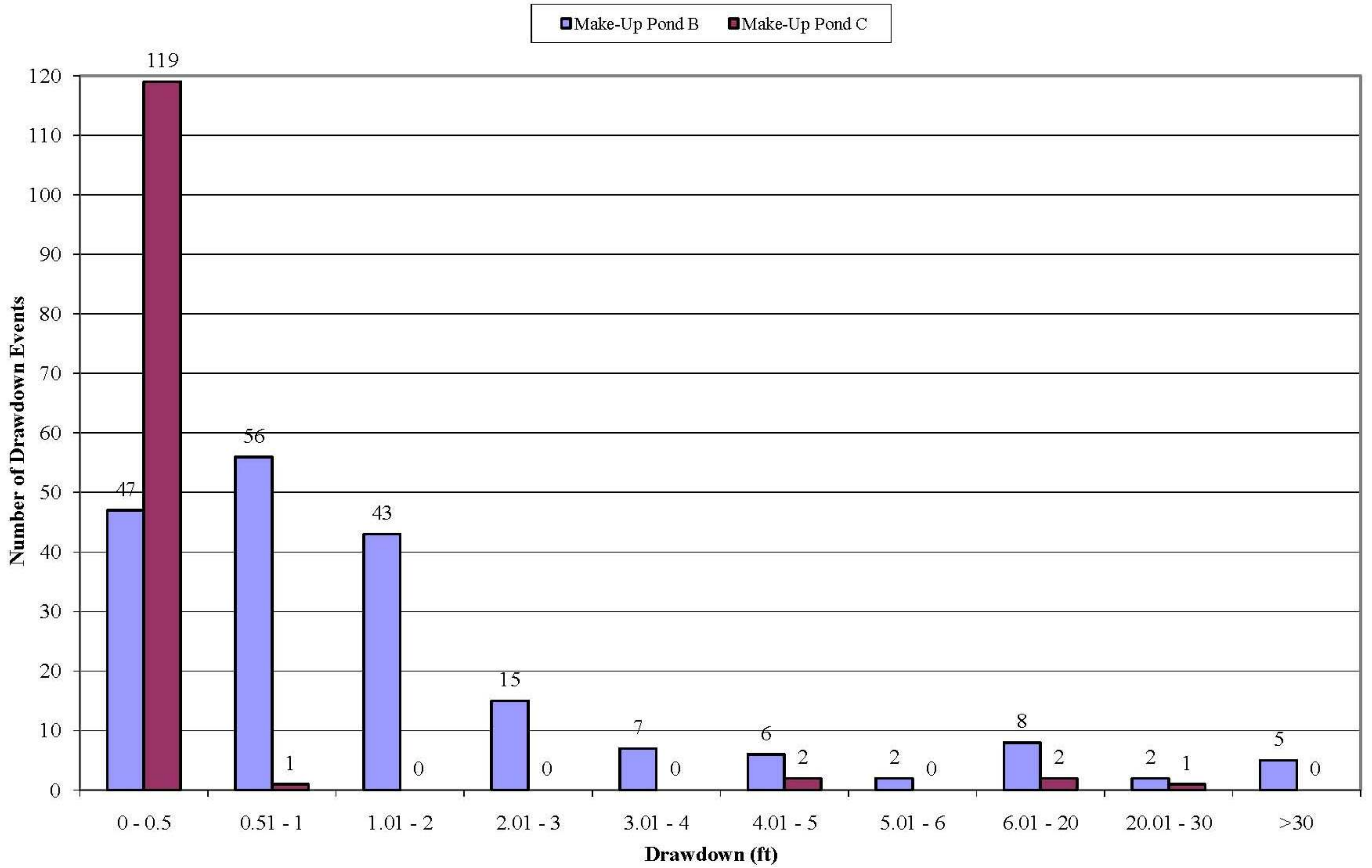
MAKE-UP PONDS B AND C DRAWDOWN OCCURRENCES (JANUARY 1926 – DECEMBER 2010; 85-YEAR RECORD)



Source: HDR|DTA 2011.

Note: All Make-Up Pond C drawdown events less than 1 foot were due to evaporative losses.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Make-Up Ponds B and C
Drawdown Occurrences

FIGURE 3-1

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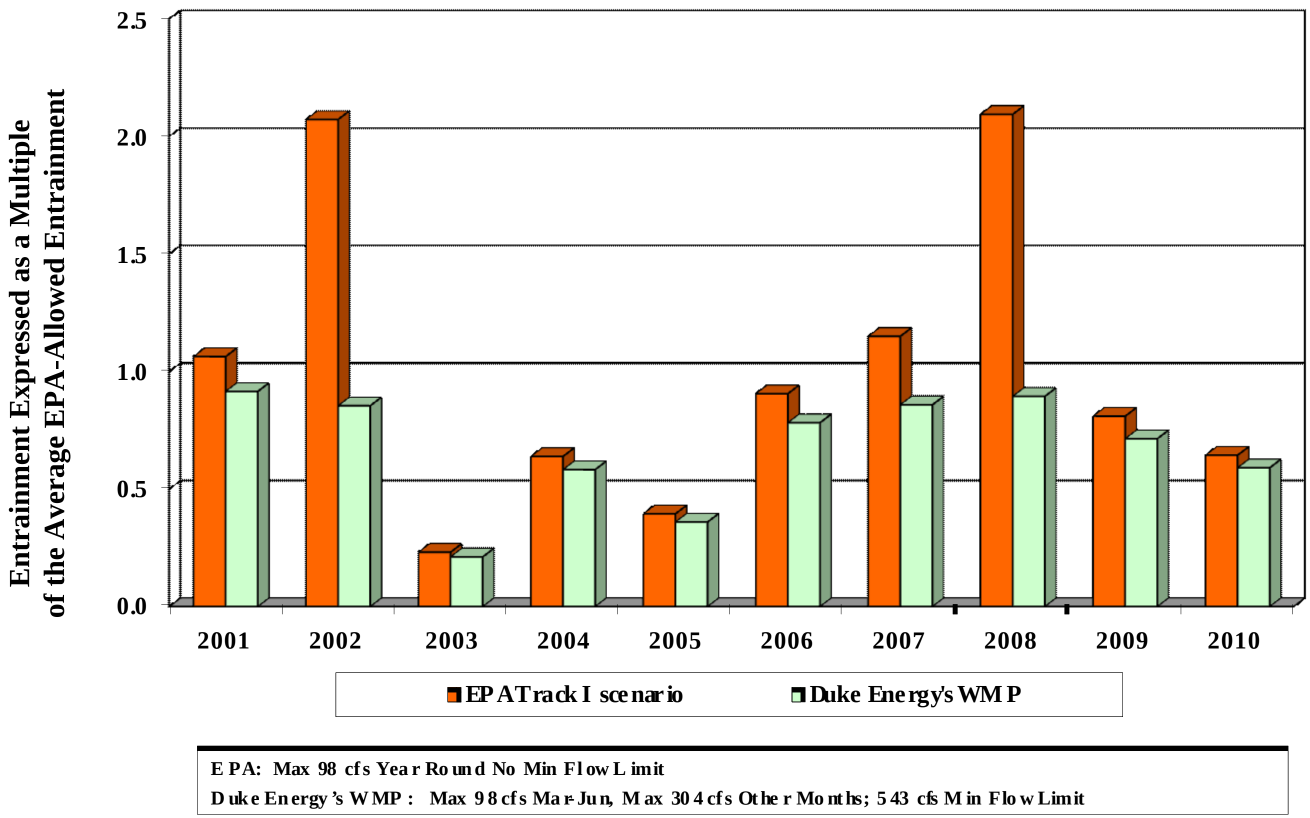
Figure 3-2
Projected Entrainment of Larvae Passing Plant
Un-weighted Average of All Species



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4.0 CONCLUSION

This demonstration contains all required information necessary for SCDHEC to find that Duke Energy's proposed cooling water intake structures comply with § 316(b). Duke Energy intends to comply with Track I of the § 316(b) implementing regulations for the following requirements:

- **Closed-Cycle Recirculating Cooling Technology [§ 125.84(b)(1)]**. The Lee Nuclear Station will utilize a closed cycle recirculating cooling system to reduce intake flow. Information demonstrating compliance as required by § 125.86(b)(1) is provided in subsection 3.1.1.
- **Velocity Limitation [§ 125.84(b)(2)]**. Maximum through-screen and through-slot design intake velocity will be no more than 0.5 fps. Information demonstrating compliance as required by § 125.86(b)(2) is provided in subsection 3.1.2 and Appendix C.
- **Thermocline Requirements for Lakes or Reservoirs [§ 125.84(b)(3)(ii)]**. Total design intake flows for the intake structures located on Ponds A, B, and C will not disrupt the natural thermal stratification or turnover pattern. Information demonstrating compliance as required by § 125.86(b)(3)(iii) is provided in subsection 3.1.3 and Appendix D.
- **Design and Construction Technologies and Operational Measures for Minimizing Impingement and Entrainment [§ 125.84(b)(4) and (5)]**. Intake design and operation strategies for minimizing impingement and entrainment are provided in Appendix A. No threatened, endangered, or otherwise protected species have been documented within the HZI. No commercial species of impingement concern have been documented within the vicinity of the intakes (Appendix A). Sport fish species and migratory fish (suckers) are not expected to be an impingement or entrainment concern due to the life histories of these species noted in Appendix A and the location of the intakes.

Duke Energy proposes an alternative requirement for the Track I Proportional Flow Limitation [§ 125.84(b)(3)(i)]. As shown in subsection 3.2.4, compliance with § 125.84(b)(3)(i) would result in:

- costs wholly out of proportion to the costs EPA considered in establishing the Proportional Flow Limitation Requirement (Option 2, Seasonal Shutdowns; Option 3, Pond C and Seasonal Shutdowns; and Option 4, Hybrid Towers); or
- significant adverse impacts on local air quality (Option 2, Seasonal Shutdowns; Option 3, Pond C and Seasonal Shutdowns; and Option 4, Hybrid Towers), local water resources other than impingement or entrainment (Option 1, No Observance of Instream Flow Restrictions), or local energy markets (Option 2, Seasonal Shutdowns; Option 3, Pond C and Seasonal Shutdowns; and Option 4, Hybrid Towers).

As compared to the Track I Proportional Flow Limitation, Duke Energy's proposed alternative requirement consisting of the operational and design restrictions set forth in its Water

Management Plan results in less entrainment of aquatic biota and is more protective of the local water resource during low-flow periods. The Water Management Plan reduces costs that are wholly disproportionate such as excessive capital costs of cooling system technology (hybrid towers) and operational costs due to parasitic loads and power replacement purchases. The Water Management Plan also avoids additional impacts to local air quality and energy markets from increased emissions of replacement power generation. The proposed alternative requirement is no less stringent than justified by the wholly out of proportion costs and significant adverse impacts on local air quality, local water resources other than impingement and entrainment, and local energy markets, since the Water Management Plan results in less entrainment, as depicted on Figure 3-2, than continually withdrawing 5 percent of the mean annual flow. Finally, this proposed alternative requirement will ensure compliance with other provisions of the Clean Water Act, such as Sections 401 and 404, and any applicable requirement of state law.

Duke Energy requests that SCDHEC, consistent with its § 316(b) regulatory authority, issue an alternative requirement for the Track I Proportional Flow Limitation, and determine that Duke Energy's proposed use of a closed-cycle recirculating cooling water system and intake structures described above, together with the operational restrictions contemplated by Duke Energy's Water Management Plan, constitute the best technology available for minimizing adverse environmental impact at the Lee Nuclear site pursuant to § 125.85(a) of the § 316(b) regulations.

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Appendix A

General Application Information Required Under § 125.86(a)(2) and § 122.21(r)

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William S. Lee III Nuclear Station
Clean Water Act § 316(b)
Compliance Demonstration

Appendix A: General Application Information Required Under § 125.86(a)(2) and § 122.21(r)

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Acronyms and Abbreviations

ac-ft	acre feet
°C	degrees Celsius
cells/mL	cells per milliliter
cfs	cubic feet per second
EPT	Ephemeroptera, Plecoptera, and Trichoptera
°F	degrees Fahrenheit
FERC	Federal Energy Regulatory Commission
fps	feet per second
FSC	Federal species of concern
gpm	gallons per minute
HZI	Hydraulic Zone of Influence
m^2	square meters
m^3	cubic meters
MGD	million gallons per day
msl	mean sea level
N	North
NCDENR	North Carolina Department of Environment and Natural Resources
SCDHEC	South Carolina Department of Health and Environmental Control
SD	standard deviation
SE	State endangered
SOP	standard operating procedure
ST	State threatened
US 29	U.S. Highway 29
USDOE	U.S. Department of Energy
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
W	West
µg/L	micrograms per liter

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1.0 GENERAL APPLICATION INFORMATION REQUIRED UNDER §§ 125.86(a)(2) AND 122.21(r)

Section 125.86(a)(2) requires applicants to submit basic information about the physical and biological characteristics of the waterbody and the cooling water intake structure, as detailed in § 122.21(r) (2), (3), and (4), regardless of the compliance option a permittee chooses. This appendix provides that information.

1.1 SOURCE WATER PHYSICAL DATA [§ 122.21(r)(2)]

Section 122.21(r)(2)(i–iii) sets forth, in part, the data requirements concerning the physical attributes of the source waterbodies. Because Lee Nuclear Station's cooling water intake structure will operate with intakes on the Broad River as well as on sedimentation Pond A, drought contingency Pond B, and the proposed drought contingency Pond C , each of the source waterbodies are addressed below.

1.1.1 Source Water Physical Data Narrative Description [§ 122.21(r)(2)(i)]

1.1.1.1 Physical Configuration and Scaled Drawings

The Broad River and the majority of its tributaries originate in the Blue Ridge Mountains of North Carolina and flow across the Piedmont region into South Carolina (Duke Energy 2009b). The Broad River above Ninety-Nine Islands Dam lies within the Upper Broad River Basin Watershed [United States Geological Survey (USGS) Hydrological Unit 03050105]. There are four main tributaries that create the headwaters to the Broad River upstream of the Lee Nuclear Station: First Broad River, Second Broad River, Green River, and Buffalo Creek. The Lee Nuclear Station lies within USGS Subbasin Hydrological Unit 03050105-090 (Figure A-1). This subbasin contains 246 acres of lakes and impoundments and 133 stream miles (Duke Energy 2009b).

Ninety-Nine Islands Dam impounds the Broad River about one mile downstream of the proposed site for Lee Nuclear Station, effectively creating a 433-acre run-of-the-river impoundment (Duke Energy 2009b). The impoundment has an average transit time for water flow through the impoundment of approximately three hours (during low-flow conditions, the transit time slows to around 14 hours); therefore, under § 125.83, this impoundment is considered a freshwater river for purposes of the Phase I Rule. The main channel of the impoundment is well-mixed, but two backwater areas are somewhat stagnant and can become slightly stratified during warm weather (Duke Energy 2009b) (Figure A-4). In this document, this impoundment will be referred to as the Ninety-Nine Islands Reservoir and areas of the Broad River outside of the limits of the Ninety-Nine Islands Reservoir will be so noted.

See Figure A-2 for a regional map of the Broad River and Figure A-3 for a scaled drawing of the Broad River near and upstream of the project site. A map showing the surface elevation of the Ninety-Nine Islands Reservoir (Figure A-4) was developed using data from a bathymetry study conducted in 2006.

Lee Nuclear Station will operate three ponds. Pond A will serve as a sedimentation basin for cooling water makeup water to Lee Nuclear Station. Pond B and the proposed Pond C will serve as drought contingency ponds (Duke Energy 2009a). Figure 1-1 (§ 316(b) Compliance Demonstration) shows the location of these ponds.

See Figure 1-1 (§ 316(b) Compliance Demonstration) for a scaled drawing of Ponds A, B, and C. Maps showing the bottom elevations of Pond A (Figure A-5) and Pond B (Figure A-6) were developed using data from the bathymetry study conducted in 2006. The Pond C map (Figure A-7) was developed using aerial photography and topographic mapping conducted in 2009.

1.1.1.2 Surface Areas and Depths

The Broad River is generally wide and shallow (Duke Energy 2009b). The 433-acre Ninety-Nine Islands Reservoir (Duke Energy 2009b) has a maximum depth of 35 feet and a mean depth of 9 feet. The areas of backwater parallel to the main channel are shallow. The areas of backwater perpendicular to the river flow are relatively deeper waters as compared to the parallel backwater areas (Duke Energy 2009b). The width of the Broad River near the proposed cooling water intake structure is approximately 240 feet. There is a scour hole near the proposed intake that is about 30 feet deep (Duke Energy 2009b).

The surface area of Pond A is approximately 62 acres and the storage volume is 1,425 acre-feet (ac-ft) (Duke Energy 2009b). The mean depth of Pond A is 26 feet, with a maximum depth of 57 feet (Duke Energy 2009b). The surface area of Pond B is approximately 154 acres and the storage volume is approximately 3,994 ac-ft (Duke Energy 2009b). The mean depth of Pond B is 31 feet, with a maximum depth of 60 feet (Duke Energy 2009b). The proposed Pond C surface area will be about 620 acres, and the storage volume will be approximately 22,000 ac-ft, with a maximum depth of 116 feet (Duke Energy 2009a).

1.1.1.3 Salinity and Temperature

The Broad River is a freshwater river. Specific conductance data were collected and converted to salinity. The mean salinity for the Broad River was 61 micrograms per liter (μg/L), with a minimum of approximately 46 μg/L and a maximum of approximately 77 μg/L. The mean salinity for the backwater areas of the Ninety-Nine Islands Reservoir was approximately 57 μg/L, with a minimum of approximately 49 μg/L and a maximum of approximately 69 μg/L. These salinity values were determined based on in situ specific conductance and temperature values measured in the Broad

River and its backwater areas during four sampling events in February, May, August, and November 2006 (Duke Energy 2009b).

Temperature data were collected during surface water sampling studies conducted in the Broad River from September 1973 through September 1974 for the Cherokee Nuclear Station site, from April 1989 through June 1990 at the Ninety-Nine Islands Hydroelectric Station upstream and downstream of the dam, and again from February 2006 through November 2006 around the site for Lee Nuclear Station. Instantaneous field measurements for temperature were averaged for each study period. Many of the sampling locations in the more recent temperature studies were located in the same locations as the 1973–1974 study (Table A-1, Figure A-8) (Duke Energy 2009b). Results from the three study periods showed that temperature within the Broad River was relatively constant with depth, due to apparent mixing (Duke Energy 2009b). Water temperatures during the 1973–1974 period ranged from 41 degrees Fahrenheit (°F) to 86°F (5 degrees Celsius [°C] to 30°C) with a mean of 62°F (17°C) (Duke Energy 2009b). Water temperatures from the 1989–1990 study ranged from about 45°F to 86°F (7°C to 30°C) with a mean of about 60°F (16°C). Water temperatures from the 2006 study ranged from 45°F to 82°F (7°C to 28°C) with a mean temperature of 62°F (17°C) based on four locations (101, 102, 107, and 109) (Figure A-9) within the main channel of the Broad River (Duke Energy 2009b).

Duke Energy installed temperature loggers that record hourly measurements in several locations in the Broad River around the proposed site for the Lee Nuclear Station, including one mile upstream of the proposed intake, at the proposed location of the intake, and, in 2008, in the forebay of the Ninety-Nine Islands Dam (near the proposed discharge structure). Water temperatures upstream of the dam ranged from approximately 38°F to 92°F (3°C to 33°C) in 2007 and from approximately 38°F to 90°F (3°C to 32°C) in 2008 (Duke Energy 2009b).

Ponds A, B, and C are freshwater ponds. Specific conductance was measured in Ponds A and B during four sampling events in February, May, August, and November of 2006. Both surface and bottom samples were taken (Duke Energy 2009b). Specific conductance was converted to salinity. The mean salinity for both impoundments was approximately 65 μg/L, with a minimum of approximately 35 μg/L and a maximum of approximately 209 μg/L. Pond C salinity is expected to be similar to the Broad River, since the pond will initially be filled with water from this river (Duke Energy 2009a). The mean salinity for the Broad River was 61 μg/L, with a minimum of approximately 46 μg/L and a maximum of approximately 77 μg/L (Duke Energy 2009b).

Temperature data were also collected in Ponds A and B during the 2006 sampling from February through November (Duke Energy 2009b). The same methodology described above for sampling in the Broad River was also used for Ponds A and B. Ponds A and B both had temperatures ranging from 46°F to 86°F (8°C–30°C) (Duke Energy 2009b).

It is expected that the temperature of Pond C will be similar to Pond B. Ponds B and C are in the same general location and, therefore, will both be subject to the same hydrologic and meteorological conditions (Duke Energy 2009a). Ponds B and C will both be well-mixed during the winter, have similar temperatures going into the spring, and undergo surface heating during the summer, resulting in thermal stratification (Duke Energy 2009a).

1.1.1.4 Currents

Water velocities measured in 2006 at a location near the proposed intake for Lee Nuclear Station on the Broad River averaged 0.32 ± 0.04 foot per second (fps) [mean ± standard deviation (SD)]. Velocities measured in 2007 near the proposed diffuser end of the discharge pipe ranged from 0.05 to 0.40 fps under the no hydroelectric generation scenario, i.e., ambient currents (Duke Energy 2009b). Under one-unit hydroelectric generation, velocities near the diffuser end of the discharge pipe ranged from 0.25 to 1.0 fps (Duke Energy 2009b). Because the Broad River within the limits of the Ninety-Nine Islands Reservoir is effectively a run-of-the-river impoundment, currents are stronger than expected for a storage impoundment. However, the currents are still less than those upstream and downstream of the reservoir.

Due to limited size and inflow, Ponds A and B and proposed Pond C will not be subject to significant flow changes (Duke Energy 2009b).

1.1.1.5 Other Documents Supporting Determination of Waterbody Type

The Lee Nuclear Station will lie within USGS Subbasin Hydrological Unit 03050105-090 (Figure A-1). All 133 stream mi within this subbasin have the SCDHEC water classification of Freshwaters (S.C. Code Regs. 61–68) (Duke Energy 2009b).

1.1.2 Source Water Characterization [§ 122.21(r)(2)(ii)]

1.1.2.1 Hydrological and Geomorphological Features

The Broad River upstream of the Ninety-Nine Islands Reservoir has a stream-bed slope of 0.55 percent, or about 29 feet per mile (Duke Energy 2009b). Two smaller dams (Cherokee Falls and Gaston Shoals) are immediately upstream of the site on the Broad River; however, the reservoirs formed by these dams represent less than 2 percent of the total storage capacity of the basin (Duke Energy 2009b). The five larger dams that form Lake Welchel, Moss Lake/Kings Mountain, Lake Adger, Lake Lure, and Lake Summit are located upstream of the Lee Nuclear Station; they represent approximately 86 percent of the total storage capacity of the basin.

There are three distinct sections of bedforms in the Broad River between Gaston Shoals and the limits of the Ninety-Nine Islands Reservoir. Riffle and pool sequences dominate the bedforms between Gaston Shoals and USGS Gaging Station 02153500 at US Highway 29 (US 29). Between US 29 and Cherokee Falls Dam, the Broad River bedform is dominated by shallow riffles with no

pools. Riffle and pool sequences dominate again between Cherokee Falls and the Ninety-Nine Islands Reservoir (Duke Energy 2009b).

The Broad River within the Ninety-Nine Islands Reservoir includes three sections: the main river channel and two backwater sections. The river-dominated main channel is generally characterized by a strong current with a shallow sand and gravel bed extending through the center of the Broad River (Duke Energy 2009b). Shallow backwater sections parallel to river flow contain large amounts of deposited sediments, while relatively deeper backwater sections perpendicular to river flow (compared to the sections parallel to river flow) reflect local topography and original reservoir characteristics (Duke Energy 2009b). The Ninety-Nine Islands Reservoir retains few reservoir characteristics, because it has been largely filled with silt since its construction early in the last century (Duke Energy 2009b).

At normal water levels, the elevation in the Ninety-Nine Islands Reservoir is 511 feet above mean sea level (msl) (Duke Energy 2009b). The maximum depth is about 35 feet, while the mean depth is about 9 feet (Figure A-4) (Duke Energy 2009b).

The drawdown of the Ninety-Nine Islands Reservoir by Ninety-Nine Islands Hydroelectric Station is limited by its Federal Energy Regulatory Commission (FERC) operating license. Specifically, the FERC operating license for the Ninety-Nine Islands Hydroelectric Station includes seasonal limits on reservoir levels to 1 foot below full impoundment (511 feet above msl) from March through May, and 2 feet below full impoundment from June through February. This allows for a short-term potential of zero flow to occur immediately followed by the required minimum flow (FERC 1996). Minimum flow requirements below the dam are 966 cubic feet per second (cfs) (January through April); 725 cfs (May, June, and December); and 483 cfs (July through November) (FERC 1996). If the above-referenced flow requirements cannot be maintained during December through June without dropping below the reservoir level restrictions described above, then at least 483 cfs is required to be released. If there is insufficient water to maintain at least 483 cfs of continuous flow release, the operating license provides that one hydroelectric unit can be operated at its minimum hydraulic output for that portion of every hour that is necessary to release the approximate accumulated inflow; inflow can be released at the trash gate, or the inflow can be spilled (FERC 1996).

Mean annual flows for two different time periods on the Broad River, a 10-year period (2001–2010) and the 85-year period of record (1926–2010)[1], suggest different flow characteristics (Table A-2). Annual mean and mean annual flows[2] within each period are provided. The mean

[1] As referenced in Section 2.2.3.1 of §316b Compliance Demonstration document, there is considerable ambiguity in the Phase I Rule regarding annual mean flow and mean annual flow in determining compliance with § 125.84(b)(3)(i). Mean annual flow over a period of concern provides a generalized picture of conditions within a river by minimizing the year-to-year variability. The longer the period of concern, the more representative the value will be (Gordon et al. 2004).

[2] As noted above, when evaluating flow, it is important to note the differences between the terms annual mean and mean annual in reference to hydrological data. Annual mean flow is reported as the average flow value over a given year. The mean annual flow is the average of all annual means over the period of concern.

annual flow between 2001 and 2010 at the Gaffney Gage is 1,956 cfs (1,264.2 MGD). The annual mean flows for this same period ranged from 907 cfs (586.2 MGD) in 2008 to 3,774 cfs (2,439.2 MGD) in 2003. The mean annual flow from 1926 to 2010 was 2,495 cfs (1,612.6 MGD). The annual mean flow between 1926 and 2010 ranged from 907 cfs (586.2 MGD) in 2008 to 4,175 cfs (2,698.4 MGD) in 1975.

Pond A was built in the late 1970s as a sedimentation pond by constructing an earthen dam across a backwater section of the Ninety-Nine Islands Reservoir. Submerged cofferdams created bathymetric divisions within Pond A (Duke Energy 2009b). Duke Energy currently plans to remove the cofferdams in Pond A. The full pond elevation of Pond A is 547 feet above msl; Pond A has a maximum depth of 57 feet (Duke Energy 2009b) (Figure A-5).

Pond B was built in the late 1970s as a standby nuclear service water pond by constructing an earthen dam that impounded McKowns Creek to the west of Lee Nuclear Station. A submerged cofferdam, originally used to support construction of the Pond B dam, has created a bathymetric division of the pond (Duke Energy 2009b). Duke Energy currently plans to remove the cofferdam in Pond B. The normal pond elevation of Pond B is 570 feet above msl, with a maximum depth of 60 feet (Duke Energy 2009b) (Figure A-6).

Pond C will be a drought contingency storage pond, formed by impounding London Creek, a tributary of the Broad River, northwest of Pond B (Duke Energy 2009a). The Pond C surface area will be about 620 acres, and the storage volume will be approximately 22,000 ac-ft, with a maximum depth of 116 feet (Duke Energy 2009a). The bathymetry of the proposed Pond C is shown in Figure A-7.

Annual evaporation for the ponds was estimated to be approximately 38 inches (Duke Energy 2009b). Pond A maintains near full impoundment levels under natural conditions (Duke Energy 2009b).

1.1.2.2 Intake Areas of Influence

Duke Energy commissioned Geosyntec Consultants (Geosyntec) to conduct a study to identify the hydraulic zone of influence (HZI) for the intake structure on the Broad River (see Appendix B). Geosyntec used existing data from field surveys and modeling to estimate the HZI. Geosyntec also used data from a Computational Fluid Dynamics (CFD) model that Geosyntech used to predict the mixing zone (see Volume 1, Part VI, of the NPDES Permit Application)to simulate water movement caused by the intakes (Geosyntec 2011).

The modeling defined the HZI for the river as the location where the flow vector pointed directly towards the river intake structure (i.e., if a particle were to follow the direction of the flow at that point and did not change direction, it would be drawn into the intake) (Geosyntec 2011). To

evaluate the approximate normal and maximum daily water withdrawal rate conditions, three pumping scenarios were modeled for the intake on the river:

- **Scenario 1** – maximum normal withdrawal [98 cfs (43,960 gpm)] via the primary section of the river intake under annual mean river flow (511 feet above msl);
- **Scenario 2** – withdrawal [78 cfs (35,030 gpm)] via the primary section of the river intake to support normal operations prior to invoking low-flow protocols using drought contingency ponds (with the Ninety-Nine Islands Reservoir elevation set 2 feet below normal elevation); and
- **Scenario 3** – drought contingency pond refill withdrawal under higher flow conditions [206 cfs (92,500 gpm)] through the drought contingency section of the river intake plus 98 cfs (43,960 gpm) via the primary section of the river intake for normal station operation (Geosyntec 2011).

Each of the scenarios results in a small and localized HZI. Scenario 1 results in an HZI of 0.129 ac-ft, with a surface area of 0.004 acre that extends a distance of approximately 9.2 feet perpendicular to the primary section of the river intake. Scenario 2 results in an HZI of 0.200 ac-ft, with a surface area of 0.013 acre that extends a distance of 14.4 feet into the river. Scenario 3 results in an HZI of 0.316 ac-ft, with a surface area of 0.025 acre that extends 15.4 feet into the river (Geosyntec 2011).

Geosyntec also conducted a study to identify the HZI for the intake structures in Ponds A, B, and C. Geosyntec used the same methodology to estimate the HZI for Ponds A, B, and C as was used to predict the HZI for the river and drought contingency sections of the river intake. However, the HZI for the ponds was defined differently than for the river intake. This is because the flow vector in the ponds may well point toward the intake structure, but the flow velocity at that point may be so low that it is impractical to consider it to be within the HZI. Therefore, a location was included in the HZI for the pond intakes when two conditions were met: 1) the velocity towards the intake was greater than 0.1 fps and 2) the direction of the flow vector was towards the intake (Geosyntec 2011).

Using the CFD, two pumping scenarios were evaluated for the Pond A intake (the exact pump configuration is still conceptual). One scenario evaluated operation of four variable-speed pumps with a total flow rate of 78 cfs (35,030 gpm) at a normal/full pond water level elevation. The second scenario evaluated operation of four fixed-speed pumps with a full capacity flow of 134 cfs (60,000 gpm) plus screen wash for a total flow rate of 139 cfs (62,000 gpm) with 61 cfs (26,970 gpm) returned to the pond. The current design for the Pond A intake uses fixed-speed pumps, which is the more-conservative scenario when evaluating the HZI.

The modeled HZIs are localized and small for all of the ponds. Under the first Pond A scenario, the HZI volume was 0.054 ac-ft, with a surface area of 0.004 acre. The HZI extends approximately 3.7 feet into the pond. Under the second Pond A Scenario, the HZI is slightly larger than under the

first scenario due to the increased withdrawal rate. The HZI volume was 0.150 ac-ft, with a surface area of 0.011 acre that extends 9.2 feet into the pond (Geosyntec 2011).

For Pond B, the operating scenario included normal operation of three pumps at drawdown elevation of 540 feet above msl (30 feet below full pond elevation) (Geosyntec 2011). The HZI for Pond B exists only very close to the intake's cylindrical wedge-wire screens. The total HZI for Pond B was 0.039 ac-ft, with a surface area of 0.004 acre. The HZI extends approximately 7.2 feet outward of the intake structure.

For Pond C, two scenarios were modeled. The first operating scenario assumed normal operation of all three pumps and a total flow rate of 67 cfs (30,000 gpm) at an elevation of 620 feet above msl (30 feet below full pond elevation). The second scenario evaluated normal operation of all three pumps and a total flow rate of 67 cfs (30,000 gpm) at a maximum drawdown elevation of 605 feet above msl (45 feet below full pond elevation) (Geosyntec 2011). This was considered a worst case scenario. Similar to Pond B, both HZIs for Pond C exist very close to the cylindrical wedge-wire screens. The total HZI for Pond C scenario one was 0.062 ac-ft with a surface area of 0.005 acre that extends approximately 9.2 feet into the pond (Geosyntec 2011). The total HZI for Pond C scenario two was 0.061 ac-ft with a surface area of 0.005 acre that extends approximately 9.2 feet into the pond (Geosyntec 2011).

1.1.3 Locational Maps [§ 122.21(r)(2)(iii)]

The general study site location is presented in Figures 1-1 (§ 316(b) Compliance Demonstration) and A-3 (Duke Energy 2009b). The location of the Broad River is presented in Figures 1-2 (§ 316(b) Compliance Demonstration) and A-3. The locations of Ponds A, B, and C are presented in Figure 1-1 (§ 316(b) Compliance Demonstration).

1.2 COOLING WATER INTAKE STRUCTURE NARRATIVE DESCRIPTION [§ 122.21(r)(3)]

As described below, § 122.21(r)(3) requires that permittees provide a description of the intakes and their configuration, modes of operations, a water balance diagram, and engineering drawings. As noted above, the cooling water intake structure at Lee Nuclear Station, by EPA definition, will operate with a total of four intakes: one on the Broad River, which has two sections (the primary section and the drought contingency section), and one each in Ponds A, B, and C; these intakes are discussed in the following subsections.

1.2.1 Intake Description [§ 122.21(r)(3)(i)]

The cooling water intake structure for the Lee Nuclear Station will comprise the primary and the drought contingency sections of the river intake; Ponds A, B, and C; the intakes on each of the ponds; and all of the necessary cooling water pumps and piping. This includes the cooling water

pumps to move water from the primary and drought contingency sections of the river intake to and among the ponds and from Pond A to Lee Nuclear Station. At normal river flow, water will be pumped from the Broad River via the primary section of the river intake to Pond A (Duke Energy 2009b). Water may also be pumped directly into Ponds B and/or C via the drought contingency section of the river intake, as needed to refill the ponds (Duke Energy 2009a). Further, water can also be pumped between Ponds A and B and between Ponds B and C. All water for the recirculating water system will be withdrawn from Pond A (Duke Energy 2009b). Water for plant operations will always pass through Pond A.

1.2.1.1 River Intakes

Under normal operations, it is expected that Lee Nuclear Station will withdraw an average of approximately 78 cfs (35,000 gpm) of river water for cooling and process purposes. About 5 cfs (2,000 gpm) will be returned immediately to the Broad River during screen washings. The remainder of the water withdrawn from the Broad River will be piped to Pond A, which will supply the water to the Lee Nuclear Station. The cooling towers for both units will consume approximately 55 cfs (24,800 gpm) of recirculating cooling water under normal operating conditions.

Recirculating cooling water quality will be maintained, in part, by discharging a small portion of the main recirculating water system flow, either continuously or intermittently; this discharge is referred to as blowdown. Blowdown will control the level of dissolved solids in the cooling towers (Duke Energy 2009b). Average blowdown flow will be approximately 18 cfs (8,200 gpm) for both units, with a maximum of approximately 62 cfs (28,800 gpm) (Duke Energy 2009b). Therefore, approximately 55 cfs (24,800 gpm) will be consumed. A total of 23 cfs (10,200 gpm) will be returned to the river under normal operating conditions; this will comprise the 18 cfs of blowdown plus the 5 cfs of screen wash water.

The primary section of the river intake will provide make-up water to both the recirculating cooling water and service water systems to replace losses resulting from evaporation, drift, and blowdown, and will also provide intake screen wash flow and strainer backwash flow (Duke Energy 2009b).

The primary section of the river intake will be located on the west side of the Broad River within the Ninety-Nine Islands Reservoir. The primary section of the river intake will comprise four intake bays that will be aligned parallel to the shore of the Broad River (Geosyntec 2011). Each intake bay is designed at 11 feet 9 inches wide by 11 feet high (Shaw Nuclear 2010). Each of the four intake bays will house one variable-speed pump [rated at 46.8 cfs (20,980 gpm)] that will move water into Pond A for normal plant operation (Shaw Nuclear 2010). This subsystem will also have screen wash pumps with a total rating of 2,000 gpm (5 cfs). Under normal conditions, water levels at the pump bays for the primary section of the river intake will be at an elevation of 511 feet above msl. Each unit will have two pumps: one for normal operation and one for use as backup (Geosyntec 2011).

Each of the four intake bays will be fitted with a fine-mesh, Ristroph dual-flow traveling screen (Shaw Nuclear 2010). The screens will have dual-pressure spray header systems with a separate return system. The fish return system will return the fish downstream of the intake structure, which will prevent reimpingement (Duke Energy 2009b). Water withdrawn from the Broad River will pass through bar screens and traveling screens designed to minimize uptake of aquatic biota and debris (Duke Energy 2009b).

The drought contingency section of the river intake will be used very infrequently to refill Ponds B and C after they have been drawn down following extreme drought conditions. As currently designed, this section of the river intake will consist of four intake bays; the width of each is designed at 11 feet 9 inches wide by 11 feet high. The drought contingency section of the river intake will be aligned parallel to the shore and flow of the Broad River. Within each bay there will be one fixed-speed pump rated at approximately 50 cfs (22,500 gpm) (Shaw Nuclear 2010); the total capacity will be 200 cfs (90,000 gpm) (Geosyntec 2011). This subsystem will also have screen wash pumps with a total rating of approximately 2,500 gpm (6 cfs). Each of the four intake bays will be fitted with a fine-mesh, Ristroph dual-flow traveling screen (Shaw Nuclear 2010). The drought contingency section of the river intake will also be equipped with a fish return system.

1.2.1.2 Pond Intakes

The Pond A intake will be located on the west side of the pond. The raw river water discharge structure will be located at the northwest corner of the pond. As a sedimentation pond, Pond A will perform the function of settling the suspended solids before water is withdrawn through the Pond A intake to Lee Nuclear Station. As currently designed, the Pond A intake will be aligned parallel to the shore and will have a total of six intake bays that are 11 feet 9 inches wide by 11 feet high. The intake will be fully submerged at normal full pond elevation of 547 feet above msl. There will be a sediment seal located 2 feet off the pond bottom that is accounted for in the intake bay design (Geosyntec 2011). Each of the intake bays will be equipped with a fixed-speed pump with a design capacity of 33 cfs (15,000 gpm) (Shaw Nuclear 2010). Of the six pumps, four pumps continually provide cooling water for station operations (two for each unit) and two pumps serve as backup (one for each unit). The pumps will be operated at full capacity with a system flow controlled by a flow-control return loop and a fine-mesh, Ristroph dual-flow traveling screen (Shaw Nuclear 2010; Figures in Appendix C). This subsystem will also have screen wash pumps with a total rating of approximately 2,000 gpm (5 cfs).

Pond B will operate with two pump bays/wet wells and five pumps. As currently designed, one common wet well will have two pumps; each pump will be rated at 22.3 cfs (10,000 gpm). The other wet well will be equipped with two, 22.3-cfs (10,000-gpm) pumps and one, 13-cfs (6,000-gpm) ancillary pump (Shaw Nuclear 2010). Three 22.3 cfs (10,000 gpm) rated pumps will support the two units while the fourth 22.3 cfs (10,000 gpm) rated pump will serve as backup. The ancillary pump will deliver water from Pond B to Pond C and will not be operated simultaneously with the

primary 22.3-cfs (10,000-gpm) rated pumps. During drought conditions, three pumps will deliver an effective flow of approximately 67 cfs (30,000 gpm) from Pond B to Pond A (Geosyntec 2011). The wet wells will each be equipped with two cylindrical wedge-wire screens with narrow slots (see figures in Appendix C). The cylindrical wedge-wire screens will be 5.00 feet to 5.83 feet in diameter and 6.44 to 8.13 feet long and will extend into the pond at a centerline elevation of about 528 feet above msl, parallel with the intake pump structure causeway and will be spaced approximately 17 to 18 feet apart.

Pond B will be refilled with water from the river via Pond A or directly from the river via the drought contingency section of the river intake. When not providing consumptive water for plant operations, Pond B levels will generally be maintained within 2 feet of its overflow elevation of 570 feet above msl.

Drought contingency Pond C will be formed by constructing an earthen dam that will impound London Creek, upstream of the confluence of Little London Creek, as shown in Figure A-10. Pond C will be filled using water from the Broad River pumped through Pond A and then Pond B, or directly from the Broad River (Duke Energy 2009a). As currently designed, the Pond C intake will operate with one common pump bay/wet well, equipped with three 22.3-cfs (10,000-gpm) pumps. All three pumps will deliver water from Pond C to Pond B. Under drought conditions, all three single-speed pumps will deliver an effective flow rate of 67 cfs (30,000 gpm) (Geosyntec 2011). The wet well will also be equipped with two cylindrical wedge-wire screens with narrow slots (see figures in Appendix C) (Shaw Nuclear 2010). Cylindrical wedge-wire screens will be 5.00 to 5.83 feet in diameter and 6.44 to 8.13 feet long and will extend into the pond parallel with the intake structure causeway. Elevation of the centerline of the cylindrical wedge-wire screen will be about 553 feet above msl. The cylindrical wedge-wire screens will be spaced approximately 14 feet apart (Geosyntec 2011).

Evaporation rates for Pond C are estimated to range from 0.11 foot/month during cooler, wetter months (e.g., December and January) to 0.41 foot/month during warmer, drier months (e.g., July). Based on these evaporation rates, the estimated monthly average evaporative loss of Pond C when it is full will be 1.1–4.2 cfs (494–1,885 gpm) (Duke Energy 2009a). When not providing consumptive water for plant operations, Pond C levels will generally be maintained within 2 feet of its overflow elevation of 650 feet above msl. Pond C will be refilled with water directly from the river via the drought contingency section of the river intake, or from the river via Pond B (Figure A-11).

1.2.1.3 Locations in Waterbodies

The primary and drought contingency sections of the river intake will be located north of the site on the west side of the Broad River, and oriented parallel to river flow. The primary section of the river

intake water flow direction will be perpendicular to the direction of river flow (Duke Energy 2009b).

The Pond A intake will be located on the west side of Pond A. The drought contingency Pond B intake will be located on the east side of Pond B, and the drought contingency Pond C intake will be located on the south side of Pond C (Duke Energy 2009a).

1.2.1.4 Locations in Water Column

The primary and drought contingency sections of the river intake will require a minimum depth of 9 feet of water for the pumps to operate. The top elevation of both river intakes will occur at 500 feet above msl. At this elevation, the river intakes will have a submerged depth of 11 feet at the Broad River's annual mean flow elevation of 511 feet above msl and 9 feet at the low flow elevation of 509 feet above msl.

The design of the Pond A intake is not yet finalized. As currently proposed, the top elevation of the Pond A intake will occur at 523.5 feet above msl. At this elevation, the intake will have a submerged depth of 23.5 feet at the normal pool elevation, which will be constantly maintained at 547 feet above msl.

The cylindrical wedge-wire screens coupled to the Pond B intake will have a centerline elevation of 528 feet above msl. The Pond B intake will have a submerged centerline depth of 42 feet at the full pond elevation of 570 feet above msl and 12 feet at the 30-foot drawdown to an elevation of 540 feet above msl.

The cylindrical wedge-wire screens coupled to the Pond C intake will have a centerline elevation of 553 feet above msl. The Pond C intake will have a submerged centerline depth of 97 feet at the full pond elevation of 650 feet above msl and 67 feet at the 30-foot drawdown to elevation of 620 feet above msl.

1.2.2 Intake Latitude and Longitude [§ 122.21(r)(3)(ii)]

Latitude and longitude coordinates will be 35° 02' 36.65" North (N) and 81° 30' 27.54" West (W), respectively for the primary and drought contingency sections of the river intake (Volume 1, Part III, Preliminary Engineering Report, Table 1). The coordinates for the Pond A intake will be 35° 01' 57.09" N and 81° 30' 18.79" W; the coordinates for the drought contingency Pond B intake will be 35° 02' 13.11" N and 81° 31' 11.41" W; and the coordinates for the drought contingency Pond C intake will be 35° 02' 44.98" N and 81° 32' 39.36" W.

1.2.3 Operation of Intakes [§ 122.21(r)(3)(iii)]

This section provides a narrative description of the operation of the intakes.

1.2.3.1 Design Intake Flows

Greater than 95 percent of the time, water for plant operations will be pumped from the Broad River to Pond A via the primary section of the river intake. The average withdrawal from the river will be 78 cfs (35,000 gpm). Approximately 18 cfs (8,200 gpm) will be returned to the river as blowdown and 5 cfs (2,000 gpm) will be returned as intake screen wash for a total of 23 cfs (10,200 gpm). Approximately 55 cfs (24,800 gpm) will be consumed. During refill operation, an additional 20 cfs (9,000 gpm) may be withdrawn from the primary section of the river intake. Up to an additional 206 cfs (92,200 gpm) may be withdrawn through the drought contingency section of the intake, comprising 200 cfs (90,000 gpm) for refill and 6 cfs (2,500 gpm) returned as screenwash.

Normal operation of the Pond A intake will withdraw 139 cfs (62,000 gpm), which includes an average of 73 cfs (33,000 gpm) for station operations, 5 cfs (2,000 gpm) for screen wash, and 61 cfs (27,000 gpm) recycled back to the pond by the fixed-speed pumps. During drought conditions, the Pond B intake structure will deliver an effective flow of approximately 67 cfs (30,000 gpm) from Pond B to Pond A. Under drought conditions, the Pond C intake structure normal operation will consist of an effective flow rate of 67 cfs (30,000 gpm).

1.2.3.2 Daily Hours of Operation

Duke Energy will operate the Lee Nuclear Station as a base load nuclear station, and anticipates that it will be in service 24 hours a day (Duke Energy 2009b). The facility will withdraw make-up water from Pond A 24 hours a day. The primary section of the river intake will operate 24 hours a day. Based upon the review of the historical period of record flows, the operation of the drought contingency section of the river intake and the drought contingency Ponds B and C intakes is predicted to occur rarely. For example, over the period 1926–2010, Ponds B and C intakes would have been required approximately 3 percent of the time. During refill the intake will operate 24 hours a day as needed when flows allow. As discussed in Sections 1 and 3 of the § 316b Compliance Demonstration, the Pond B and/or C intakes will only operate during extreme drought conditions and the drought contingency section of the river intake will only be operated to refill the Ponds B and/or C after those periods of extreme drought, once river flows will be higher.

1.2.3.3 Number of Days of Year in Operation

As a base load unit, Duke Energy anticipates the station will be in service 365 days a year (Duke Energy 2009b). The Pond A intake will be in operation whenever Lee Nuclear Station is in service. The primary section of the river intake will be in operation 365 days a year. The operation of the drought contingency section of the river intake and the drought contingency the Ponds B and/or C intakes will only occur in extremely rare instances, as discussed below.

1.2.3.4 Seasonal Changes, if Applicable

As discussed in subsection 2.4.2 of the § 316b Compliance Demonstration, Duke Energy operates the Ninety-Nine Islands Hydroelectric Station in accordance with its FERC operating license, which limits reservoir drawdown and establishes a protocol for releases to the Broad River.

Duke Energy proposes to minimize withdrawal of water for Lee Nuclear Station from the Broad River during low flow periods by using Ponds B and/or C to meet Lee Nuclear Station operational water requirements. During normal flow periods on the Broad River (>538 cfs), Duke Energy will withdraw all of its operational water requirements from the Broad River through the primary section of the river intake into Pond A. The primary section of the river intake will have a design intake flow of 98 cfs. Pond A will provide water for plant processes and cooling tower makeup. Based on the historical Broad River flow conditions, Duke Energy anticipates this will be the normal withdrawal scheme employed greater than 95 percent of the time (over the period 2001–2010 Ponds B and C would have been required approximately 3 percent of the time).

As Broad River flows drop below 538 cfs and begin to approach 483 cfs, Duke Energy will proportionally withdraw its consumptive water requirements (≤63 cfs) from the Broad River and drought contingency Ponds B and/or C. When Broad River flow is at or below 483 cfs, only non-consumptive cooling water (approximately 23 cfs) will be withdrawn from the Broad River, which will be immediately returned to the river after use in order to maintain minimum flows in the Broad River. Consumptive water requirements (≤63 cfs), in contrast, will be drawn from drought contingency Ponds B and C. Pond B will be drawn down first. If Pond B drawdown reaches 30 feet, withdrawal from Pond B will cease and water will be withdrawn from Pond C to a nominal drawdown ≤30 feet. Based on modeling using worst-case droughts over the 85-year period of record, Duke Energy does not anticipate that any additional drawdown will be needed. However, should it be warranted to support station operations during emergency drought conditions, any additional drawdown or other water management protocols will be performed pursuant to a drought contingency plan to be developed in accordance with the South Carolina Water Withdrawal Law after consultation with appropriate regulatory agencies.

After a low flow condition has passed, Ponds B and/or C will be refilled via the drought contingency section of the river intake. As soon as the flow within the Broad River has been established above 538 cfs (347.7 MGD), Lee Nuclear Station will resume withdrawing 98 cfs (43,960 gpm) from the river and begin to refill the drought contingency ponds. Additional withdrawals to refill drought contingency Ponds B and/or C will only occur from July through February, when river flows are higher and the potential for entrainment is lower (see subsection 3.2.6.1 of § 316b Compliance Demonstration). The drought contingency section of the river intake will have a maximum design intake flow of 206 cfs. However, the actual refill rate will be determined using a flow-sensitive approach to ensure Broad River flows do not fall below 483 cfs due to refill of the drought contingency ponds. Further, regardless of river flows, refilling of Ponds B and/or C will not occur

from March through June in order to minimize entrainment. Figure A-12 depicts the proposed water system pipeline for the cooling water intake structures.

This plan for operating the drought contingency ponds is consistent with the recently enacted South Carolina Water Withdrawal Law (SC S.B. 452), which was established in part to require drought contingency planning and to promote an adequate water supply through the use of supplemental, off-stream water sources.

1.2.4 Flow Distribution and Water Balance Diagram [§ 122.21(r)(3)(iv)]

The water balance diagram with flow distribution for Lee Nuclear Station is provided in Figures A-11 and A-13 .

1.2.5 Engineering Drawings of Intakes [§ 122.21(r)(3)(v)]

Engineering drawings of the cooling water intake structures, as required by § 122.21(r) are provided in Figures A-14 through A-23.

1.2.6 Biological Conditions in the Vicinity of the Intakes [§ 122.21(r)(4)]

Under § 122.21(r)(4), Duke Energy is required to provide information characterizing the biological community in the vicinity of the Lee Nuclear Site intakes.

1.2.7 Identification of Unavailable Data [§ 122.21(r)(4)(i)]

Duke Energy conducted monitoring programs and a thorough literature search for relevant data. Data and information to address the requirements of § 122.21(r)(4)(ii) through (vi) are provided in subsections 1.2.8 through 1.2.12 below, and in Attachment A.2.

1.2.8 Descriptions of Biological Communities and Relative Abundance [§ 122.21(r)(4)(ii)]

For purposes of this and subsequent discussion in subsections 1.2.8.1 through 1.2.8.4, Duke Energy characterized the aquatic life present in the main stem and backwater areas of the Broad River within the limits of the Ninety-Nine Islands Reservoir. Data collected downstream of the Ninety-Nine Islands Dam (downstream of the Primary Study Area) and in Ponds A and B, but believed to be representative of the fauna that may also occur in the Primary Study Area, are also presented below. The specific fish species that will be present in Pond C (once London Creek is impounded) are unknown, but will likely resemble other area reservoirs typical to the Piedmont of South Carolina that are dominated by bass, sunfish, catfish, and shad.

The aquatic community in the Broad River consists of a lotic community in the main river channel, upstream of the limits of the Ninety-Nine Islands Reservoir and downstream of Ninety-Nine Islands Dam and lentic communities in the limits of the Ninety-Nine Islands Reservoir and two backwater regions on both sides of the main channel (Figure 1-1, § 316(b) Compliance Demonstration). The shallower backwater areas of the Broad River are downstream of the river intake. Backwater areas have a biological community of fish and plankton more typical of lakes and ponds than of communities found in streams. Benthos, periphyton, and aquatic macrophytes are limited within the Ninety-Nine Islands Reservoir due to unsuitable substrate, limited light penetration from turbidity, and fluctuating water levels. The aquatic community includes four main groups, which are described below: (1) fish; (2) benthic macroinvertebrates; (3) zooplankton; and (4) phytoplankton and algae.

1.2.8.1 Fish

Rhode et al. (2009) noted that approximately 75 percent of the freshwater fish in South Carolina are warmwater species and include only five families: 1) Cyprinidae (44 species of carps, minnows, and shiners); 2) Catostomidae (16 sucker species); 3) Centrarchidae (20 sunfish species); 4) Percidae (16 darter species); and 5) Ictaluridae (13 catfish species). The fish community in the vicinity of the proposed primary and drought contingency sections of the river intake is well represented by these five families. Table A-3 presents a summary of the species collected from the river in the vicinity of the river intake.

The fish community in the Broad River is a recreational fishery and has remained relatively stable in species composition and abundance over time, based on studies conducted by Duke Energy (Duke Power 1978) and the SCDNR (Duke Energy 2009b; Bettinger et al. 2003). A total of 39 species were collected in 1973–1974; 43 species were collected in 1974–1976; 38, in 2000–2002; and 39, in 2006 (Duke Energy 2009b; Duke Power 1978). The most abundant species collected from 1973–1976 by electrofishing and gillnetting were gizzard shad (*Dorosoma cepedianum*), whitefin shiner (*Cyprinella nivea*), white catfish (*Ameiurus catus*), bluegill (*Lepomis macrochirus*), quillback (*Carpiodes cyprinus*), and largemouth bass (*Micropterus salmoides*) (Duke Power 1975; Duke Power 1978).

Table A-4 presents a summary of fish collected in 2006. Bluegill was numerically the dominant species collected by electrofishing upstream and downstream of the river intake (Duke Energy 2009b). Other species frequently collected at both locations included largemouth bass, redbreast sunfish (*L. auritus*), and redear sunfish (*L. microlophus*). In the winter and fall, whitefin shiner and gizzard shad, respectively, were the second-most abundant species collected from upstream locations. Twenty-three taxa were collected by gillnetting from the upstream and downstream locations (Table A-5 and Figure A-24). Gizzard shad, quillback, black crappie *(Pomoxis nigromaculatus*), and channel catfish (*Ictalurus punctatus*) were the most abundant species

(Barwick et al. 2006). The highest number of fish was collected in July, while the lowest collections were observed in October.

Larval fish densities were measured at multiple sampling locations in the Broad River during the 1976 spawning season (late April through early September) (Cloutman and Edwards 1977). The mainstream locations had lower densities of larval fish [average = 123.3/1,000 cubic meters (m^3)] than the backwater locations (average = 1,776.1/1,000 m^3, (Table A-6, Figure A-25), (Cloutman and Edwards 1977). The mainstream locations were dominated by shad (*Dorosoma* spp.) (42.9 percent), minnows (except common carp [*Cyprinus carpio*]) (28.8 percent), and catfish (12 percent), while the backwater locations were dominated by shad (78.3 percent), sunfish (21 percent), and crappie (*Pomoxis* spp.) (0.5 percent). Shad densities peaked in mid-May in the mainstream locations (399.5/1,000 m^3), while in the backwater locations they remained high from late April through mid-July (684/1,000–2,958.6/1,000 m^3). Peak densities for minnows (335.9/1,000 m^3) and catfish (81.5/1,000 m^3) in the mainstream locations occurred in early August and early July, respectively. Peak densities for sunfish (1,331.5/1,000–2,558.6/1,000 m^3) in the backwater locations occurred in mid to late July.

Electrofishing was performed in Ponds A and B in 2006 and a total of 1,589 fish representing 12 species were collected (Barwick et al. 2006). Pond B, the largest onsite pond, had the most diverse fish population (11 species) of the ponds sampled, but had the lowest catch rate (427 fish/hour) (Barwick et al. 2006). The dominant species in electrofishing collections from Ponds A and B were bluegill, redbreast sunfish, and largemouth bass, which comprised 74.1, 7.9, and 6 percent of the total collections, respectively (Barwick et al. 2006). Other frequently collected species from these two ponds included warmouth (*L. gulosus*), redear sunfish, flat bullhead (*Ameiurus platycephalus*), and black crappie (Barwick et al. 2006).

1.2.8.2 Macroinvertebrates

Benthic macroinvertebrates (benthos) include aquatic insects, crustaceans (e.g., crayfish), mollusks (e.g., mussels and clams), gastropods (e.g., snails), oligochaetes (e.g., worms), and others. The benthos collected in prior (1973–1974, 1987) and current (2006) studies are summarized in Table A-7 (Duke Energy 2009b). The collection of more than 100 genera in both the 1973–1974 and 2006 sampling in the Broad River upstream of the Ninety-Nine Islands Reservoir and downstream of the Ninety-Nine Islands Dam indicates a relatively diverse and abundant macroinvertebrate fauna typical of Piedmont rivers. However, very limited benthic fauna were found in the Ninety-Nine Islands Reservoir (Duke Power 1975). Diptera, principally the midges *Chaoborus punctipennis* and Chironomidae, were the dominant organisms collected in the Ninety-Nine Islands Reservoir. The mean density of *C. punctipennis* was 922 organisms/square meter (m^2); observed densities ranged from 0 to 4,522/m^2. This species, generally associated with standing water habitats, was present in nearly 70 percent of the Broad River samples, but was relatively uncommon in other habitats.

Benthic macroinvertebrates were sampled in the river in April, August, and October 2006 in the Primary Study Area (four locations upstream and within the Ninety-Nine Islands Reservoir) (Figure A-26). Samples were also collected downstream of the Ninety-Nine Islands Dam. The total number of macroinvertebrates collected varied in 2006 among seasons and locations. The highest number of taxa for all locations combined occurred in April, while the lowest number of taxa for all locations occurred in August. The number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) taxa in the Ninety-Nine Islands Reservoir in 2006 was low (1–10) in comparison to the number collected just downstream of the Cherokee Falls Dam (26) or downstream of the Ninety-Nine Islands Dam (25) (Derwort and McCorkle 2006).

1.2.8.3 Zooplankton

The zooplankton (small invertebrates suspended in the water) of the Broad River consist primarily of rotifers (about 76 percent by number), with lesser numbers of small crustaceans (cladocerns and copepods); this composition is typical of flowing waters (Duke Power 1978). In the Ninety-Nine Islands Reservoir, the proportion of crustaceans was considerably greater than the numbers elsewhere in the Broad River. Both rotifers and copepods tended to be most abundant in the fall and early spring, although the peaks were short-lived and density differences among locations and sampling periods were often great.

1.2.8.4 Phytoplankton and Algae

Phytoplankton, together with periphyton and aquatic macrophytes, account for the primary production in an aquatic ecosystem such as the Broad River; however, in a turbid stream, such as the Broad River, the importance of plants is limited (Duke Power 1975). Light is essential to photosynthesis and algal growth, but there are only limited locations with depths where light penetration is sufficient in the Broad River [i.e., Secchi depth is generally about 1 foot (0.3 meter)] (Duke Power 1975); therefore, primary productivity can be low.

Approximately 300 species and subspecies of phytoplankton and periphyton were identified in samples from the Broad River (Table A-8) (Duke Power 1975). Upstream of the river intake, phytoplankton were numerically dominated by diatoms, especially during the winter and early spring. For example, along the upstream main channel, 89.6 percent of the taxa were diatoms, while blue-green algae accounted for 6.3 percent in October 1973. In contrast, diatoms accounted for only 3.4 percent of the total biovolume, while blue-greens accounted for 96.5 percent. These relationships were consistent throughout the year, except in March, when green algae dominated in both categories (total counts and biovolume).

The most common genera of diatoms upstream of the river intake were Melosira, Pinnularia, Synedra, Cymbella, Achnanthes, and Navicula. The most common green algae further downstream were Scenedesmus, Chlamydomonas, and Ankistrodesmus. The genera of blue-green algae that accounted for most of the volume included Anabena, Merismopedia, and Oscillatoria. Total

phytoplankton densities at river locations ranged from about 100 cells/milliliter (cells/mL) in the fall to approximately 500 cells/mL in the spring and summer. In the Broad River, densities were generally higher. For example, in October 1973 there were 5,562 cells/mL at location 13, although counts between 1,000 and 3,000 cells/mL were much more common during the late fall and winter. Light penetration does develop in the spring and summer, as reflected by greater densities in surface samples, compared to bottom samples at the same location.

1.2.9 Identification of Species Most Susceptible to Impingement and Entrainment for Analysis of Plant Effects [§ 122.21(r)(4)(iii)]

The potential for impingement is very low due to the design and locations of the Lee Nuclear Station cooling water intake structure. Each section of the cooling water intake structure is designed with a maximum through-screen velocity of <0.5 fps. As EPA has recognized (EPA 2001), velocities ≤0.5 fps are generally protective of free swimming organisms and greatly reduce the potential for impingement. Furthermore, the intake on the river will withdraw water from a deep scour pool, which will aid in avoiding sensitive habitats along the shore and backwaters of the river. The river intake will include fish handling and return systems to improve survival of fish that may be impinged.

The cooling water intake structures on Ponds B and C will include narrow-slot, cylindrical wedge-wire screens located in deeper regions of the reservoirs. These locations will help avoid impingement of smaller fish that inhabit littoral zones of the ponds. Pond A intake will utilize fine mesh travelling screens with a Ristroph fish handling system to improve survival of any fish that might be impinged. In addition, the volume of water diverted from each of these waterbodies is relatively low and their HZIs are small (Appendix B). Larger, healthy fish would be unaffected by the low velocities in the HZI. Since Lee Nuclear Site will employ the best technology available by complying with measures to reduce impingement, it is unlikely that impingement-related impacts would result in adverse environmental impacts.

This section presents a qualitative assessment of entrainment potential based on the spawning habits and early life history of the species likely to be present in the vicinity of the Lee Nuclear Site cooling water intake structures. Life stages susceptible to entrainment include eggs, larvae, and small juveniles that may pass through a narrow opening. As described in this subsection and in subsection 1.2.10, many of the species and/or life stages of the species present in the Primary Study Area are not likely to be susceptible to entrainment. However, entrainment of the early life stages of some species is expected. A detailed analysis was conducted to quantify the potential entrainment associated with the Lee Nuclear Site cooling water intake structures and is provided in Appendix L.

The following subsections present information for taxa in the Broad River and Ponds A and B for the purpose of identifying the species and life stages that may be susceptible to entrainment. Early

life history information as derived from a literature review is provided in Table A-9 and the species potentially susceptible to entrainment as identified through historic and recent field data collection in the vicinity of the Lee Nuclear Site are listed in Tables A-3 through A-7.

With respect to the potential for entrainment on the Broad River, only species collected at one or more locations upstream of the Ninety-Nine Islands Dam were considered. While the reach of river downstream of the dam was sampled, species that were collected from this area only were not included in this assessment since they do not appear to be common in the vicinity of the Lee Nuclear Site river intake. Several taxa occur in the Broad River, but were not collected from Ponds A and B. If the species were not collected from the ponds, it is unlikely that the species occur in any appreciable numbers and entrainment is considered unlikely.

1.2.9.1 Centrarchidae

The Centrarchidae family includes sunfish (*Lepomis* spp.), crappie (*Pomoxis* spp.) and black bass (*Micropterus* spp.). The species that occur in the vicinity of Lee Nuclear Site includes bluegill, redbreast sunfish, redear sunfish, pumpkinseed (*L. gibbosus*), warmouth, largemouth bass, smallmouth bass (*M. dolomieu*), and black and white (*P. annularis*) crappie. Of these, bluegill was the overwhelming majority of sunfish collected, whereas, redbreast sunfish and largemouth bass were also common. The remaining species were collected less frequently and almost all of the smallmouth bass were collected downstream of the Ninety-Nine Islands Dam

All of the sunfish species spawn in nests along the shoreline and early life stages remain in littoral habitats along the river shoreline. Available ichthyoplankton data from the Duke Energy (Cloutman and Edwards 1977) study identified three taxa within the sunfish family — *Lepomis* spp, largemouth bass, and *Pomoxis* spp. These data are in agreement with what is known about the habitats of the early life stages. The overwhelming majority (98 percent) of *Lepomis* spp. larvae were collected from the backwater locations of the Broad River and very few (2 percent) were collected from the mainstream locations. The densities of sunfish were some of the highest observed in the study, with an average density over the study of 373/1,000 m^3. Sunfish larvae were first collected in June, with peak densities in July.

The abundance of largemouth bass larvae was low, with an average density over the study period of 3.3/1,000 m^3. All of the largemouth bass larvae were collected in June from the mainstream locations.

Crappie larvae were also low in abundance, with an average density over the study period of 9.2/1,000 m^3. All crappie larvae were collected from backwater locations in April and May, suggesting that spawning was limited to early spring.

The potential for centrarchid entrainment at the Lee Nuclear Site river intake is expected to be low. Since these species spawn in nests along the shoreline and early life stages inhabit shallow, littoral habitats, it is unlikely that eggs or larvae would occur in the HZI in any appreciable numbers.

The dominant species in electrofishing collections from Ponds A and B were bluegill, redbreast sunfish, and largemouth bass. As previously described, these species, as well as other sunfish species, spawn in nests along shallow, shoreline areas. Although eggs and larvae are presumably abundant in the spring, it is unlikely that these life stages would occur in the HZI of the intakes in the ponds since the cooling water intake structures will be located in deep water.

1.2.9.2 Cyprinidae

The following presents information on the species collected within the family Cyprinidae. These include: whitefin shiner, spottail shiner (*Notropis hudsonius*), sandbar shiner (*N. scepticus*), golden shiner (*Notemigonus crysoleucas*), and common carp. The whitefin shiner was one of the most dominant species collected in 1973–1974 and the second most dominant species collected by electrofishing in the winter of 2006 immediately upstream of the river intake. The spottail shiner, which was the dominant common species collected by electrofishing in 2001–2002, was collected at a location immediately downstream of the Cherokee Falls Dam (Figure A-27) (Bettinger et al. 2003). In contrast, the sandbar shiner only represented 1.2 percent of the 2006 electrofishing collections in the Broad River and all but two of the specimens were collected downstream of the Ninety-Nine Islands Dam.

In the Duke Energy ichthyoplankton survey (Cloutman and Edwards 1977), minnow larvae were grouped into one taxa. Minnow larvae were collected in relatively low densities, averaging approximately 39/1,000 m^3 per sample event. Of these, most were collected from the mainstream locations. Larvae were collected throughout the study (April through August), but the majority of larvae were collected in August, suggesting late summer spawning of one or more species. As described in Table A-9, the eggs of the most prevalent species (whitefin shiner) are adhesive, which reduces the likelihood of their presence in the HZI. The eggs of species occurring primarily downstream of the river intake (e.g., sandbar shiner) are unlikely to be present in the HZI. Other minnows that occur in the Broad River spawn in shallow riffles over sand/gravel substrates. Since this type of habitat does not occur near the Lee Nuclear Site river intake, the presence of early life stages would be uncommon in the HZI.

Two Cyprinid species were collected from Pond B. These species apparently do not occur in the ponds in appreciable numbers and the probability of entrainment is expected to be low.

1.2.9.3 Ictaluridae

The catfish collected in previous studies include: channel catfish, flat bullhead, white catfish, and snail bullhead (*Ameiurus brunneus*).

White catfish was the most common catfish species in the 1970s gillnet collections in the river (Duke Power 1978). The channel catfish was infrequently collected in the 1970s (Duke Power 1975; Duke Power 1978), but was common in gillnet collections in 2006 (Table A-5, Barwick et al. 2006). White catfish, flat bullhead, and snail bullhead were uncommon in the 2006 gillnet survey.

In the Duke Energy ichthyoplankton survey (Cloutman and Edwards 1977), catfish larvae were grouped into one taxa. Catfish larvae were collected at low densities, averaging 14.8/1,000 m^3 over the study period. Most of the larvae were collected during June and July and were collected from the mainstream locations. Most catfish are considered structure spawners, depositing eggs in cavities; however, the snail bullhead deposits eggs in runs among rocks and gravel (see Table A-9). Due to their presence in mainstream locations, it is possible that one or more species of catfish may be susceptible to entrainment, but at relatively low numbers due to the very small HZI and the life history of most catfish species.

Flat bullhead comprised 3.7 percent of the total catch from Pond B in 2006 and snail bullhead were collected infrequently. White catfish were collected infrequently in Ponds A and B (Barwick et al. 2006).

1.2.9.4 Clupeidae

Gizzard shad is the primary clupeid species in the Broad River and was one of the most abundant species in electrofishing and gillnetting samples (see Tables A-3 through A-5) In the Duke (1976) ichthyoplankton survey, shad larvae were identified as *Dorosoma* spp.; however, it is possible that almost all of the larvae were gizzard shad. Of all the larval fish collected, gizzard shad were the overwhelming majority, with an average density over the study period of 1,390/1,000 m^3. Larvae were collected throughout the study period, but were most common from May through July. The overwhelming majority (97 percent) of larvae were collected from the backwater locations. Although gizzard shad spawn in the backwaters of the Broad River, it is possible that some larvae may encounter the HZI due to their high densities.

Gizzard shad were not collected from Pond A and comprised only 1.1 percent of the total electrofishing collections from Pond B during the 2006 survey (Barwick et al. 2006). While it is possible that gizzard shad exist in Pond A, expected entrainment at both ponds is expected to be low due to the location of the intakes in the deep regions of the ponds. Gizzard shad larvae inhabit shallow shoreline and pelagic waters and are not expected to occur in the vicinity of the HZI. However, gizzard shad have high fecundity rates and the potential for an increase in larval densities exists, possibly increasing the chance of entrainment.

1.2.9.5 Catostomidae

Catastomids that occur upstream of the Ninety-Nine Islands Dam in the vicinity of Lee Nuclear Site include the quillback, notchlip redhorse (*Moxostoma collapsum*), and brassy jumprock (*Moxostoma* sp.) [see Tables A-3 and A-4]. The quillback appears to be the most common species.

In the Duke Energy ichthyoplankton survey (Cloutman and Edwards 1977), all of the sucker species were grouped together as one taxa. Larval suckers were collected from April through June in the mainstream locations, but at low densities. The average number of larval suckers over the study period was 6.7/1,000 m^3.

Suckers generally spawn in flowing water over sand, gravel, and cobble substrates. Some species spawn in tributaries, whereas other species spawn in riffle and runs of the river. As a result of spawning in flowing water, some eggs and larvae may drift downstream into the vicinity of the HZI. However, since densities are relatively low, potential entrainment is also expected to be low.

There were no suckers collected in the surveys of Ponds A and B. Since these species appear to be absent from the ponds, entrainment is unlikely.

Sucker species comprised 5.4 percent of the larval fish collections in 1976. No catostomids were collected during the 2006 electrofishing of Ponds A and B (Barwick et al. 2006).

1.2.9.6 Percidae

The family Percidae, represents darters which include the fantail darter (*Etheostoma flabellare*), piedmont darter (*Percina crassa*) and tessellated darter (*E. olmstedi*). The fantail darter is a state species of concern that was collected infrequently in the 1970s (Duke Power 1975; Duke Power 1978) and more recently in low numbers in the riffles downstream of the Lee Nuclear Site (Bettinger et al. 2003). Only one fantail darter and one tessellated darter were collected from the Broad River in 2006 (see Table A-4).

Of the darters, the piedmont darter was the most common darter species in electrofishing collections and was the only darter species collected in the Duke Energy ichthyoplankton survey (Cloutman and Edwards 1977) (see Table A-6). All of the larvae were collected in April and May, but were collected at very low densities, with a study period average of 1.7/1,000 m^3. All of the piedmont darter larvae were collected from the mainstream of the river, downstream of the Ninety-Nine Islands Dam. Therefore, this species does not appear to inhabit the Broad River upstream of the dam and in the vicinity of the Lee Nuclear Site. Due to the very low abundance of fantail and tessellated darters in the vicinity of the river intake, and their preference for shallow water habitats, entrainment of darters is expected to be very low.

With respect to Ponds A and B, entrainment of any darter species is not likely to occur. No darters were collected in any of the surveys of Ponds A and B.

1.2.10 Identification and Evaluation of the Primary Period of Reproduction, Larval Recruitment, and Period of Peak Abundance for Relevant Taxa [§ 122.21(r)(4)(iv)]

The information presented in this subsection is summarized in Table A-9, and further details are presented in Appendix L. Appendix L uses empirical data on fish larvae to characterize the temporal patterns of abundance of the larvae of fish species that inhabit the Broad River. Likely levels of entrainment were estimated by considering the proportion of the Broad River flow past Lee Nuclear Site that would be withdrawn during the period of entrainment vulnerability for fish inhabiting the Broad River. The assessment compares levels of entrainment that would be likely under Duke Energy's proposed Water Management Plan to the likely levels of entrainment that would be allowed under EPA's interpretation of §125.84(b)(3)(i) of the Phase I Rule.

1.2.11 Data Representative of the Seasonal and Daily Activities of Biological Organisms in the Vicinity of the Intake [40 CFR § 122.21(r)(4)(v)]

Scientific literature provides information on the seasonal and daily activities of many species present in the vicinity of the river intake, including channel catfish and redbreast sunfish. Studies conducted by Duke Energy provide additional information on seasonal and daily activities of additional species present in the vicinity of the river intake.

1.2.11.1 Seasonal and Daily Activity Data Provided by Literature Searches

Adult channel catfish typically inhabit deep pools during the day, often near cover such as logs and stumps, but may move into shallower water at night to feed (Marcy et al. 2005). Young-of-year channel catfish are often found in shallower water than adults. Riverine populations occupy rather small home ranges in the summer and typically move less than three miles. Channel catfish are more likely to be found in the main river channel during the winter, where they tend to prefer deep water with slow currents.

Adult and juvenile redbreast sunfish are generally found in deeper pools often associated with woody debris, stumps, or undercut banks (Marcy et al. 2005). They are relatively sedentary with small home ranges. Adult and juvenile bluegills tend to overwinter in deeper water, often in aggregations (Keast 1978).

1.2.11.2 Seasonal and Daily Activity Data Provided by Duke Energy Field Studies

Duke Energy sponsored and/or conducted several field studies in the Broad River in the vicinity of the intake for Lee Nuclear Station. These included:

- fish, benthic macroinvertebrate, and phytoplankton/algae studies in 1973–1976;

- fish and larval fish studies in 1975 and 1976; and
- fish, benthic macroinvertebrate, and mussel studies in 2006.

Combined, these studies provide information on the seasonal occurrence of these species. Information on the daily activities of the fish species is provided by the larval fish studies performed in 1976.

The 1973–1976 fish and ichthyoplankton studies (Cloutman and Edwards 1977; Duke Power 1978) calculated when peak larval densities occurred. Shad densities peaked in mid-May in the mainstream locations (399.5/1,000 m^3); in the backwater locations, densities remained high from late April through mid-July (684/1,000–2,958.6/1,000 m^3). Peak densities for the minnows (335.9/1,000 m^3) and the catfish (81.5/1,000 m^3) in the mainstream locations occurred in early August and early July, respectively. The peak densities for the sunfish in the backwater locations (1,331.5/1,000–2,558.6/1000 m^3) occurred in mid to late July.

Diel sampling of larval fish in 1976 demonstrated a significant relationship between time of day and total larval densities. Larval densities measured in total darkness at 3:00 AM (0300 hours) and the early morning at 9:00 AM (0900 hours) were similar and significantly lower than those measured in the afternoon at 3:00 PM (1500 hours) and in the evening at 9:00 PM (2100 hours). While densities measured in the afternoon and evening did not differ significantly, mean densities measured in the evening were greater. Based on these data, larval fish in the Broad River appear to be more susceptible to drift collection during the afternoon and evening than during other times of the day.

1.2.12 Identification of All Threatened, Endangered, and Other Protected Species That Might Be Susceptible to Impingement and Entrainment at the Intake [§ 122.21(r)(4)(vi)]

No aquatic T&E species are listed as being present in the vicinity of the Lee Nuclear Station river intake on the websites maintained by either the United States Fish and Wildlife Service (USFWS) (2010) or SCDNR (2006). No federally listed threatened, endangered, candidate, or species of concern for Cherokee County were collected by SCDNR personnel during boat and backpack electrofishing surveys performed in 2001 and 2002 at location 7 in the Broad River, upstream from the primary and drought contingency sections of the river intake (Figure A-27) (Bettinger et al. 2003). However, one fantail darter (a state species of concern) was collected by Duke Energy personnel in electrofishing surveys performed during February 2006 at location 463 (Figure A-24) in the Broad River (Barwick et al. 2006).

The Cherokee Environmental Report (Duke Power 1975) reported the collection of seven robust redhorse (*Moxostoma robustum*) at location 15, the confluence of the Broad River and Kings Creek immediately downstream of the Ninety-Nine Islands Reservoir (Figure A-28). However, further

identification by additional taxonomic experts conducted at the request of Duke Energy revealed that the report was a result of misidentification due to incomplete understanding of the taxonomy of the species at the time (Duke Energy 2009b, 2008a, 2008b). In any event, this sampling location is downstream of the Ninety-Nine Islands Dam; therefore, if present, this species would not be subject to entrainment or impingement by the river intake.

According to SCDNR (2006), no aquatic state-endangered (SE) or state-threatened (ST) species are present in the immediate vicinity of the Lee Nuclear Station. However, species of state concern potentially occurring in the vicinity of the Lee Nuclear Station include: four fish species, fantail darter, Carolina darter (*Etheostoma collis*), highfin carpsucker (*Carpiodes* sp. cf. *velifer*), and v-lip redhorse (*Moxostoma pappillosum*); one mussel, paper pondshell (*Utterbacki imbecillis*); and one snail, gravel elimia (*Elimia catenaria*). No Carolina darters were collected in any of the fish surveys in the immediate vicinity of the Lee Nuclear Station (Duke Power 1975, Bettinger et al. 2003, Barwick et al. 2006). Carolina darters prefer small Piedmont streams (Rhode et al. 2009) and would not be expected to occur near the Broad River or any of its backwater habitats. The highfin carpsucker was collected in low numbers (one to eight) upstream of the limits of the Ninety-Nine Islands Reservoir during the 2001–2002 SCDNR surveys (Bettinger et al. 2003). Similarly, the v-lip redhorse was collected in low numbers (one to two) up and downstream of the Ninety-Nine Islands Dam during the recent Duke Energy and SCDNR fish surveys (Barwick et al. 2006, Bettinger et al. 2003). At three locations in Pond A, seven live paper pondshell were collected in 2006 (Alderman 2006).

1.2.13 Documentation of Any Public Participation or Consultation With Federal or State Agencies [§ 122.21(r)(4)(vii)]

Duke Energy sought consultations with federal and state agencies. In response to Duke Energy's request, USFWS, in a letter dated August 22, 2007, stated that no federally listed T&E species were likely to be found in the vicinity of the Lee Nuclear Station. This letter is provided in Attachment A.1. USFWS, however, noted the robust redhorse as a federal species of concern (FSC), which could potentially occur in the Broad River downstream of the Lee Nuclear Station.

In April 2006, Duke Energy submitted a letter to SCDNR requesting information on any species under the jurisdiction of SCDNR that might occur in the vicinity of Lee Nuclear Station. SCDNR responded in a letter dated April 14, 2006 and did not identify any aquatic state-endangered or state-threatened species for Cherokee County and the immediate vicinity of the Lee Nuclear Station. This letter is also provided in Attachment A.1.

1.2.14 Supporting Documentation for the Source Water Baseline Biological Characterization [§ 122.21(r)(4)(viii)]

Supporting data and documentation for the Source Water Baseline Biological Characterization were originally developed for the construction of Cherokee Nuclear Station in the 1970s. These data have

been supplemented with more recent studies to further characterize the biology in the area of influence and beyond the river intake for the Lee Nuclear Station. All studies used to support this subsection are listed below:

- Cherokee Nuclear Station Environmental Report, Duke Power, 1975;
- Evaluation of potential entrainment at Cherokee Nuclear Station. Olmsted, L.L. (ed). 72–93. Cloutman, D.G. and T.J. Edwards. 1977;
- Baseline environmental summary report on the Broad River in the vicinity of Cherokee Nuclear Station. Olmsted, L.L. and A.S. Leiper (eds). Duke Power Company, 1978;
- Broad River Aquatic Resources Inventory Completion Report. Broad River Comprehensive Entrainment Mitigation and Fisheries Resource Program. SCDNR. Bettinger, J., J. Crane, and J. Bulak. 2003;
- Macroinvertebrate surveys in the vicinity of the proposed Lee Nuclear Station. Derwort, J.E., and S.F. McCorkle. 2006; and
- Fishery resources associated with the Lee Nuclear Site. Barwick, D.H., D.J. Coughlan, G.E. Vaughan, B.K. Baker, and W.R. Doby. 2006.

For these studies, Duke Energy is providing: a description of the methods and quality assurance procedures for field sampling and data analysis; a description of the study area, the taxonomic identification of sampled and evaluated biological assemblages, and sampling and data analysis methods. Studies conducted prior to 2006 are described in Attachment A.2.

Duke Energy (and its predecessors) have maintained and operated a biological laboratory employing standard operating procedures (SOPs) and rigorous quality assurance/quality control methods employed by highly trained scientists (Duke Energy 2010a). The biological and chemical laboratories have been certified by both the North Carolina Department of Environment and Natural Resources (NCDENR) and SCDHEC to conduct biological investigations and perform water quality analyses for as long as each agency has implemented a certification program. All biological programs conducted by Duke Energy discussed in this section and in Attachment A.2 have been implemented in accordance with these procedures.

1.2.14.1 Macroinvertebrate Surveys in the Vicinity of the Lee Nuclear Station

Benthic invertebrate sampling occurred in April, August, and October 2006 at five sampling locations (Figure A-27) (Derwort and McCorkle 2006). Sampling procedures were determined using the Standard Qualitative Bioassessment Method as outlined in the North Carolina Department of Environmental and Natural Resources Standard Operating Procedures of July 2006 (NCDENR 2006). Samples were collected from each major habitat, and the organisms were sorted from debris in the field. Organisms were placed in labeled containers, preserved in 95 percent alcohol, returned to the laboratory, and identified to the lowest practicable taxon. This sampling also included a

visual assessment of the substrate and habitat, and a bioclassification of each location (Duke Energy 2009b).

Five locations were sampled in 2006 in the Broad River for macroinvertebrates. Location 465 is just downstream of Cherokee Falls Dam, while locations 463 and 460 are in the vicinity of the Lee Nuclear Station proposed river intake, upstream and downstream, respectively. Location 459 is in the vicinity of the Lee Nuclear Station discharge, while location 453 is downstream of the Ninety-Nine Islands Dam, in the vicinity of Kings Creek (Figure A-26) (Derwort and McCorkle 2006).

Macroinvertebrates were identified to the lowest practicable taxon (Derwort & McCorkle 2006). The number of individual organisms per taxon in each sample were classified as: rare (one to two individuals collected), common (three to nine individuals collected), or abundant (ten or more individuals collected). Analysis resulted in a bioclassification for each location, which gave equal consideration to the number of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa present to determine a biotic index (EPT). A biotic index was calculated for all taxa collected from a given location. NCDENR biologists have assigned biotic index values for benthic taxa based on their relative tolerance to environmental perturbations. A score is assigned to the EPT value and the mean biotic index. The mean of these two scores was used to assign one of five bioclassifications from poor to excellent (NCDENR 2006) for each location. Taxa collected in 2006 were compared to those collected in the 1970s program.

1.2.14.2 Fishery Resources Associated With the Lee Nuclear Station Site

Fish sampling occurred in February, April, July, and October 2006 in the Broad River in the vicinity of the Lee Nuclear Site and downstream of the Ninety-Nine Islands Dam (Barwick et al. 2006). Methods used included boat-mounted, pulsed (120 pulses per second), direct current electrofishing. Two 100-meter segments of shoreline (one on each side of the Broad River) were electrofished for about 1,000 seconds per segment, and all stunned fish were netted. In July and October, water levels were low downstream of the Ninety-Nine Islands Dam, which necessitated the use of a tote barge electrofisher (same equipment and settings as the electrofishing boat). In April 2006, the two on-site ponds (Pond A and Pond B) were sampled with the same boat-mounted electrofisher and settings described for the Broad River sampling.

Additionally, experimental monofilament gillnets (30.5 meters long x 2.4 meters deep) comprised of five alternating 6.1-meter panels of 25-, 38-, 51-, 63-, and 76-millimeter square mesh were set perpendicular to the shore at the two Broad River backwater locations. The nets were deployed from the afternoon through the following morning. The gillnets consisted of a series of different mesh sizes (experimental gillnets) and were employed to representatively sample different size ranges of fish (Duke Energy 2009b).

Five locations (458, 460, 462, 463, and 464) in the Broad River upstream of the Ninety-Nine Islands Dam, one location (453) downstream of the Ninety-Nine Islands Dam, and shoreline segments in the two on-site ponds were sampled by electrofishing (Figure A-24) (Barwick et al. 2006).

All fish at all locations were identified to species, enumerated, and measured for total length (mm). Most fish collected by electrofishing were returned alive to the river in the vicinity of their collection. Fish collected by gillnet were released, if alive, or buried. Small fish were preserved in 10 percent formalin for taxonomic identification at the Duke Energy Environmental Center. Representative voucher specimens of most species were placed into the Duke Energy Fish Museum.

Species composition in 2006 was compared to the results in the same area in 1974–1976. The number of each fish species collected by location during electrofishing or gillnetting per sample date is presented in Barwick et al. 2006. Additionally, the catch rate (number of fish/hour) was reported for abundant species within the on-site ponds.

Table A-1
Surface Water Sampling Locations

Station ID	Location	Sample Collection Depth	Corresponding Historical Station ID
101	Broad River – North of the site	Surface (0.3 m/Mid-depth)	NA
102	Broad River – Upstream of the site	Surface (0.3 m/Mid-depth)	#7, #8
103	Impoundment – stormwater pond	Surface (0.3 m) Bottom	NA
104	Backwater – North of the Broad River	Surface (0.3 m)	#9, #10
105	Broad River – East of the site	Surface (0.3 m/Mid-depth)	#11
106	Backwater – West of the Broad River	Surface (0.3 m)	#12, #13
107	Broad River – Downstream of the Ninety-Nine Islands Dam	Surface (0.3 m)	#15
108	Impoundment –Pond A	Surface (0.3 m) Bottom	#21 (Intermittent Creek)
109	Broad River – Upstream of the Ninety-Nine Islands Dam	Surface (0.3 m/Mid-depth)	#14
110	Impoundment –Pond B	Surface (0.3 m) Bottom	#23 (McKowns Creek)

Table A-2
Annual Flow Data for the Broad River

Year	Annual Mean Flow (cfs)	Year	Annual Mean Flow (cfs)	Year	Annual Mean Flow (cfs)
1926	1,582	1955	1,489	1984	3,070
1927	1,562	1956	1,510	1985	1,987
1928	3,225	1957	2,640	1986	1,680
1929	3,642	1958	3,001	1987	2,656
1930	1,738	1959	2,961	1988	1,325
1931	1,802	1960	3,218	1989	2,346
1932	2,707	1961	2,942	1990	3,049
1933	2,174	1962	2,874	1991	2,603
1934	2,407	1963	2,239	1992	3,001
1935	2,373	1964	3,662	1993	3,038
1936	3,707	1965	2,871	1994	2,477
1937	3,279	1966	2,262	1995	3,439
1938	1,933	1967	2,482	1996	2,783
1939	2,131	1968	2,234	1997	2,442
1940	1,812	1969	2,807	1998	2,644
1941	1,552	1970	2,307	1999	1,523
1942	2,161	1971	3,117	2000	1,377
1943	2,398	1972	2,977	2001	973
1944	2,657	1973	3,951	2002	1,180
1945	2,555	1974	3,409	2003	3,774
1946	2,760	1975	4,175	2004	2,656
1947	2,450	1976	3,182	2005	2,693
1948	2,932	1977	2,564	2006	1,746
1949	3,608	1978	2,638	2007	1,367
1950	2,453	1979	3,866	2008	907
1951	1,932	1980	3,021	2009	2,081
1952	2,543	1981	1,440	2010	2,340
1953	1,992	1982	2,284		
1954	1,691	1983	3,208		

Table A-3
Fish Collected in the Vicinity of the River Intake (Locations 460 & 463)
During 2006 Electrofishing Sampling in Ninety-Nine Islands Reservoir

	LOCATION		
SPECIES	**460**	**463**	**Grand Total**
Black crappie	1		1
Bluegill	204	140	344
Brassy jumprock		1	1
Channel catfish	3	5	8
Common carp	2	5	7
Fantail darter		1	1
Flat bullhead		2	2
Gizzard shad		13	13
Largemouth bass	21	10	31
Notchlip redhorse	5	1	6
Pumpkinseed		1	1
Redbreast sunfish	6	20	26
Redear sunfish	9	8	17
Smallmouth bass		3	3
Snail bullhead	0	1	1
Spottail shiner	2	1	3
Tessellated darter		1	1
Warmouth	5	1	6
White catfish		2	2
Whitefin shiner	3	15	18
Grand Total	261	231	492

Sources: Modified from Duke Energy 2009b Table 2.4-8.
See Figure A-24 for fishery sampling locations.

Table A-4

Fish Collected in the Broad River at the Lee Nuclear Site, 2006

Family	Common Name	Number Collected February Location[a]					Number Collected April Location					Number Collected July Location					Number Collected October Location					Total
		453	458	460	462	463	453	458	460	462	463	453	458	460	462	463	453	458	460	462	463	
Catostomidae	White sucker[b]	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Quillback	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	Northern hogsucker[b]	25	0	0	0	0	12	0	0	0	0	41	0	0	0	0	74	0	0	0	0	152
	Notchlip redhorse	1	0	1	0	1	6	1	1	0	0	0	2	3	0	0	6	0	0	1	0	23
	Shorthead redhorse[c]	12	0	0	0	0	8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	21
	V-Lip redhorse[c]	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Striped jumprock[b]	21	0	0	0	0	4	0	0	0	0	5	0	0	0	0	7	0	0	0	0	37
	Brassy jumprock[c]	14	0	0	0	1	24	0	0	0	0	1	0	0	0	0	14	0	0	0	0	54
	Subtotal	77	0	1	0	2	54	1	1	0	0	48	2	3	0	0	101	1	0	1	0	292
Centrarchidae	Redbreast sunfish[b]	4	0	1	0	7	23	0	3	0	5	46	0	1	0	3	58	0	1	0	5	157
	Pumpkinseed[b]	0	16	0	5	0	0	0	0	0	1	0	8	0	1	0	0	7	0	0	0	38
	Warmouth[b]	0	0	0	2	0	0	0	0	2	0	0	2	1	1	1	0	1	3	3	0	16
	Bluegill[b]	7	150	38	333	24	32	110	82	188	58	20	98	26	118	18	70	194	58	186	40	1850
	Redear sunfish[c]	1	3	2	8	1	7	2	0	2	0	0	2	2	1	2	5	13	5	2	5	63
	Sunfish hybrid	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2
	Smallmouth bass[b]	6	0	0	0	1	8	0	0	0	0	80	0	0	0	0	64	0	0	0	2	161

Sheet 1 of 3

Fish Collected in the Broad River at the Lee Nuclear Site, 2006

Family	Common Name	Number Collected February Location[a]					Number Collected April Location					Number Collected July Location					Number Collected October Location					Total
		453	458	460	462	463	453	458	460	462	463	453	458	460	462	463	453	458	460	462	463	
	Largemouth bass[b]	0	13	8	6	1	3	10	5	11	5	3	9	1	12	2	3	14	7	14	2	129
	Black crappie[b]	0	0	1	4	0	2	4	0	4	0	0	0	0	3	0	0	3	0	14	0	35
	White crappie	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	4
	Subtotal	18	182	50	359	34	75	126	90	207	69	149	119	31	136	26	200	234	74	222	54	2455
Clupeidae	Gizzard shad[b]	0	0	0	0	0	6	12	0	2	0	0	0	0	1	0	0	5	0	15	13	54
	Threadfin shad[b]	0	0	0	0	0	0	0	0	14	0	0	2	0	5	0	0	1	0	9	0	31
	Subtotal	0	0	0	0	0	6	12	0	16	0	0	2	0	6	0	0	6	0	24	13	85
Cyprinidae	Thicklip chub[b]	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	4
	Whitefin shiner[b]	19	0	1	0	12	13	0	0	0	1	33	0	0	0	0	107	0	2	0	2	190
	Fireyback shiner[b]	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
	Greenfin shiner[b]	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	0	0	0	3
	Common carp[b]	0	0	0	5	0	0	5	1	3	2	0	1	1	1	0	0	5	0	6	3	33
	Bluehead chub[b]	8	0	0	0	0	0	0	0	0	0	6	0	0	0	0	2	0	0	0	0	16
	Golden shiner[b]	0	1	0	3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	7	0	12
	Spottail shiner[b]	111	0	1	0	1	1	0	0	0	0	33	0	1	1	0	39	0	0	0	0	188
	Sandbar shiner[b]	41	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	43
	Creek chub[b]	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Subtotal	188	1	3	8	13	14	5	1	3	3	75	1	2	3	0	151	5	2	13	5	496

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Table A-4

Fish Collected in the Broad River at the Lee Nuclear Site, 2006

Family	Common Name	Number Collected February Location[a]					Number Collected April Location					Number Collected July Location					Number Collected October Location					Total
		453	458	460	462	463	453	458	460	462	463	453	458	460	462	463	453	458	460	462	463	
Ictaluridae	Snail bullhead[b]	4	0	0	0	1	29	0	0	0	0	82	0	0	0	0	79	0	0	0	0	195
	White catfish[b]	0	0	0	4	0	0	8	0	3	1	0	10	0	0	1	0	2	0	0	0	29
	Channel catfish[b]	0	0	0	0	0	1	1	0	0	3	0	0	2	1	0	0	0	1	1	2	12
	Flat bullhead[b]	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0	6
	Margined madtom[b]	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0	6	0	0	0	0	21
	Subtotal	4	0	0	4	3	30	9	0	3	4	98	10	2	1	1	87	3	1	1	2	263
Percidae	Fantail darter[b]	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Tessellated darter[b]	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Yellow perch[c]	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2
	Piedmont darter[b]	0	0	0	0	0	4	0	0	0	0	19	0	0	0	0	3	0	0	0	0	26
	Subtotal	0	0	0	0	2	4	1	0	0	0	19	0	0	0	0	3	0	0	1	0	30
	Total	**287**	**183**	**54**	**371**	**54**	**183**	**154**	**92**	**229**	**76**	**389**	**134**	**38**	**146**	**27**	**542**	**249**	**77**	**262**	**74**	**3621**
	Total Number of Species (Excluding Hybrids)	**19**	**5**	**9**	**9**	**13**	**17**	**10**	**5**	**9**	**8**	**17**	**9**	**9**	**12**	**6**	**19**	**13**	**7**	**13**	**9**	**39**

Figure A-25

a) See Figure A-25 for sample station locations.
b) Also reported in Duke Power 1975 and SCDNR 2003
c) Also reported in either Duke Power 1975 or SCDNR

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Source: Duke Energy 2009b. Table 2.4-8

Table A-5

Total Numbers of Fish Collected During Gillnetting at Two Locations on Ninety-Nine Islands Reservoir in 2006

		Months and locations								
		February		April		July		October		
Family and scientific name	Common name	458	462	458	462	458	462	458	462	Total
Clupeidae										
Dorosoma cepedianum	Gizzard shad	49	107	62	56	79	50	39	42	484
Dorosoma petenense	Threadfin shad								1	1
Cyprinidae										
Cyprinus carpio	Common carp		3	3	4	1	2		1	14
Notemigonus crysoleucas	Golden shiner	7	1	4	12	2		2	6	34
Catostomidae										
Carpiodes cyprinus	Quillback	4	9	38	26	30	50	62	43	262
Catostomus commersoni	White sucker						1	2		3
Ictiobus bubalus	Smallmouth buffalo						1			1
Moxostoma collapsum	Notchlip redhorse				1					1
Scartomyzon sp.	Brassy jumprock			3						3
Ictaluridae										
Ameiurus brunneus	Snail bullhead		1				1			2
Ameiurus catus	White catfish	6	2		1		1		1	11
Ameiurus nebulosus	Brown bullhead		4	4	1					9
Ameiurus platycephalus	Flat bullhead			3						3
Ictalurus punctatus	Channel catfish	2	7	25	8	11	14	2	2	71
Moronidae										
Morone chrysops	White bass		1							1
Morone hybrid	Morone hybrid	1								1
Centrarchidae										
Lepomis auritus	Redbreast sunfish					1				1
Lepomis gulosus	Warmouth			3						3
Lepomis macrochirus	Bluegill		1	1	4	3	2	1		12
Lepomis microlophus	Redear sunfish		1		4					5
Micropterus salmoides	Largemouth bass	4	4	1	4	2	4	1		20
Pomoxis nigromaculatus	Black crappie	26	35	5	3	19	31	18	18	155
Percidae										
Perca flavescens	Yellow perch		1		1			1		3
Total number of individuals		99	177	152	125	148	157	128	114	1100

Source: Barwick, D.H., D.J. Coughlan, G.E. Vaughan, B.K. Baker and W.R. Doby. 2006.

Table A-6

Ichthyoplankton Densities During the 1976 Spawning Season

		Ichthyoplankton Densities (1976)																		Average Number of Adults/100 m Shoreline Shocke
		22 Apr	5 May	13 May	24 May	1 Jun	7 Jun	14 Jun	21 Jun	30 Jun	7 Jul	15 Jul	19 Jul	26 Jul	2 Aug	16 Aug	24 Aug	7 Sep	Seasonal Average	
Dorosoma spp. (Shad)	Backwater	793.0	1712.8	2036.0	2904.4	2827.5	1326.5	684.0	2958.6	4514.9	1010.0	1101.4	958.4	410.6	160.9	115.9	79.2	35.5	1390.0	2.0
	Mainstream	67.1	90.0	399.5	0.0	25.3	102.6	137.0	5.0	91.9	58.0	--	48.0	14.0	8.3	0.0	1.9	2.6	52.9	0.2
Cyprinids (Minnows) (Excluding carp)	Backwater	0.0	0.0	7.9	0.0	0.0	0.0	5.8	16.2	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0
	Mainstream	5.0	11.7	25.9	0.0	1.6	3.1	10.6	0.0	0.0	3.1	--	13.8	14.7	335.9	139.5	2.9	0.0	35.5	1.7
Cyprinus carpio (Carp)	Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
	Mainstream	19.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.4
Catostomids (Suckers)	Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mainstream	59.4	5.9	10.5	1.6	0.0	0.0	1.3	0.0	1.8	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0
Ictalurus spp. (Catfish)	Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	Mainstream	0.0	0.0	0.0	0.0	1.4	0.0	0.0	5.0	59.0	81.5	--	3.6	12.8	0.0	0.0	0.0	0.0	14.8	0.1
Lepomis spp. (Sunfish)	Backwater	0.0	0.0	0.0	0.0	74.1	39.5	172.4	248.4	0.0	219.8	16.9	2558.6	1331.5	186.6	6.4	0.0	0.0	373.4	20.8
	Mainstream	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	25.3	--	29.1	10.9	4.8	1.4	0.0	0.0	6.5	2.0
Micropterus salmoides (Largemouth bass)	Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9
	Mainstream	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.1
Pomoxis spp. (Crappie)	Backwater	31.7	14.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.2	0.8
	Mainstream	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Percina crassa (Piedmont darter)	Backwater	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Mainstream	4.3	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	--	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.0
Total Fish	Backwater	824.7	1727.2	2043.9	2904.4	2901.6	1366.0	862.2	3223.2	4520.1	1229.8	1118.3	3517.0	1742.1	347.5	122.3	79.2	35.5	1776.1	27.0
	Mainstream	155.6	112.0	435.9	1.6	28.3	105.7	158.2	10.0	152.7	167.9	--	94.5	52.4	349.0	140.9	4.8	2.6	123.3	4.6

-- Sample Not Collected

Source: Cloutman, D.G. and T.J. Edwards. 1977.

Table A-7
Benthic Macroinvertebrates Collected in the Broad River
Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected 1973–74	1987	2006
Annelida				
Rhynchobdellida				
Glossiphoniidae	*Placobdella*			X
Oligochaeta				
Haplotaxida				
Tubificida				
Naididae	*Nais*			X
	Pristinella			X
	Ripistes			X
	Slavina			X
	Stylaria			X
Tubificidae	*Branchirua*			X
	Limnodrilus			X
	Tubifex			X
Lumbriculida				
Lumbriculidae	*Lumbriculus*			X
Arthropoda				
Crustacea				
Amphipoda				
Talitridae	*Hyalella*			X
Decapoda				
Cambaridae	*Cambarus*	X		X
Isopoda				
Asellidae	*Asellus*	X		
	Caecidotea			X
Insecta				
Coleoptera				
Crysomelida	*Donacia*	X		
Dryopidae	*Helichus*			X
Dytiscidae	*Neoporus*			X
Elmidae	*Ancyronyx*		X	X
	Dubiraphia	X		
	Macronychus	X	X	X
	Optioservus	X		

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Table A-7

Benthic Macroinvertebrates Collected in the Broad River Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected 1973–74	1987	2006
	Stenelmis	X	X	X
Eubriidae	*Ectopria*		X	
Gyrinidae	*Dineutus*	X		X
	Gyrinus		X	
Haliplidae	*Peltodytes*			X
Hydrophilidae	*Sperchopsis*			X
Psephenidae	*Psephenus*	X		
Ptilodactylidae	*Anchytarsus*	X		X
Tingidae	*Corythuca*	X		
Diptera				
Ceratopogon-idea	*Palpomyia-Bezzia complex*	X	X	X
	Culicoides	X		
	Dasyhelia	X		
Chaoboridae	*Chaoborus*			X
Chironom-idea/Chiro-nominae	*Axarus*			X
	Chironomus			X
	Cladopelma		X	
	Cladotanytarsus	X		X
	Cryptochironomus	X		X
	Cryptocladopelma	X		
	Cryptosadisus	X		
	Cryptotendipes			X
	Demicryptochironomus	X		
	Dicrotendipes	X		X
	Diplocladius	X		
	Endochironomus			X
	Glyptotendipes			X
	Parachironomus		X	
	Paralauterborniella	X		X
	Paratanytarsus		X	
	Paratendipes			X
	Phaenopsectra	X		X

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Table A-7

Benthic Macroinvertebrates Collected in the Broad River Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected		
		1973–74	1987	2006
	Polypedilum	X	X	X
	Pseudochironomus		X	
	Rheotanytarsus	X	X	X
	Robackia			X
	Stenochironomus	X		X
	Stictochironomus		X	X
	Tanytarsus	X	X	X
	Tribelos		X	X
Chironom-idea/Dia-mesinae	*Potthastia*			X
	Diamesa		X	
Chironom-idea/Ortho-cladiinae	*Ablabesmyia*	X		
	Brillia		X	X
	Cardiocladius		X	X
	Chironomus	X	X	X
	Corynoneura	X	X	
	Cricotopus	X	X	X
	Eukiefferiella	X		X
	Metriocnemus	X		
	Microtendipes	X		
	Nanocladius	X	X	X
	Orthocladius		X	X
	Paracladopelma	X		
	Paratrichocladius		X	X
	Psectrocladius	X	X	
	Rheocricotopus		X	
	Synorthocladius			X
	Thienemanniella	X	X	X
	Trichocladius	X		
	Trissocladius	X		
	Tvetenia		X	X

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Table A-7

Benthic Macroinvertebrates Collected in the Broad River Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected 1973–74	1987	2006
Chironom-idea/Tany-podinae	*Ablabesmyia*			X
	Coelotanypus	X		X
	Conchapelopia	X		X
	Labrundinia			X
	Nilotanypus		X	X
	Procladius	X		X
	Rheopelopia		X	
Chaoboridae	*Chaoborus*	X		
Dixidae	*Dixa*	X		
Empididae	*Hemerodromia*	X		
Simuliidae	*Simulium*	X	X	X
Tabanidae	*Tabanus*	X		X
Tipulidae	*Antocha*	X		X
	Erioptera	X		
	Helobia	X		
	Tipula	X	X	X
Ephemeroptera				
Baetidae	*Acentrella*			X
	Ameletus	X		
	Baetis	X	X	X
	Baetisca	X		
	Caenis	X		
	Centroptilum			X
	Cloeon	X		
	Heterocloeon			X
	Plauditus			X
	Pseudocloeon		X	
Caenidae	*Caenis*		X	X
Ephemerellidea	*Danella*			X
	Ephemerella	X	X	X
	Eurylophella		X	X
	Serratella			X
Ephemeridae	*Hexagenia*	X	X	X

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Benthic Macroinvertebrates Collected in the Broad River

Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected 1973–74	1987	2006
Heptageniidae	*Heptagenia*		X	X
	Stenacron			X
	Stenonema	X	X	X
Leptophlebiidea	*Leptophlebia*			X
Neoephemeridea	*Neoephemera*			X
Oligoneuriidea	*Isonychia*	X	X	X
	Paraleptophlebia	X		
	Pseudiron	X		
Tricorythidae	*Tricorythodes*	X	X	X
Hemiptera				
Belostomatidae	*Belostoma*	X		
Corixidae	*Sigara*			X
Gerridea	*Gerris*	X	X	
Nepidae	*Ranatra*			X
Veliidae	*Rhagovelia*	X		
Megaloptera				
Corydalyidae	*Chauliodes*	X		
	Corydalus	X	X	X
Sialidae	*Sialis*			X
Odonata/Anisoptera				
Aehnidae	*Boyeria*		X	X
	Gomphaeschna	X		
Corduliidae	*Epicordulia*			X
	Neorocordula			X
Cordulegastridae	*Cordulegaster*		X	
Cordultidae	*Neurocordulia*		X	
Gomphidae	*Dromogomphus*	X	X	X
	Gomphus	X		X
	Hagenius			X
	Ophiogomphus	X		X
	Progomphus	X		
	Stylogomphus			X
	Stylurus		X	
Libellulidae	*Libellula*			X
Macromiidae	*Macromia*			X

Table A-7

Benthic Macroinvertebrates Collected in the Broad River Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected		
		1973–74	1987	2006
Odonata/Zygoptera				
Calopterygidae	*Calopteryx*			X
	Hetaerina		X	X
Coenagrionidea	*Argia*	X	X	X
	Enallagma			X
	Ischnura	X		X
Plecoptera				
Nemouridae	*Allocapnia*	X		
	Amphinemoura	X		
	Brachyptera	X		
	Leuctra	X		
	Nemoura	X		
	Oemopteryx	X		
	Taeniopteryx	X		
Perlidae	*Acroneuria*	X		X
	Eccoptura	X		
	Neoperla			X
	Paragnetina			X
	Perlesta	X	X	X
	Perlinella	X		
Peltoperidae	*Peltoperia*	X		
Perlodidae	*Isoperia*	X		
Trichoptera				
Glossosomatidae	*Glossosoma*	X		
Hydropsychidea	*Cheumatopsyche*	X	X	X
	Hydropsyche	X	X	X
	Macrostenum		X	X
Hydroptilidae	*Hydroptila*	X		X
	Stactobiella	X		
Lepidostomatidea	*Lepidostome*		X	
Leptoceridae	*Nectopsyche*			X
	Oecetis	X		X
	Triaenodes			X
Limnephilidae	*Drusinus*	X		
	Neophylax	X		

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Table A-7

Benthic Macroinvertebrates Collected in the Broad River Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected 1973–74	1987	2006
Molannidae	*Molanna*	X		
Philopotamidae	*Chimarra*			X
Polycentropodidea	*Cyrnellus*			X
	Neureclipsus			X
	Polycentropus	X		X
Psychomyiidae	*Lype*	X		
	Psychomyia			X
Rhyacophilidae	*Rhyacopnila*	X		
Mollusca				
Gastropoda				
Basommatophora				
Physidae	*Physella*			X
Limnophila				
Ancylidae	*Laevapex*			X
Mesogastropoda				
Hydrobiidae	*Amnicoloa*			X
Pleuroceridae	*Leptoxis*			X
Pulmonata				
Ancylidae	*Ferrissia*	X		
Lymnaeidae	*Lymnaea*	X		
Planorbidae	*Menetus*			X
Pelecypoda				
Heterodonta				
Sphaeriidae				X
Heterodontida				
Corbiculidae	*Corbicula*			X
Tricladida				
Platyhelminthes				
Turbellaria				
Tricladida				
Planariidea	*Dugesia*			X
	Phagocata	X		
Plumatellina				
Lophopodidae	*Pectinatella*	X		

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Table A-7

Benthic Macroinvertebrates Collected in the Broad River Near the Lee Nuclear Site, 1973-2006

Order and Family	Genus	Year Collected 1973–74	1987	2006
Paludicellidae	*Paludicella*	X		
Ctenobranchiata				
Amnicolidae	*Gilliaa*	X		
	Pyrgulopsis	X		
Rhynchobdellida				
Glossiphoniidae	*Helobdella*	X		
	Number of Taxa Collected	109	56	125
	Percent of Total Taxa Collected (201)	54	28	62

Sources: 1973-1974 Data (Duke 1975)
1987 Data (SCDNR 2003)

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Source: Duke Energy 2009b.

Table A-8
Master Species List of Phytoplankton and Periphyton Collected From the Broad River

Taxon	Genus & Species
Group Phytoplankton-Periphyton	
Phylum Chlorophyta	
Class (no classes given)	
Order Volvocales	
Family Polyblepharidaceae	
Genus & Species	*Spermatozoopsis exultans*
Family Chlamydomonadaceae	
Genus & Species	*Carteria cordiformis*
	Chlamydomonas sp. A
	Chlamydomonas globosa
	Chlamydomonas polypyrenoideum
Family Haematococcaceae	
Genus & Species	*Haematococcus lacustris*
Family Volvocaceae	
Genus & Species	*Eudorina elegans*
	Gonium pectorale
	Pandorina morum
	Volvox globator
Order Tetrasporales	
Family Gloeocystaceae	
Genus & Species	*Asterococcus limneticus*
Order Chlorococcales	
Family Chlorococcaceae	
Genus & Species	*Characium debaryanum*
	Schroederia setigera
	Tetraedron caudatum
	Tetraedron duospinum
	Tetraedron minimum
Family Oocystaceae	
Genus & Species	*Ankistrodesmus convolutus*
	Ankistrodesmus falcatus
	Cerasterias staurastroides
	Chlorella ellipsoidea
	Chlorella vulgaris
	Lagerheimia quadriseta
	Lagerheimia subsalsa
	Closteriopsis longissima

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	Franceia droescheri
	Kirchneriella lunaris
	Kirchneriella obesa
	Oocystis sp. A
	Selenastrum westii
	Treubaria setigerum
Family Micractiniaceae	
Genus & Species	Golenkinia paucispina
	Micractinium pusillum
Family Dictyosphaeriaceae	
Genus & Species	Dictyosphaerium ehrenbergianum
Family Scenedesmaceae	
Genus & Species	Actinastrum hantzschii
	Coelastrum cambricum
	Coelastrum microporum
	Coelastrum sphaericum
	Crucigenia crucifera
	Crucigenia tetrapedia
	Scenedesmus denticulatus
	Scenedesmus dimorphus
	Scenedesmus obliquus
	Scenedesmus quadricauda
Family Hydrodictyaceae	
Genus & Species	Pediastrum biradiatum
	Pediastrum duplex clathratum
	Pediastrum duplex gracilimum
	Pediastrum tetras tetraodon
Family Coccomyaceae	
Genus & Species	Dispora crucigenioides
Order Ulotrichales	
Family Ulotrichaceae	
Genus & Species	Geminella interrupta
Order Siphonocladales	
Family Cladophoraceae	
Genus & Species	Cladophora glomerata
Order Zygnematales	
Family Zygnemataceae	
Genus & Species	Mougeotia sp. A
	Spirogyra stictica

Family Desmidiaceae
Genus & Species

Arthrodesmus octocornis
Closterium acerosum
Closterium ehrenbergii
Cosmarium cucumis
Cosmarium nitidulum
Cosmarium subcrenatum
Euastrum pulchellum
Staurastrum alternans
Staurastrum gracile
Staurastrum hexacerum
Staurastrum margaritaceum
Staurastrum polymorphum

Unidentified green filament A
Unidentified green coccoid A
Unidentifed green filament B

Phylum Euglenophyta
Class (no classes given)
Order Euglenales
Family Euglenaceae
Genus & Species

Unidentified flagellate
Euglena acus rigida
Euglena elastica
Lepocinclis fusiformis
Phacus sp. A
Phacus acuminatus
Phacus caudatus
Phacus longicauda
Phacus swirenkoi
Trachelomonas girardiana
Trachelomonas hispida
Trachelomonas playfairii
Trachelomonas schauinslandii
Trachelomonas varians

Phylum Pyrrophyta
Class Dinophyceae
Order Dinokontae
Family Gymnodiniaceae
Genus & Species

Gymnodinium sp. A

Family Glenodiniaceae
Genus & Species

Glenodinium sp. A

Family Peridiniaceae
Genus & Species

Peridinium sp. A

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Family Ceratiaceae	
Genus & Species	Ceratium hirundinella
Phylum Chrysophyta	
Class Subphylum Xanthophyceae	
Order Mischococcales	
Family Pleurochloridaceae	
Genus & Species	Arachnochloris minor
Family Sciadaceae	
Genus & Species	Centritractus belanophorus
Class Subphylum Chrysophyceae	
Order Rhizochrysidales	
Family Rhizochrysidaceae	
Genus & Species	Rhizochrysis limnetica
Order Ochromonadales	
Family Dinobryaceae	
Genus & Species	Dinobryon bavaricum
	Dinobryon divergens
Family Synuraceae	
Genus & Species	Mallomonas tonsurata
Class Subphylum Bacillariophyceae	
Order Centrales	
Family Coscinodisciaceae	
Genus & Species	Cyclotella sp. A
	Cyclotella sp. B
	Cyclotella sp. C
	Cyclotella comata
	Cyclotella michiganiana
	Cyclotella radians
	Cyclotella stelligera
	Melosira granulata angustissima
	Melosira sp. B
	Melosira granulata
	Melosira granulata angustissima spiralis
	Melosira varians
	Microsiphona potamos
Order Pennales	
Family Fragilariaceae	
Genus & Species	Asterionella formosa formosa
	Asterionella formosa gracillima
	Fragilaria sp. A
	Fragilaria construens venter
	Fragilaria crotonensis crotonensis

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Fragilaria vaucheriae vaucheriae
Meridion sp. A
Meridion circulare constrictum
Opephora martyi martyi
Synedra sp. A
Synedra sp. B
Synedra acus acus
Synedra amphicephala austriaca
Synedra delicatissima angustissima
Synedra delicatissima delicatissima
Synedra fasciculata truncata
Synedra goulardi
Synedra pulchella pulchella
Synedra radians radians
Synedra rumpens familiaris
Synedra rumpens menegniana
Synedra rumpens rumpens
Synedra socia socia
Synedra tenera
Synedra ulna amphirhyncus
Synedra ulna contracta
Synedra ulna oxyrhyncus mediocontracta
Synedra ulna ramesi
Synedra ulna ulna
Tabellaria fenestrata fenestrata
Tabellaria flocculosa flocculosa

Family Eunotiaceae
Genus & Species

Eunotia arcus bidens
Eunotia curvata curvata
Eunotia exigua exigua
Eunotia incisa incisa
Eunotia maior maior
Eunotia naegelii naegelii
Eunotia pectinalis minor
Eunotia perpusilla perpusilla

Family Achanthaceae
Genus & Species

Achnanthes sp. A
Achnanthes sp. B
Achnanthes sp. C
Achnanthes sp. D
Achnanthes affinis affinis
Achnanthes coarctata
Achnanthes exigua constricta
Achnanthes exigua exigua

Achnanthes hauckiana hauckiana
Achnanthes hauckiana rostrata
Achnanthes lanceolata dubia
Achnanthes lanceolata lanceolata
Achnanthes lemmermanii lemmermanii
Achnanthes linearis linearis
Achnanthes microcephala microcephala
Achnanthes stewartii
Achnanthes sublaevis crassa
Achnanthes wellsiae
Cocconeis placentula euglypta
Cocconeis placentula lineata
Rhiocosphenia curvata curvata

Family Naviculaceae
Genus & Species

Amphipleura pellucida pellucida
Caloneis sp. A
Caloneis ventricosa truncatula
Caloneis ventricosa subundulata
Capartogramma crucicula crucicula
Frustulia sp. A
Frustulia rhomboides amphipleuroides
Frustulia rhomboides capitata
Frustulia rhomboides crassinervia
Frustulia rhomboides rhomboides
Frustulia rhomboides saxonica
Frustulia weinholdii weinholdii
Gyrosigma sp. A
Gyrosigma sp. B
Gyrosigma nodiferum nodiferum
Gyrosigma obtusatum obtusatum
Navicula sp. A
Navicula sp. B
Navicula sp. C
Navicula accomoda
Navicula aikenensis
Navicula arvensis arvensis
Navicula atomus atomus
Navicula capitata capitata
Navicula contenta biceps
Navicula cryptocephala
Navicula decussis decussis
Navicula elginensis elginensis
Navicula elginensis lata

Navicula exigua capitata
Navicula festiva festiva
Navicula gottlandica
Navicula hambergii hambergii
Navicula heufleri leptocephala
Navicula hustedtii
Navicula incomposita minor
Navicula lateropunctata
lateropunctata
Navicula minima minima
Navicula mobiliensis minor
Navicula mutata
Navicula mutica stigma
Navicula mutica mutica
Navicula notha notha
Navicula placenta placenta
Navicula pupula capitata
Navicula pupula mutata
Navicula pupula pupula
Navicula pupula rectangularis
Navicula radiosa parva
Navicula rhyncocephala germainii
Navicula rhyncocephala rhyncocephala
Navicula schroeteri escambia
Navicula seminulum hustedtii
Navicula symmetrica symmetrica
Navicula variostriata
Navicula ventralis chilensis
Navicula viridula linearis
Navicula viridula rostellata
Navicula viridula viridula
Neidium binode
Neidium ladogense denestriatum
Neidium temperei temperei
Pinnularia sp. A
Pinnularia biceps biceps
Pinnularia borealis rectangularis
Pinnularia formica formica
Pinnularia hilseana hilseana
Pinnularia mesolepta mesolepta
Pinnularia microstauron
microstauron
Pinnularia obscura obscura
Pinnularia subcapitata
paucistriata
Pinnularia viridis viridis
Stauroneis sp. A
Stauroneis anceps americana
Stauroneis anceps gracilis

Stauroneis kriegeri kriegeri
Stauroneis obtusa
Stauroneis phoenicenteron gracilis
Stauroneis smithii incisa

Family Gomphonemaceae
Genus & Species

Gomphonema sp. A
Gomphonema sp. B
Gomphonema sp. C
Gomphonema sp. E
Gomphonema acuminatum
Gomphonema angustatum angustatum
Gomphonema angustatum producta
Gomphonema constrictum
Gomphonema gracile
Gomphonema lanceolatum

Family Cymbellaceae
Genus & Species

Cymbella ehrenbergii
Cymbella gracilis
Cymbella lanceolata
Cymbella naviculiformis
Cymbella obtusiuscula
Cymbella tumida
Cymbella turgida
Cymbella ventricosa

Family Epithemiaceae
Genus & Species

Epithemia sp. A
Rhopalodia sp. A
Rhopalodia gibberula

Family Nitzschiaceae
Genus & Species

Hantzschia amphioxys capitata
Nitzschia acicularis
Nitzschia clausii
Nitzschia dissipata
Nitzschia fonticola
Nitzschia ignorata
Nitzschia invisitata
Nitzschia kutzingiana
Nitzschia linearis
Nitzschia lorenziana
Nitzschia palea
Nitzschia paradoxa
Nitzschia philippanarum
Nitzschia pseudoamphioxys
Nitzschia sigmoidea
Nitzschia vermicularis

Family Surirellaceae	
Genus & Species	Cymatopleura sp. A
	Surirella sp. A
	Surirella sp. B
	Surirella angusta
	Surirella elegans
	Surirella minuta
	Surirella patella neupauri
	Surirella tenera nervosa
Phylum Cyanophyta	
Class (no classes given)	
Order Chroococcales	
Family Chroococcaceae	
Genus & Species	Aphanocapsa sp. A
	Chroococcus limneticus
	Chroococcus minutus
	Chroococcus prescotti
	Coelosphaerium naegelianum
	Dactylococcopsis acicularis
	Merismopedia tenuissima
	Microcystis aeruginosa
Order Oscillatoriales	
Family Oscillatoriaceae	
Genus & Species	Oscillatoria sp. A
	Oscillatoria agardhii
	Oscillatoria geminata
	Oscillatoria limosa
	Oscillatoria tenuis
	Spirulina major
Order Nostocales	
Family Nostocaceae	
Genus & Species	Anabaena levanderi
Order Scytonematales	
Family Hammatoideaceae	
Genus & Species	Raphidiopsis curvata

Sheet 9 of 9

Duke Energy 1975.

Table A-9
Spawning Information for Major Fish Species Collected in Ninety-Nine Islands Reservoir Upstream of Ninety-Nine Islands Dam

Scientific Name	Common Name	Spawning Period	Spawning Location	Eggs/Female	References
Clupeidae					
Dorosoma cepedianum	Gizzard shad	Spring	Near the surface, eggs are scattered in shallow water and are adhesive	59,840–378,990	Lippson and Moran (1974), Jenkins and Burkhead (1994), Rhode et al. (2009)
Cyprinidae					
Cyprinella nivea	Whitefin shiner	June to August	Rock crevices, eggs are adhesive	112–545 eggs per clutch, multiple clutches per year	Cloutman and Harrell (1987) Marcy et al. (2005), Rhode et al. (2009)
Cyprinus carpio	Common carp	late March to August	Shallow, warm, vegetated waters, eggs and small larvae attach to vegetation	100,000–500,000	Lippson and Moran (1974), Marcy et al. (2005), Rhode et al. (2009)
Notropis hudsonius	Spottail shiner	April to July	In aggregations, over sand, gravel in shallow riffles, or vegetation	1,300–2,600	Lippson and Moran 1974 Wang and Kernehan 1979 Marcy et al. (2005), Rhode et al. (2009)
Notropis scepticus	Sandbar shiner	May to early July	In clear water, pools over sand,	170–1,164	Rhode et al. (2009) Harrell and Cloutman (1978)
Catostomidae					
Carpiodes cyprinus	Quillback	March to September, but occurs early in this period in southern latitudes	Smaller tributary streams, over sandy bottoms, in calm water	15,000–360,000 depending on size	Scott and Crossman (1973), Lippson and Moran (1974), Marcy et al. (2005), Coughlan et. al. (2007), Rhode et al. (2009)
Moxostoma collapsum	Notchlip redhorse	Late May–early June	Gravel, rocky substrate		Jenkins and Burkhead (1994), Coughlan et al.(2007)
Moxostoma sp.	Brassy Jumprock	April	Pools, runs, backwater areas		Jenkins and Burkhead (1994), Rhode et al. (2009)
Ictaluridae					
Ameiurus platycephalus	Flat bullhead	June and July		207–1,742	Olmsted and Cloutman (1979), Rhode et al. (2009)

Table A-9
Spawning Information for Major Fish Species Collected in Ninety-Nine Islands Reservoir Upstream of Ninety-Nine Islands Dam

Scientific Name	Common Name	Spawning Period	Spawning Location	Eggs/Female	References
Ictalurus punctatus	Channel catfish	Late Spring to early Summer.	Secluded, semi dark nests built in holes, undercut banks, log jams, or rocks	2,000–7,000	Lippson and Moran (1974), Marcy et al. (2005), Rhode et al. (2009)
Ameiurus brunneus	Snail bullhead	May to early June	Rock runs and riffles		Jenkins and Burkhead (1994), Rhode et al. (2009)
Ameiurus catus	White catfish	Late Spring to early Summer	Nests near some type of structure	1,000–3,500	Marcy et al. (2005), Rhode et al. (2009)
Centrarchidae					
Lepomis auritus	Redbreast sunfish	May through July	Build nests in sand or fine gravel substrate in shallow water, eggs are extremely adhesive	963 at age 2, 8,250 at age 6	Wang and Kernehan (1979), Jenkins and Burkhead (1994), Rhode et al. (2009)
Lepomis macrochirus	Bluegill	Spring, May through August	Nests are constructed in shallow, littoral and backwater areas over gravel, sandy or slightly muddy sediments that are protected by rocks and fallen trees, eggs are adhesive	80,000 per year for a 120 mm TL female	Scott and Crossman (1973), Duke Power (1975), Wang and Kernehan (1979), Jenkins and Burkhead (1994), Marcy et al. (2005), Rhode et al. (2009)
Lepomis microlophus	Redear sunfish	Late Spring to early Summer	Nests are constructed in shallow water up to, and usually less than two meters deep	15,000–30,000 depending on size	Wilbur (1969), Pfleiger (1975), Jenkins and Burkhead (1994), Marcy et al. (2005), Rhode et al. (2009)
Lepomis gibbosus	Pumpkinseed	April through August	Nests are solitary or in loose aggregations in shallow water, eggs are adhesive	1,800–14,100 depending on size	Jenkins and Burkhead (1994), Marcy et al. (2005), Rhode et al. (2009)
Lepomis gulosus	Warmouth	April through August	Solitary, circular nests in shallow water near cover	798–34,257 depending on size	Marcy et al. (2005) Rhode et al. (2009)
Micropterus dolomieu	Smallmouth bass	April and early May	Coarse gravel near shore, adhesive eggs and attending male	2,601–27,716	Jenkins and Burkhead (1994), Rhode et al. (2009)

Table A-9
Spawning Information for Major Fish Species Collected in Ninety-Nine Islands Reservoir Upstream of Ninety-Nine Islands Dam

Scientific Name	Common Name	Spawning Period	Spawning Location	Eggs/Female	References
Micropterus salmoides	Largemouth bass	Spring to early Summer	Construct nests in shallow backwater, eggs are adhesive	17,501 to 21,751 eggs for age 4 and 6 females, respectively	Jenkins and Burkhead (1994), Wang and Kernehan (1979), Scott and Crossman (1973), Rhode et al. (2009)
Pomoxis nigromaculatus	Black crappie	Late February to early May	Preferred habitat of sand and fine gravel in shallow, vegetated areas	6,1000–109,000	Seifert (1969), Lippson and Moran (1974), Wang and Kernehan (1979), Barwick (1981) Jenkins and Burkhead (1994), Duke Energy (2009b), Rhode et al. (2009)
Percidae					
Etheostoma flabellare	Fantail darter	April and May	Rock and gravel-bottomed riffles	average of 34 per spawn, 5 spawns per year	Jenkins and Burkhead (1994), Rhode et al. (2009)
Etheostoma olmstedi	Tessellated darter	Late March through June	Pools and runs over sandy substrate, male guards the nest	97–1,435, multiple clutches	Rhode et al. (2009)

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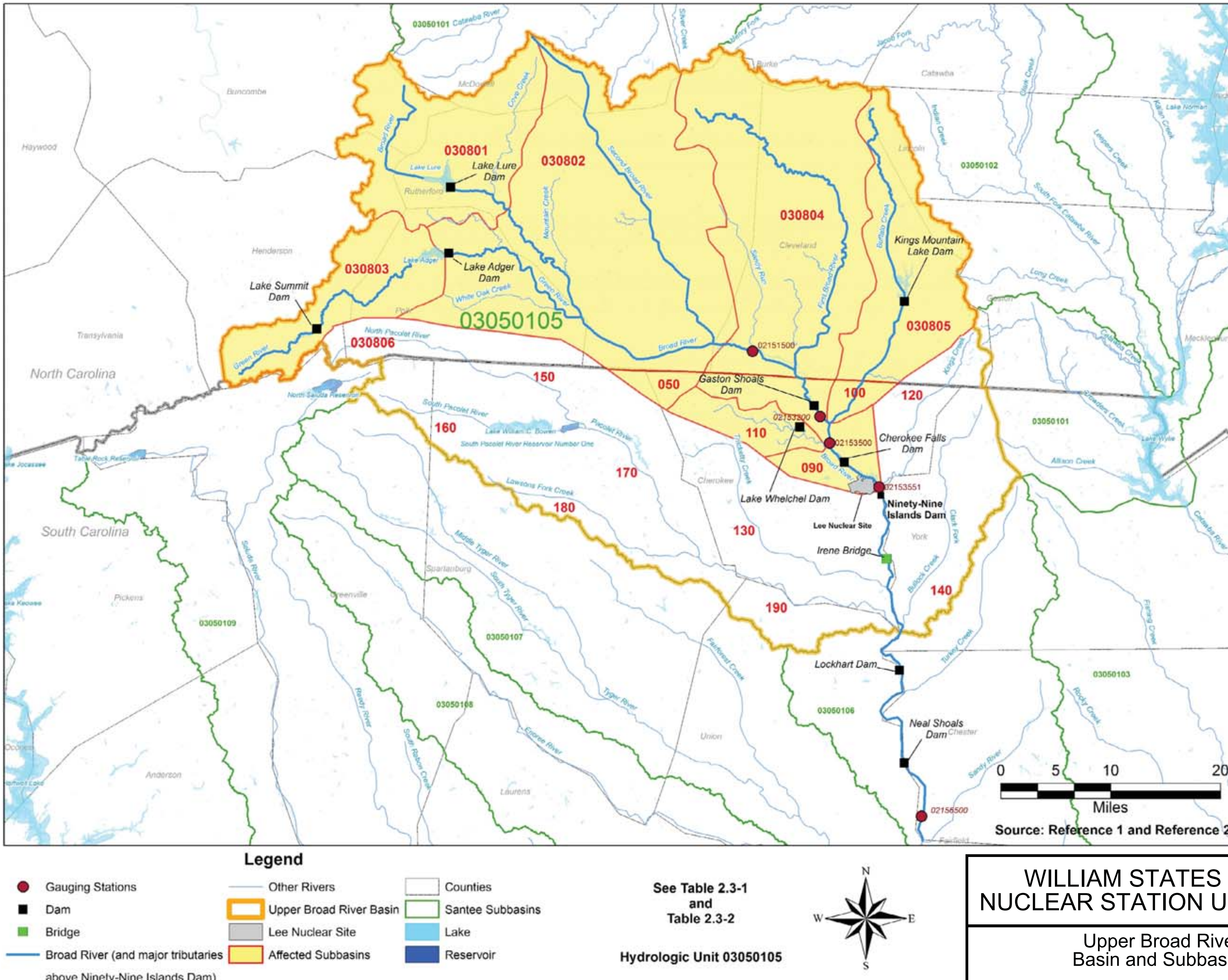

Source: Duke Energy 2009b. Figure 2.3-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Upper Broad River
Basin and Subbasins

Figure A-1

Rev 0

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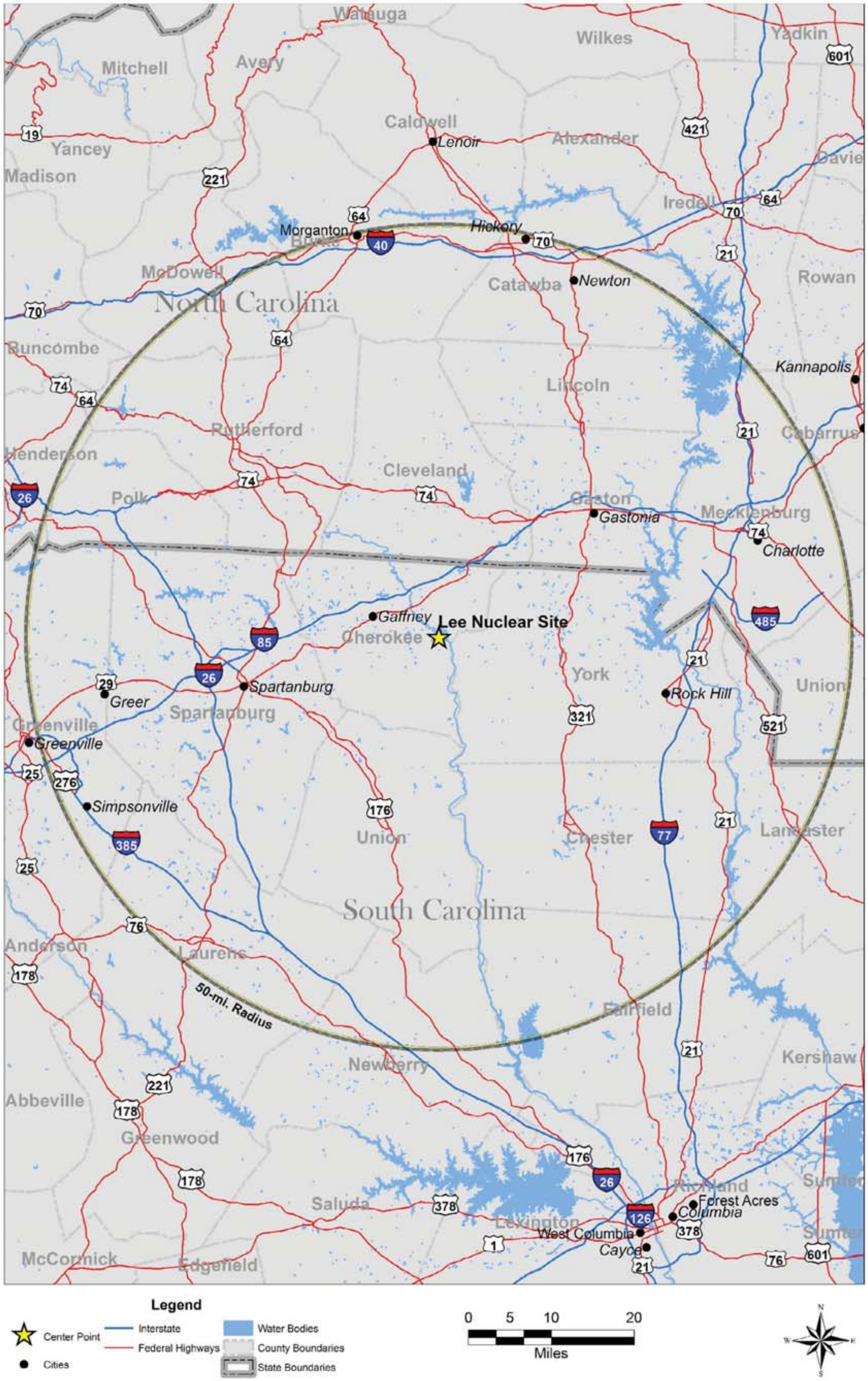

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Regional Base Map

Figure A-2

Rev 0

Source: Duke Energy 2009b. Figure 1.1-1

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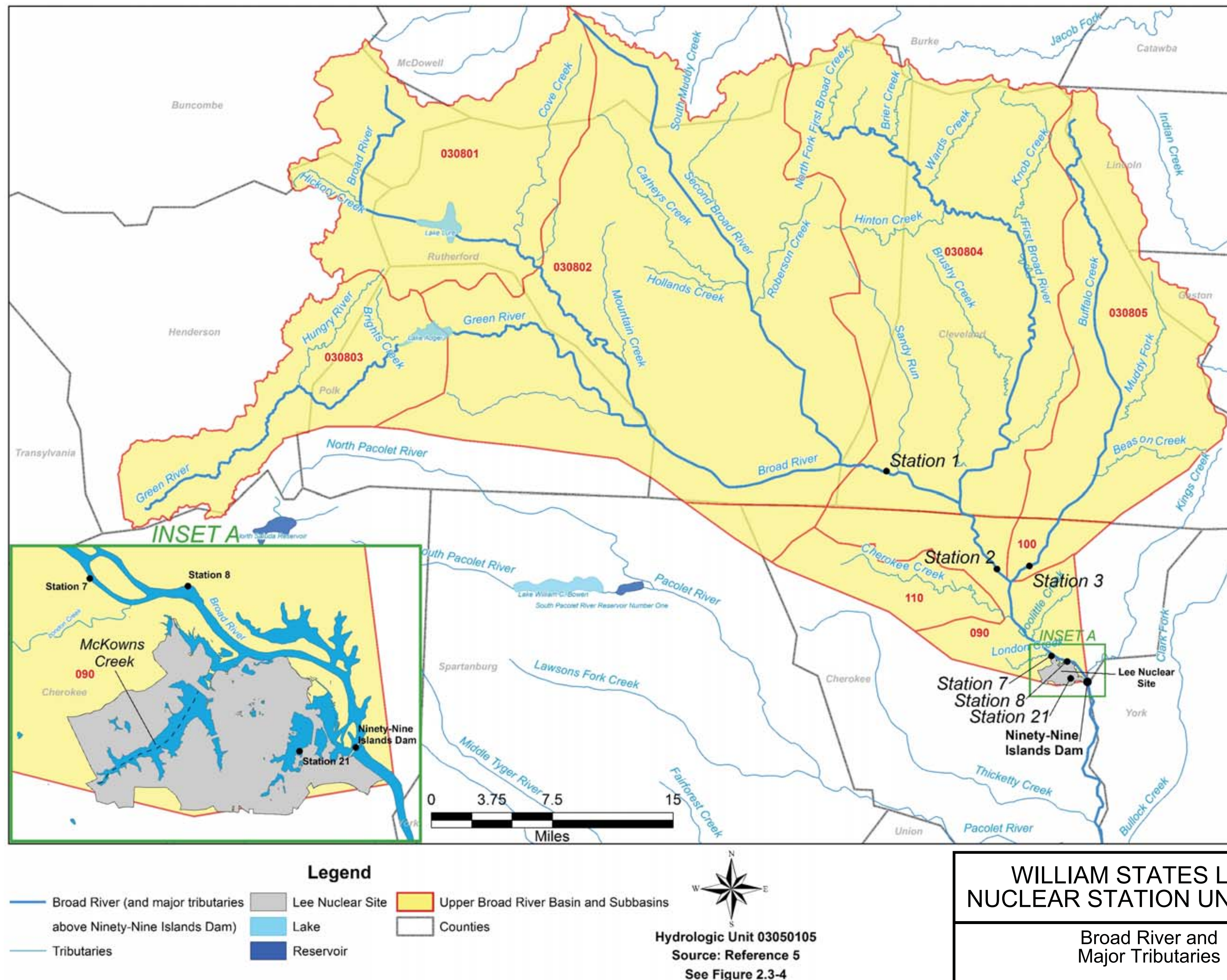

Source: Duke Energy 2009b. Figure 2.3-2

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Broad River and Major Tributaries

Figure A-3

Rev 0

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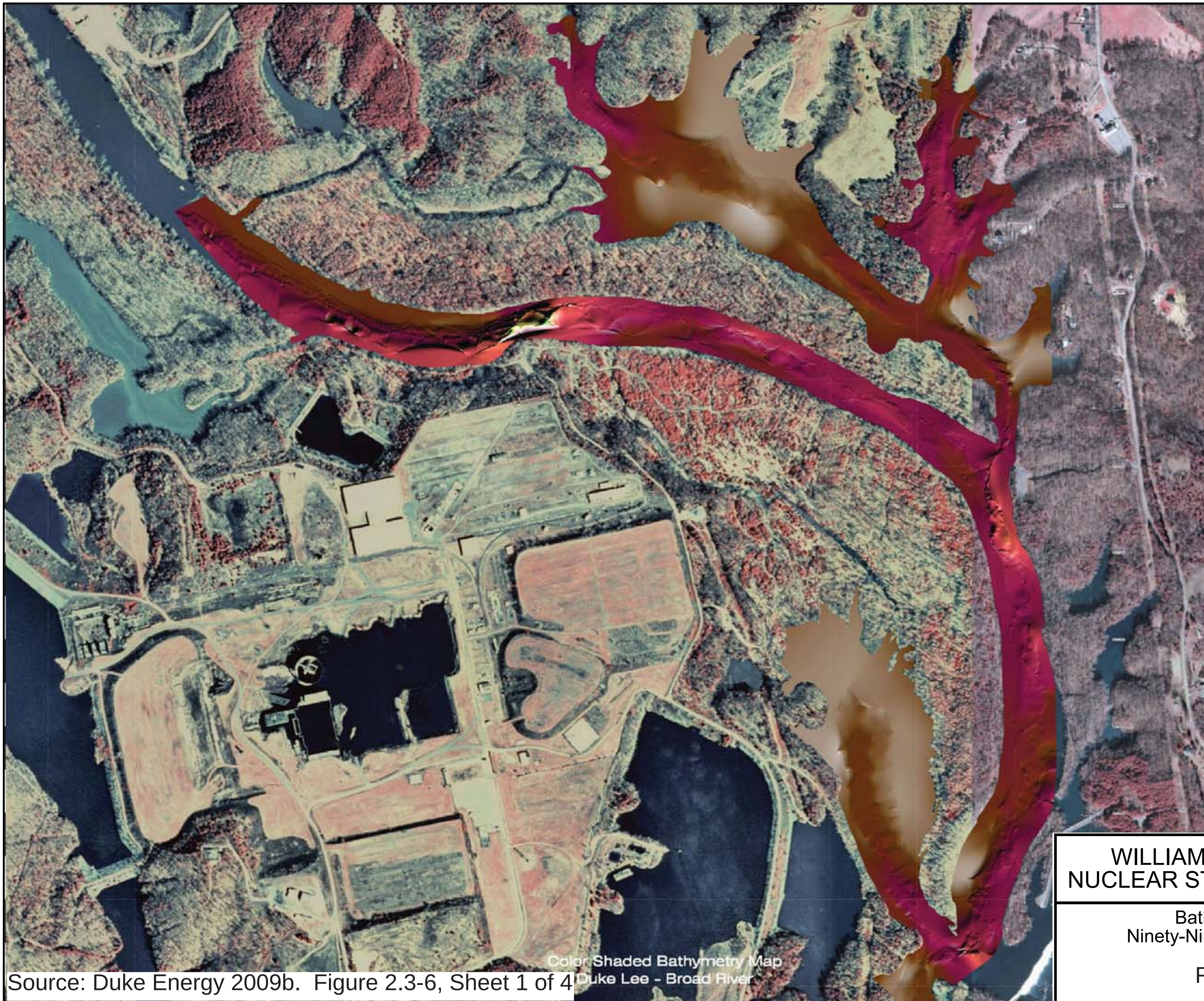

Source: Duke Energy 2009b. Figure 2.3-6, Sheet 1 of 4

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Bathymetry Map:
Ninety-Nine Island Reservoir

Figure A-4

Rev 0

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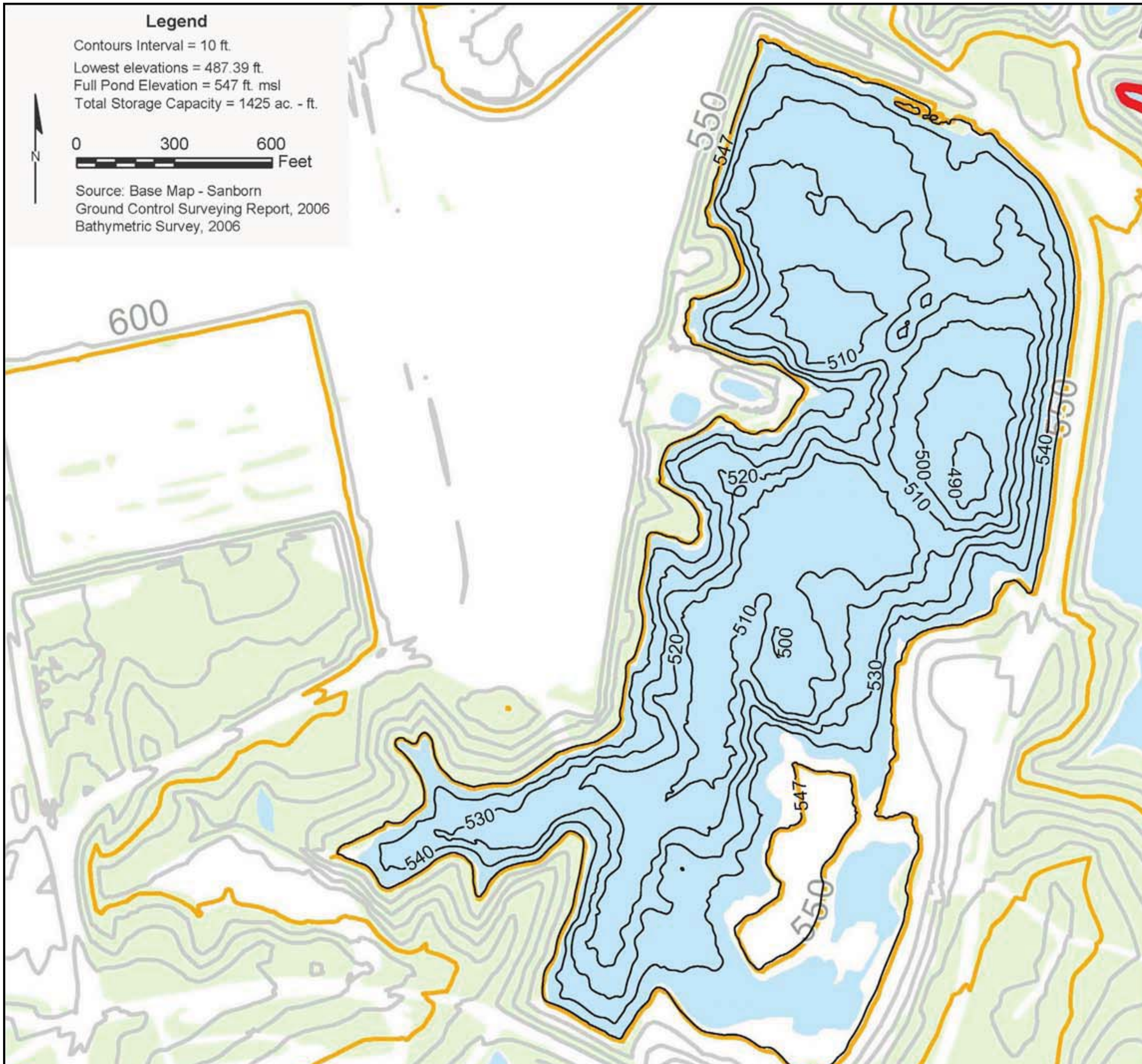

Source: Duke Energy 2009b. Figure 2.3-6, Sheet 3 of 4

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Bathymetric Map:
Pond A

Figure A-5

Rev 0

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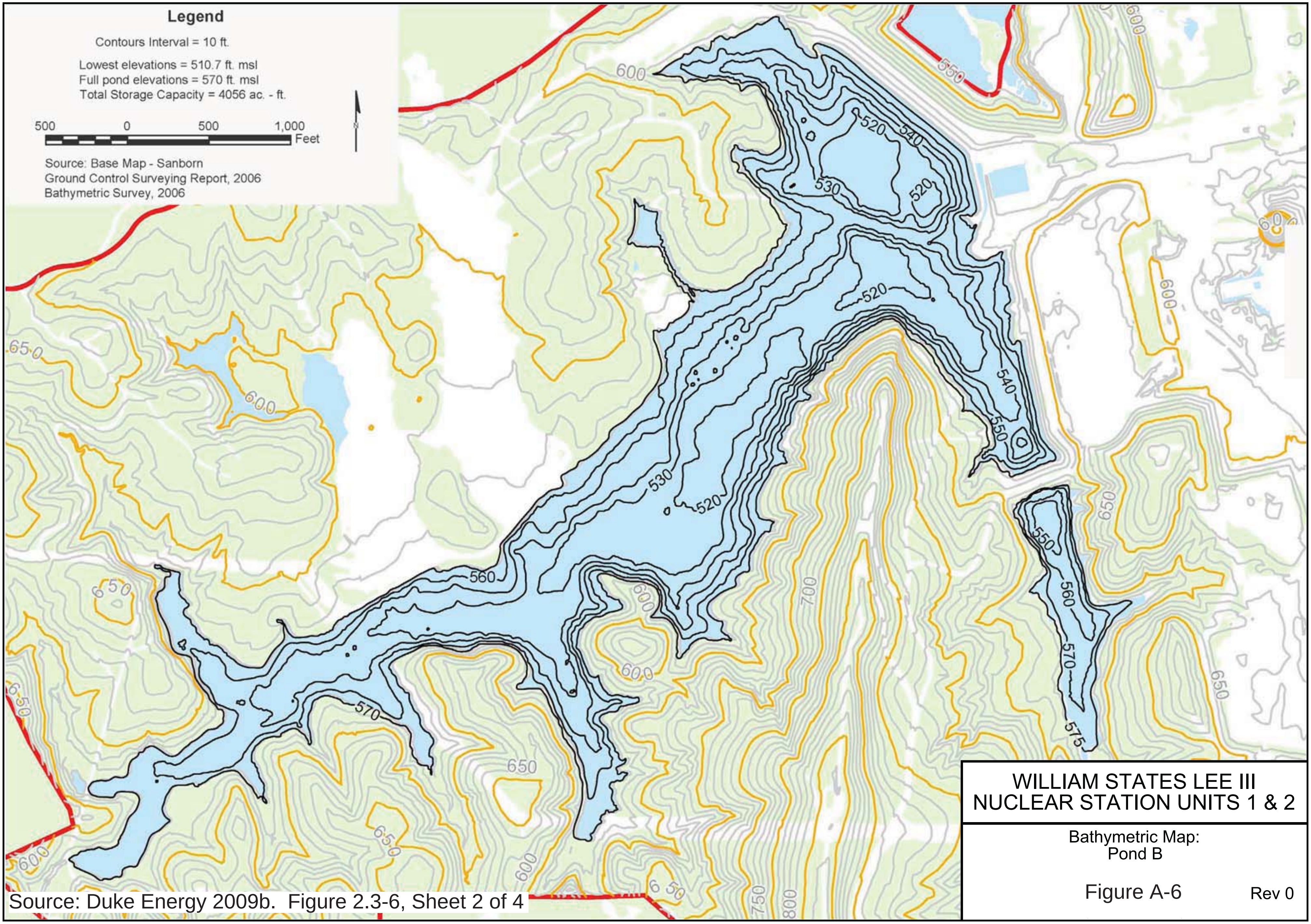

Source: Duke Energy 2009b. Figure 2.3-6, Sheet 2 of 4

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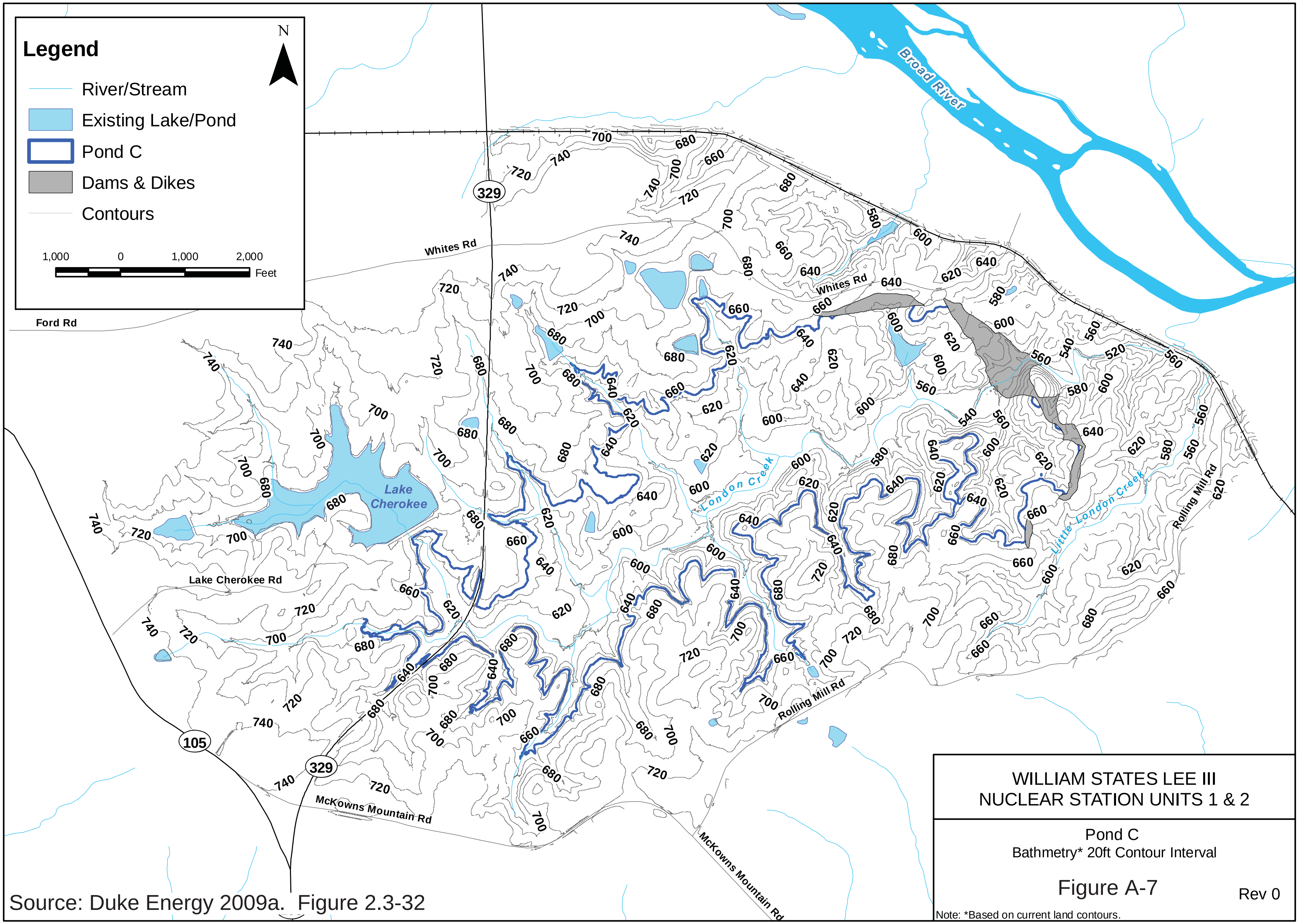

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Pond C
Bathmetry* 20ft Contour Interval

Figure A-7

Rev 0

Note: *Based on current land contours.

Source: Duke Energy 2009a. Figure 2.3-32

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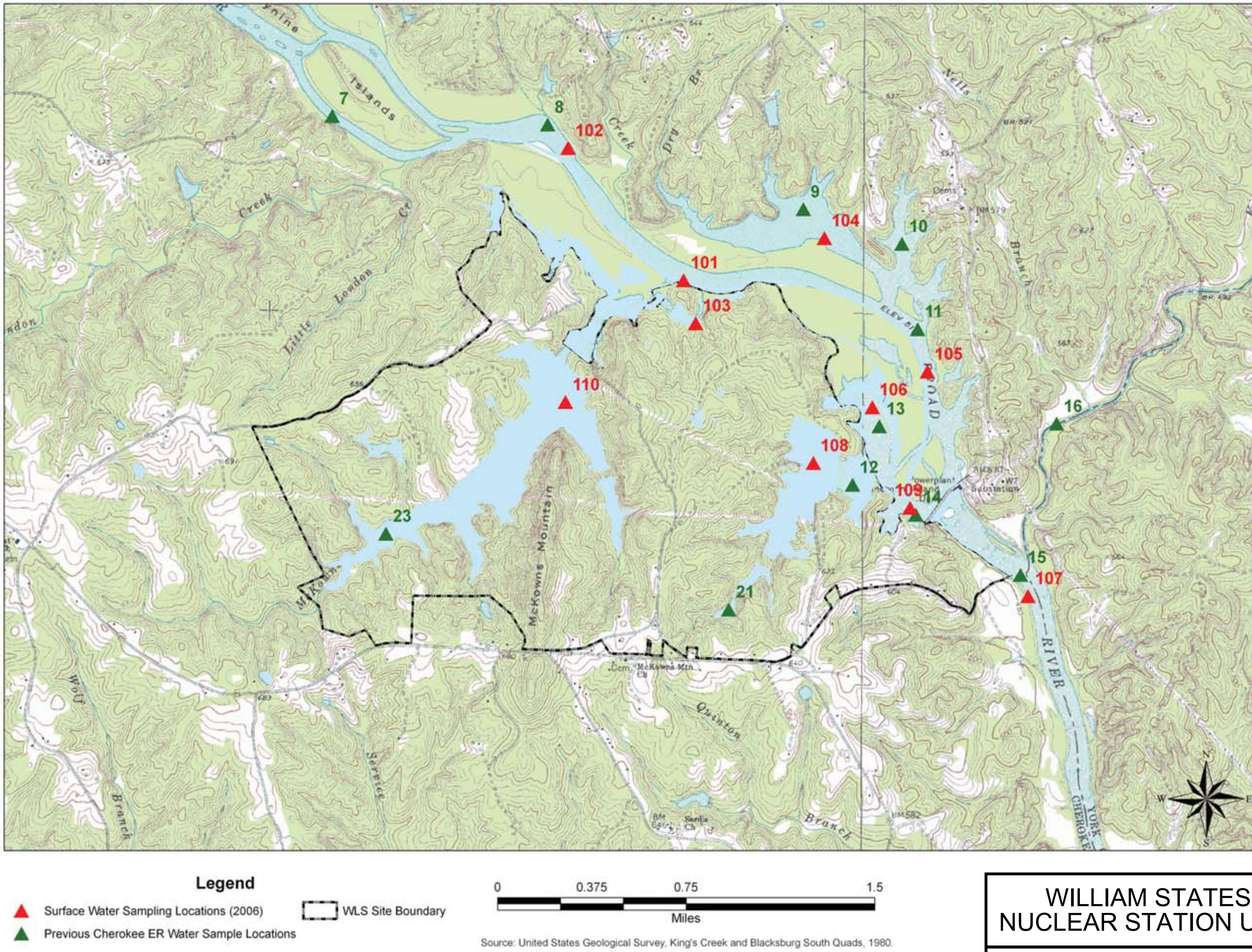

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Surface Water
Sampling Locations

Figure A-8 Rev 0

Source: Duke Energy 2009b. Figure 2.3-21

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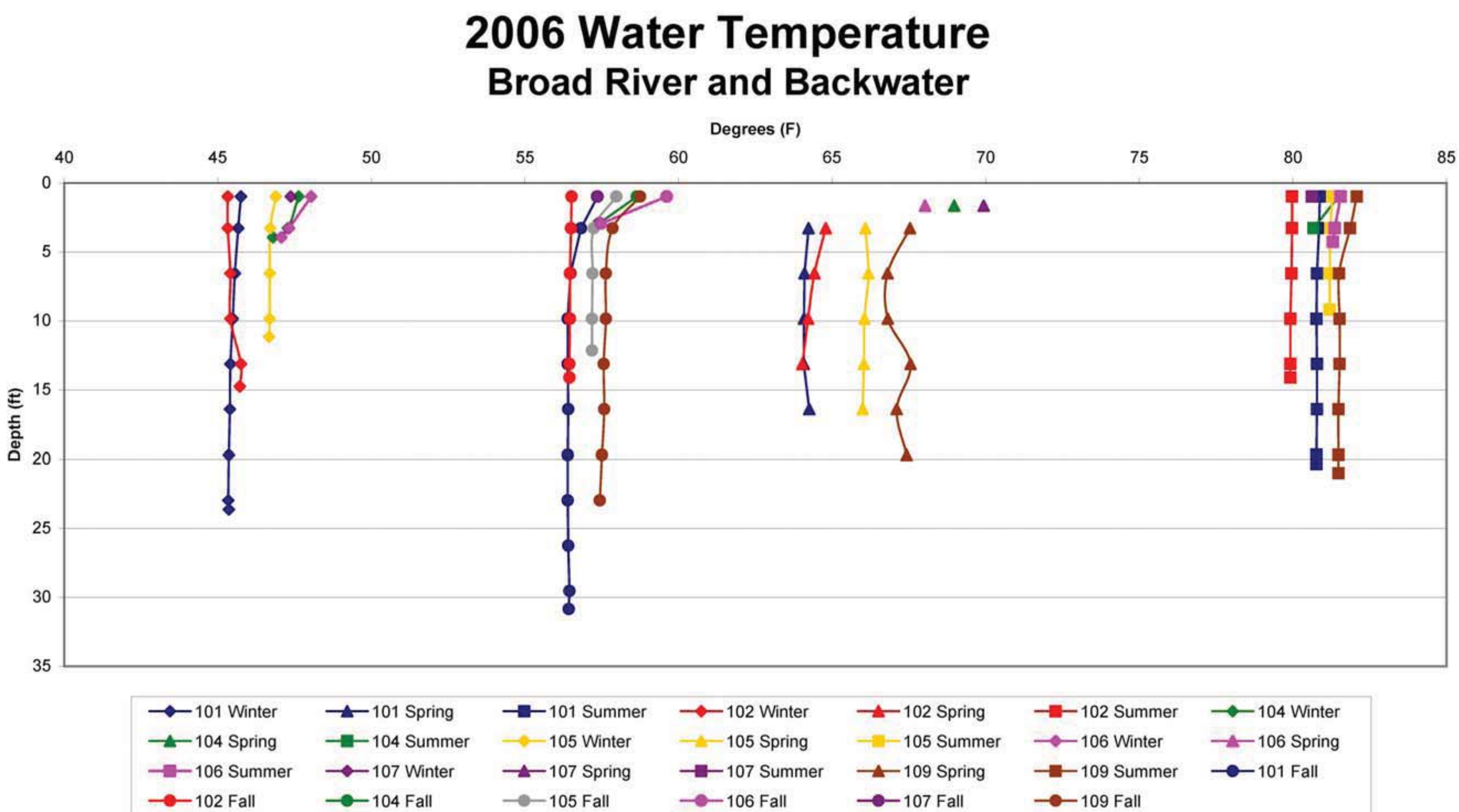

See Figure A-8 for sampling locations

Source: Duke Energy 2009b. Figure 2.3-22, Sheet 2 of 16

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Graphical Analysis of Surface Water Quality Data: Temperature

Figure A-9 Rev 0

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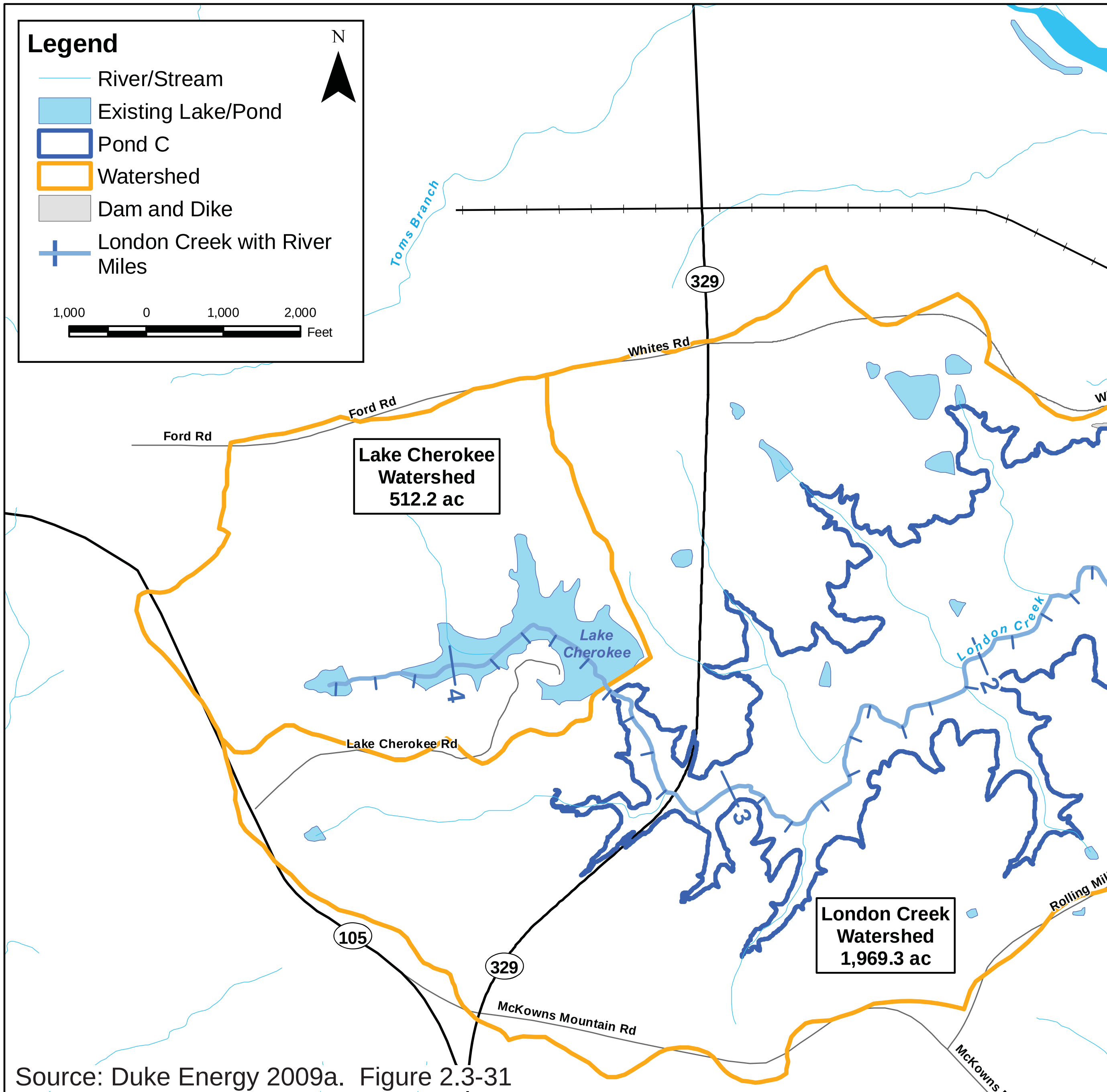

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Pond C
Watershed Including Lake Cherokee

Figure A-10

Rev 0

Source: Duke Energy 2009a. Figure 2.3-31

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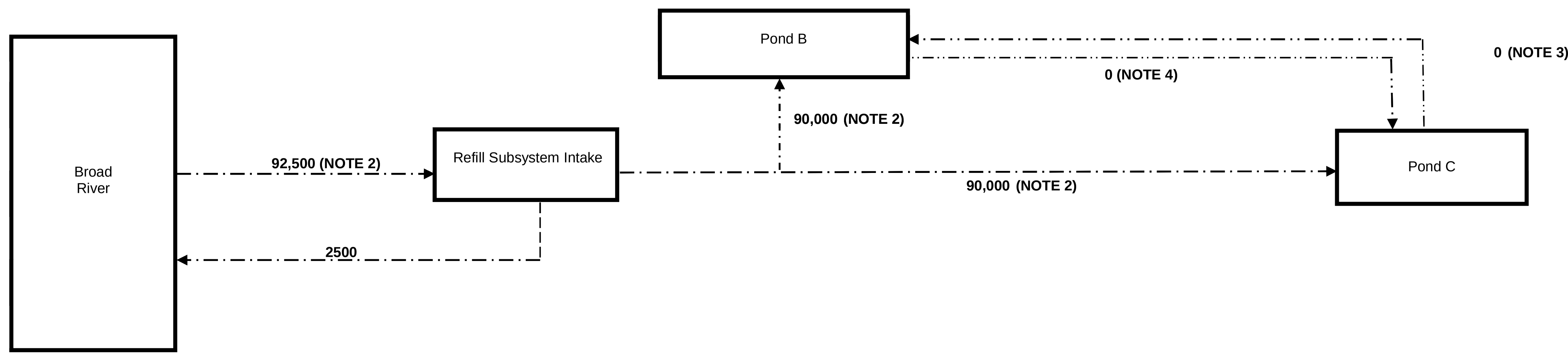

NOTES:

1. All FLOW RATES SHOWN IN GPM.

2. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER MAY BE DRAWN FROM THE BROAD RIVER AND PUMPED INTO POND B AND /OR C TO RESTORE WATER LEVEL.

3. DURING LOW FLOW CONDITIONS WATER (30,000 gpm) WILL BE DRAWN FROM POND C AND PUMPED INTO POND B TO RESTORE LEVEL.

4. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER (6,000 gpm) MAY BE DRAWN FROM POND B AND PUMPED INTO POND C TO RESTORE WATER LEVEL.

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

NPDES Flow Schematic
Sheet 2 of 2
Figure A-11

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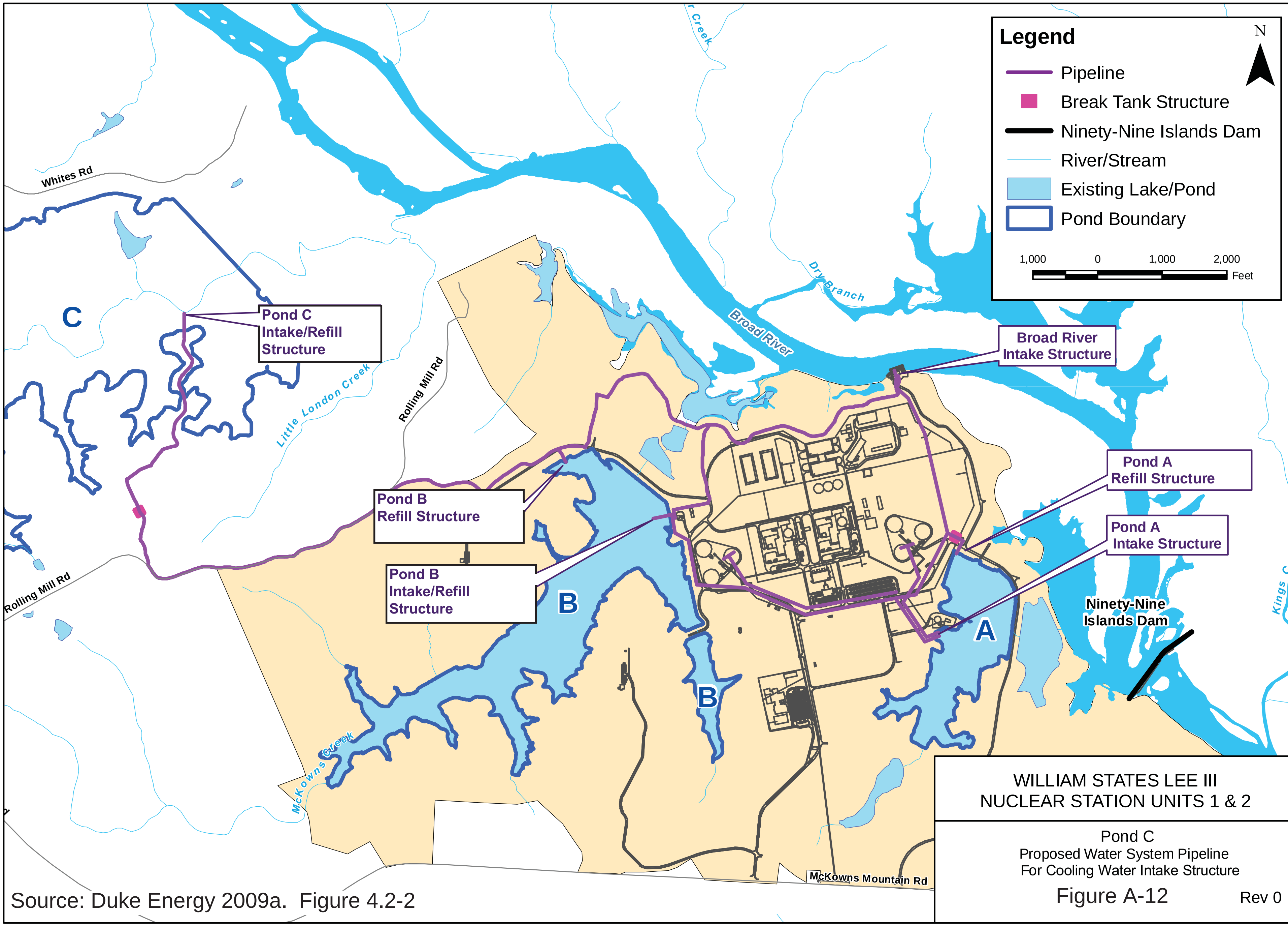

Source: Duke Energy 2009a. Figure 4.2-2

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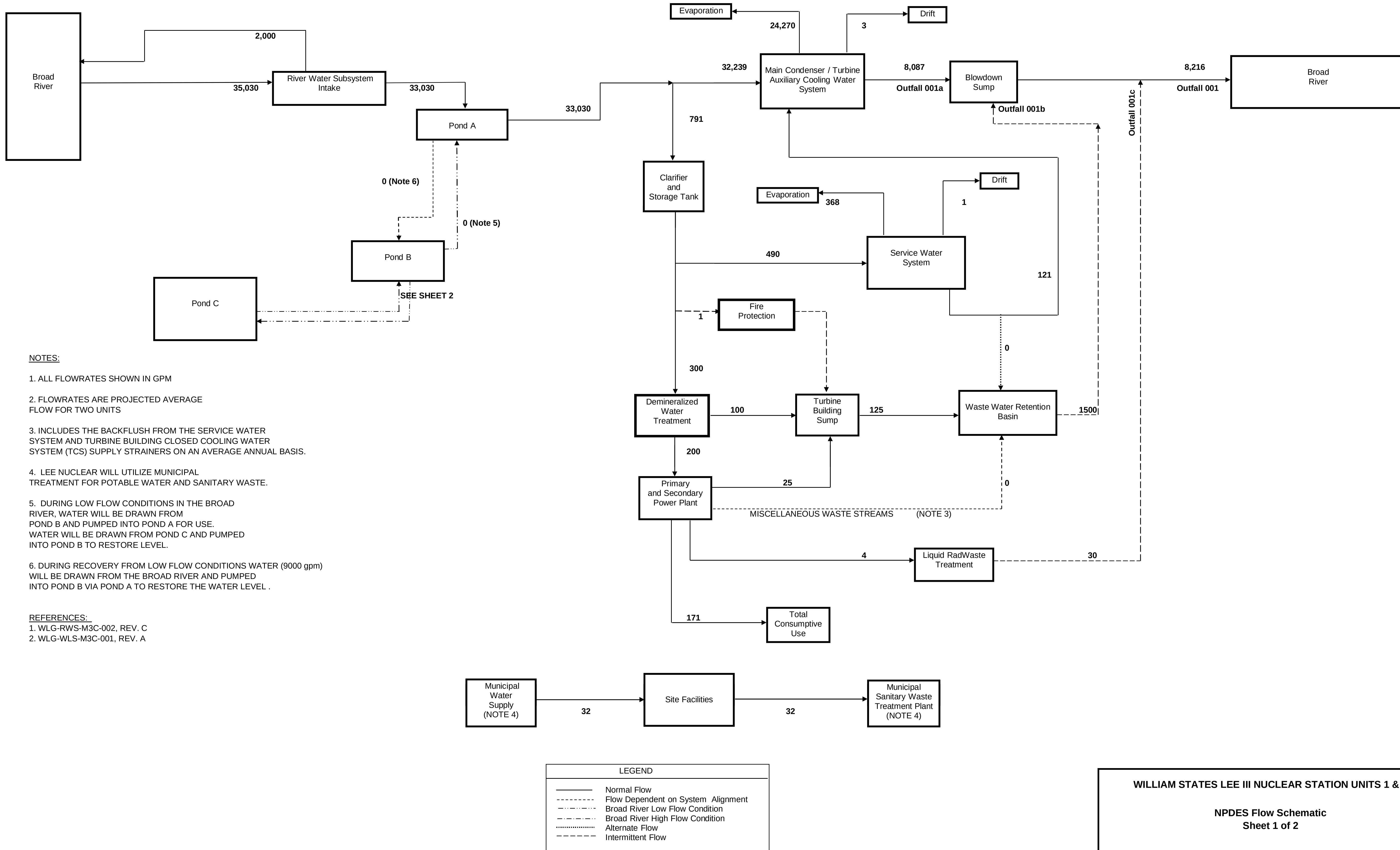

NOTES:

1. ALL FLOWRATES SHOWN IN GPM

2. FLOWRATES ARE PROJECTED AVERAGE FLOW FOR TWO UNITS

3. INCLUDES THE BACKFLUSH FROM THE SERVICE WATER SYSTEM AND TURBINE BUILDING CLOSED COOLING WATER SYSTEM (TCS) SUPPLY STRAINERS ON AN AVERAGE ANNUAL BASIS.

4. LEE NUCLEAR WILL UTILIZE MUNICIPAL TREATMENT FOR POTABLE WATER AND SANITARY WASTE.

5. DURING LOW FLOW CONDITIONS IN THE BROAD RIVER, WATER WILL BE DRAWN FROM POND B AND PUMPED INTO POND A FOR USE. WATER WILL BE DRAWN FROM POND C AND PUMPED INTO POND B TO RESTORE LEVEL.

6. DURING RECOVERY FROM LOW FLOW CONDITIONS WATER (9000 gpm) WILL BE DRAWN FROM THE BROAD RIVER AND PUMPED INTO POND B VIA POND A TO RESTORE THE WATER LEVEL .

REFERENCES:
1. WLG-RWS-M3C-002, REV. C
2. WLG-WLS-M3C-001, REV. A

WILLIAM STATES LEE III NUCLEAR STATION UNITS 1 & 2

NPDES Flow Schematic
Sheet 1 of 2

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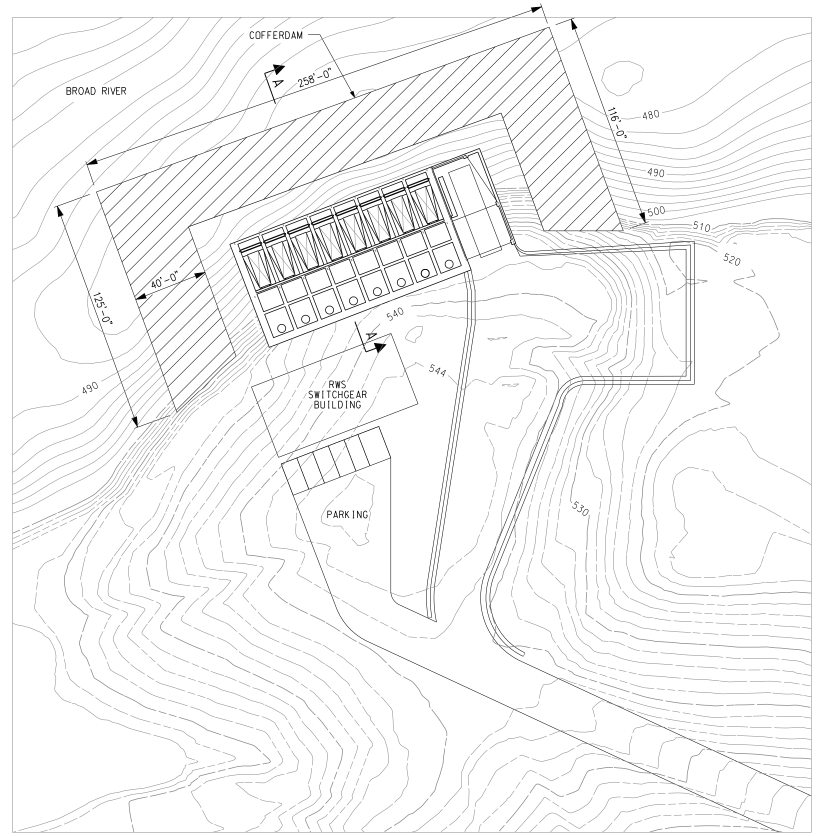
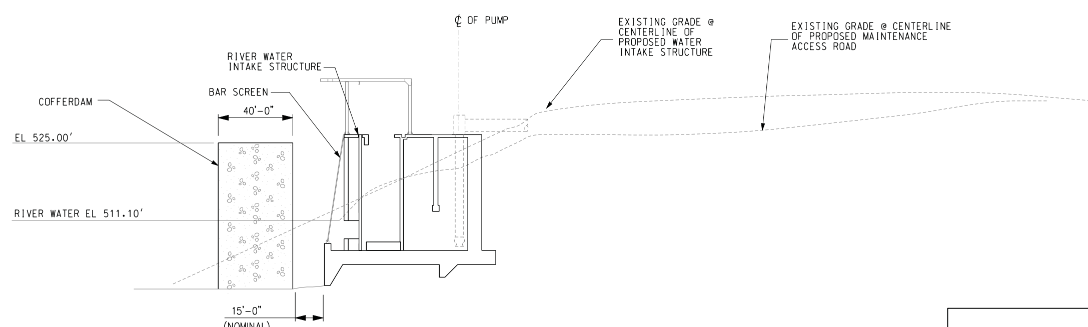
EXISTING CONDITION



PROPOSED PLAN ARRANGEMENT



SECTION A-A

COFFERDAM AND INTAKE STRUCTURE

PUMP AND PIPE OUTLINE ARE NOT TO SCALE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

River Intake Structure

Sheet 1 of 3

Figure A-14

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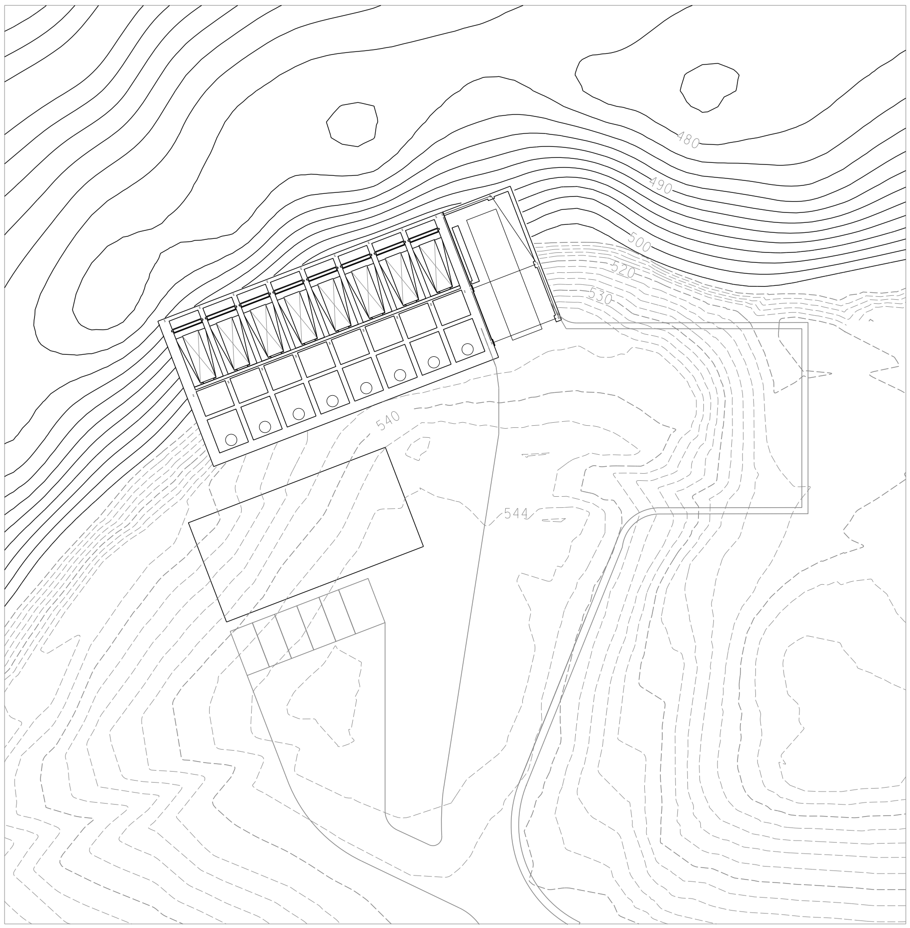

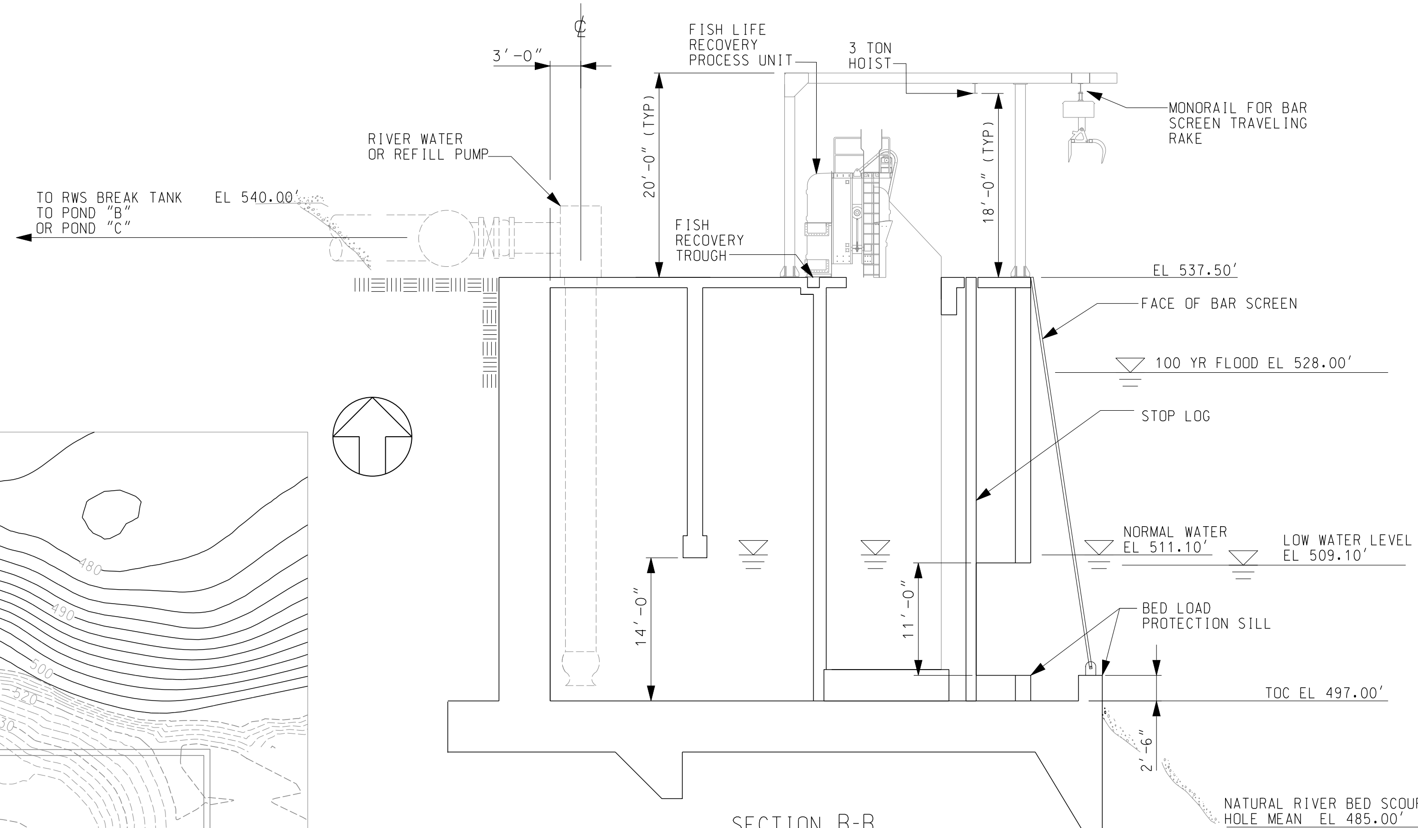

SECTION B-B

PUMP AND PIPE OUTLINE NOT TO SCALE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

River Intake Structure

Sheet 2 of 3

Figure A-15

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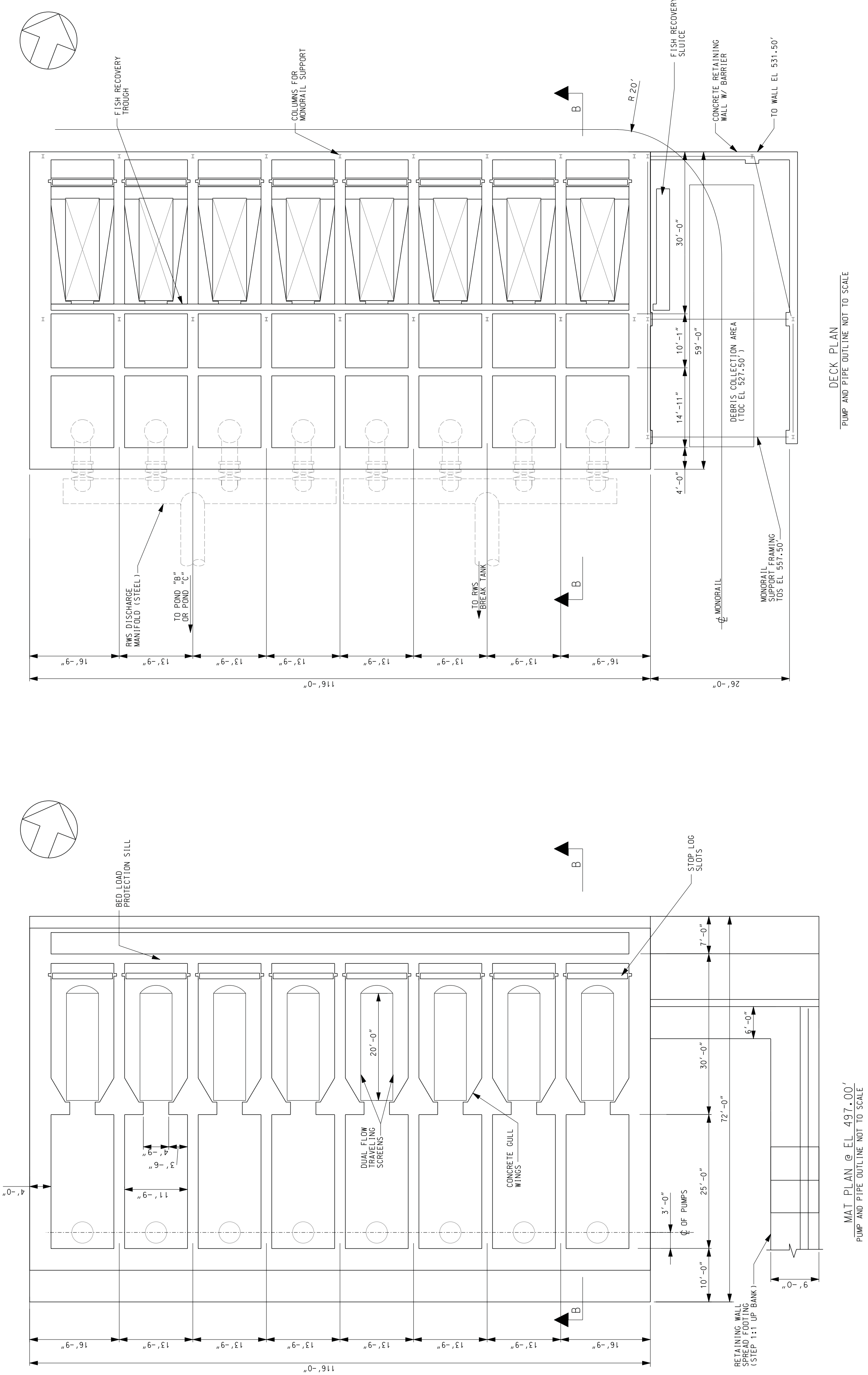

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

River Intake Structure
Sheet 3 of 3
Figure A-16

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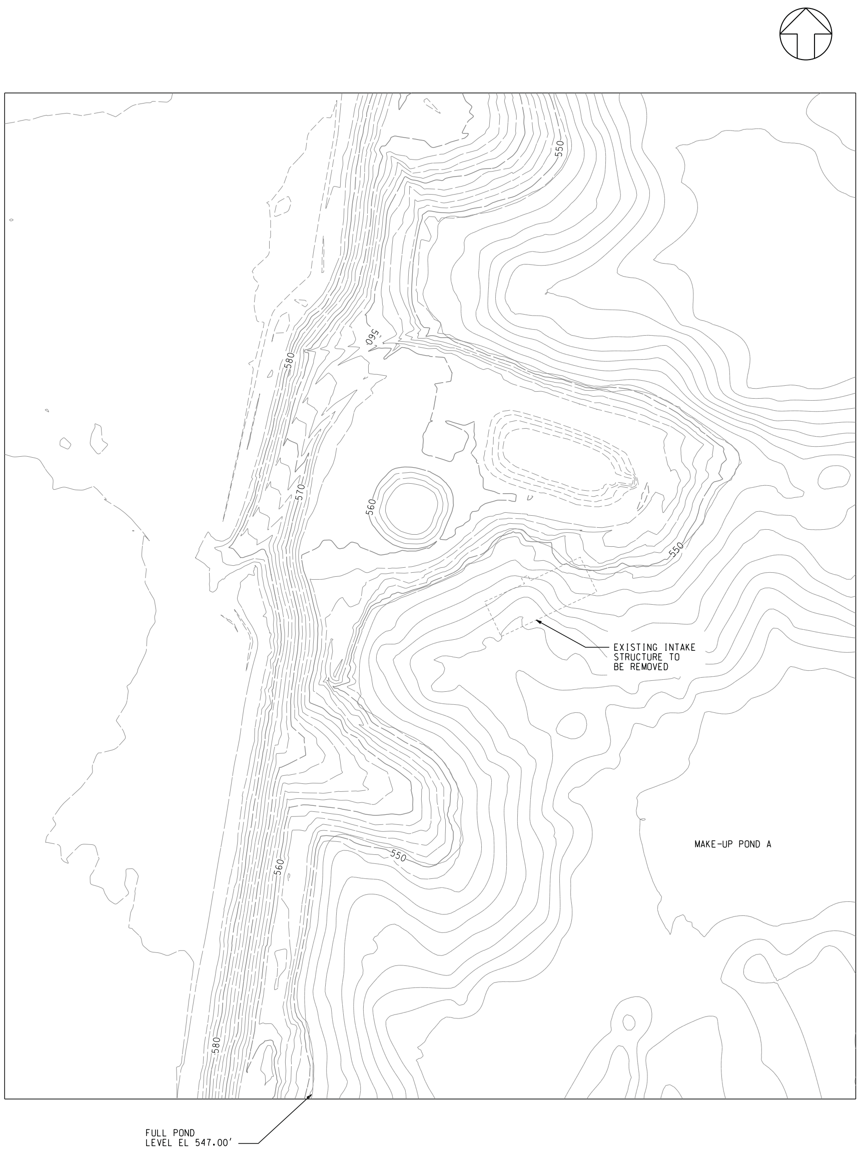

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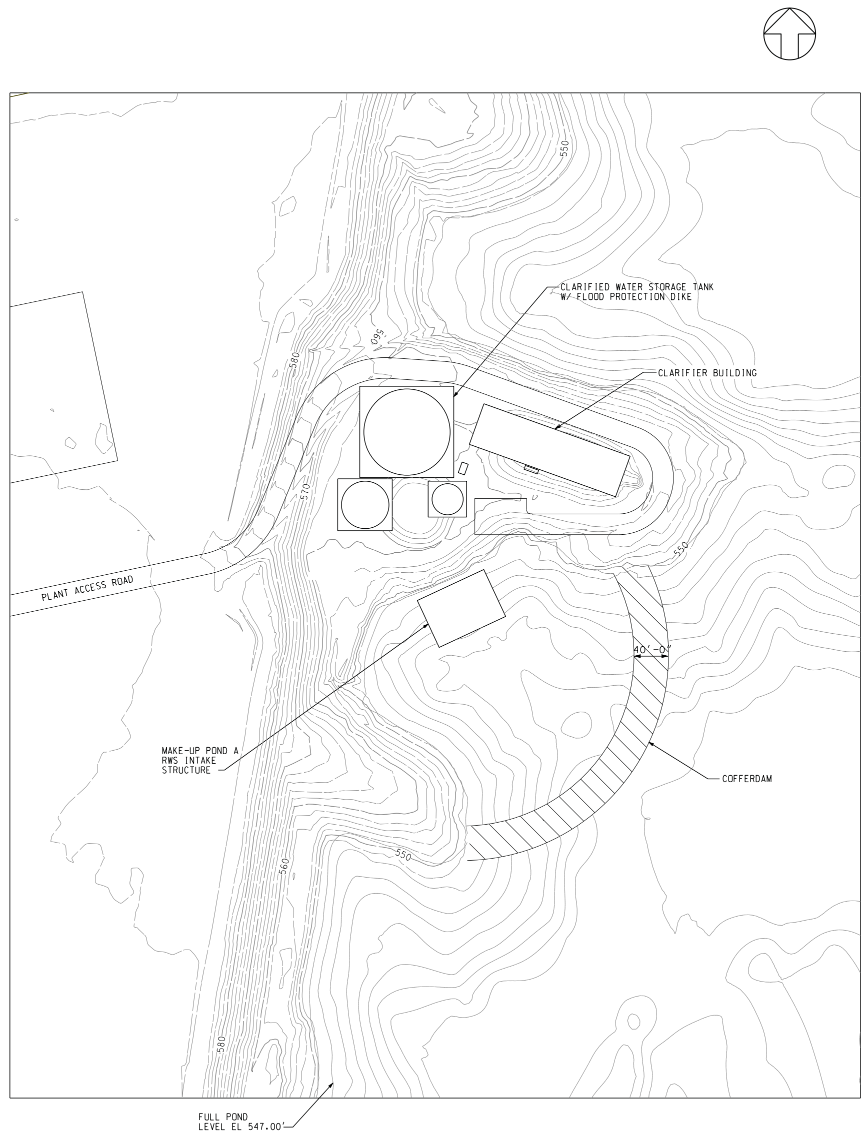

LOCATION PLAN - MAKE-UP POND A RWS INTAKE STRUCTURE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond A Intake Structure

Sheet 1 of 2

Figure A-17

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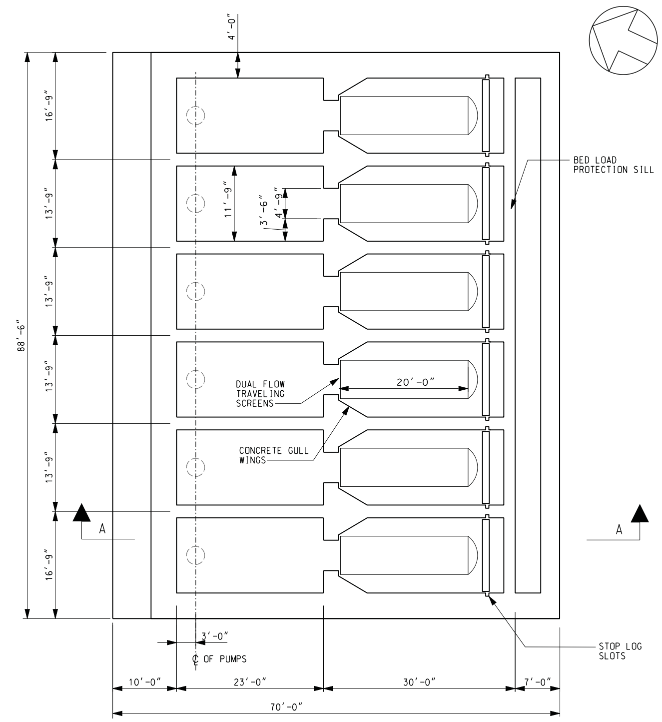
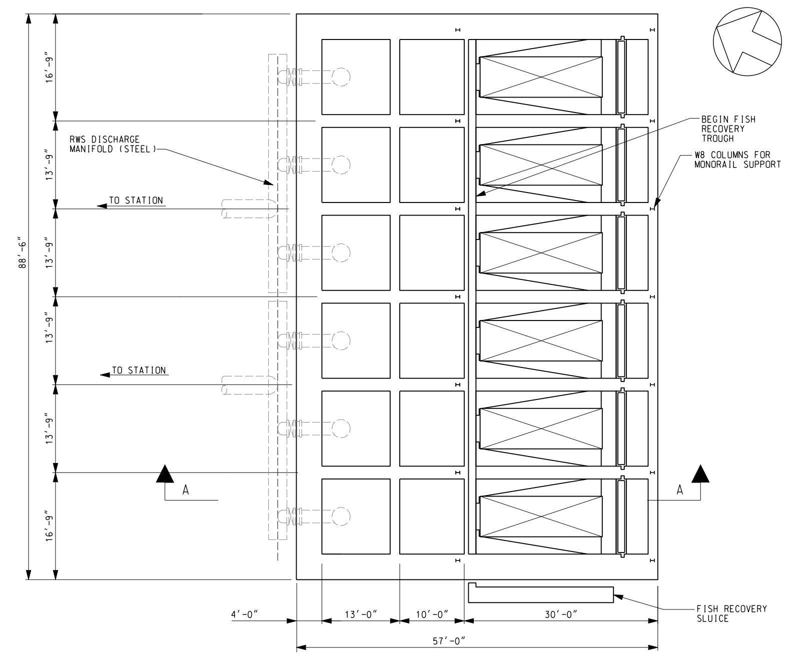


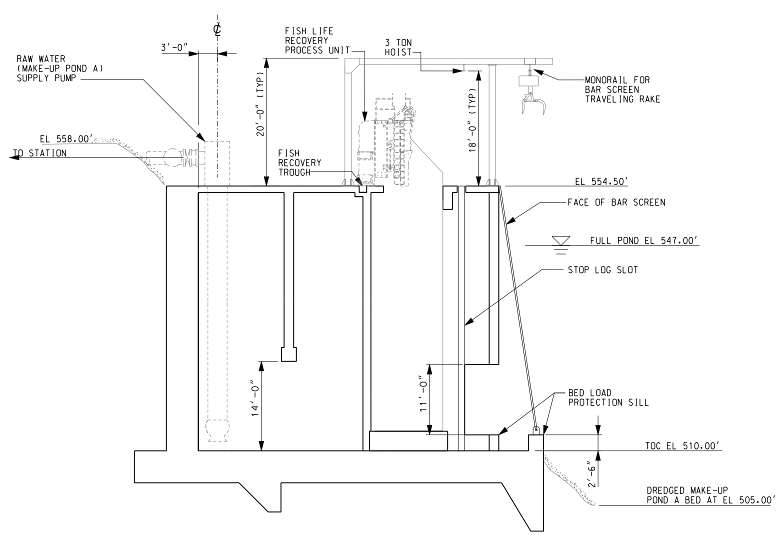
MAT PLAN @ EL 510.00'

PUMP AND PIPE OUTLINE ARE NOT TO SCALE



DECK PLAN

PUMP AND PIPE OUTLINE ARE NOT TO SCALE



SECTION A-A

PUMP AND PIPE OUTLINE ARE NOT TO SCALE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond A Intake Structure

Sheet 2 of 2

Figure A-18

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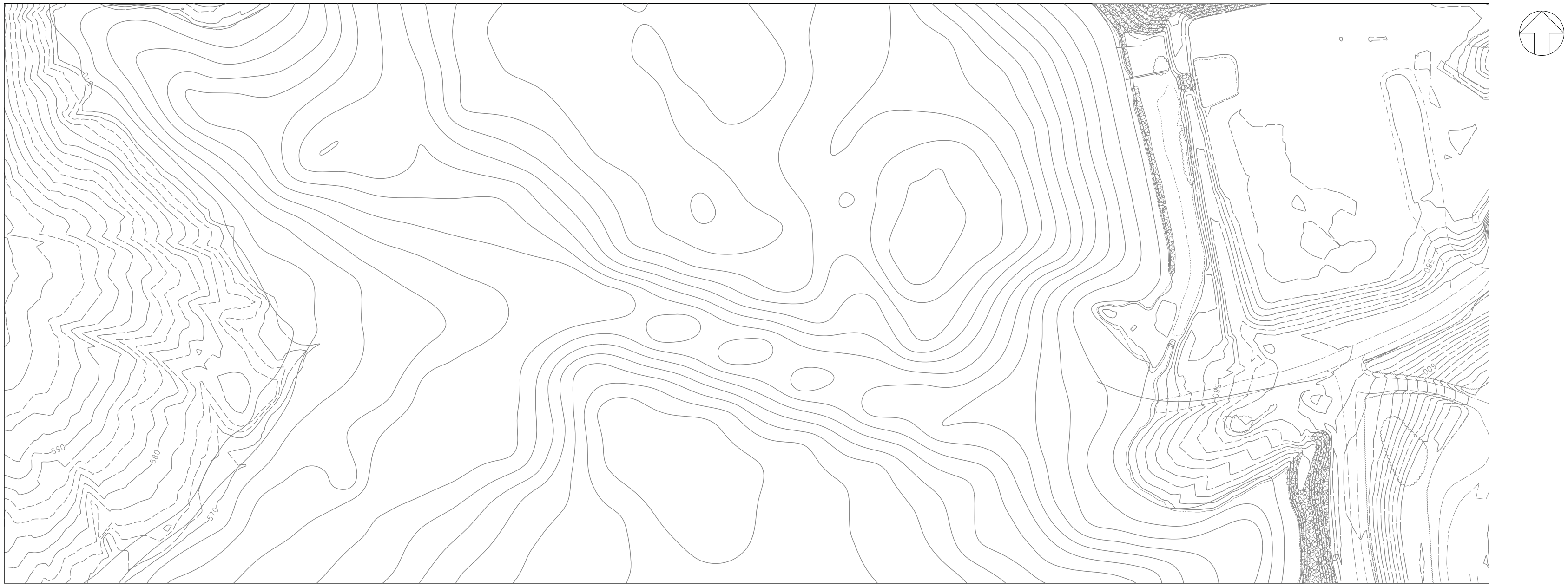
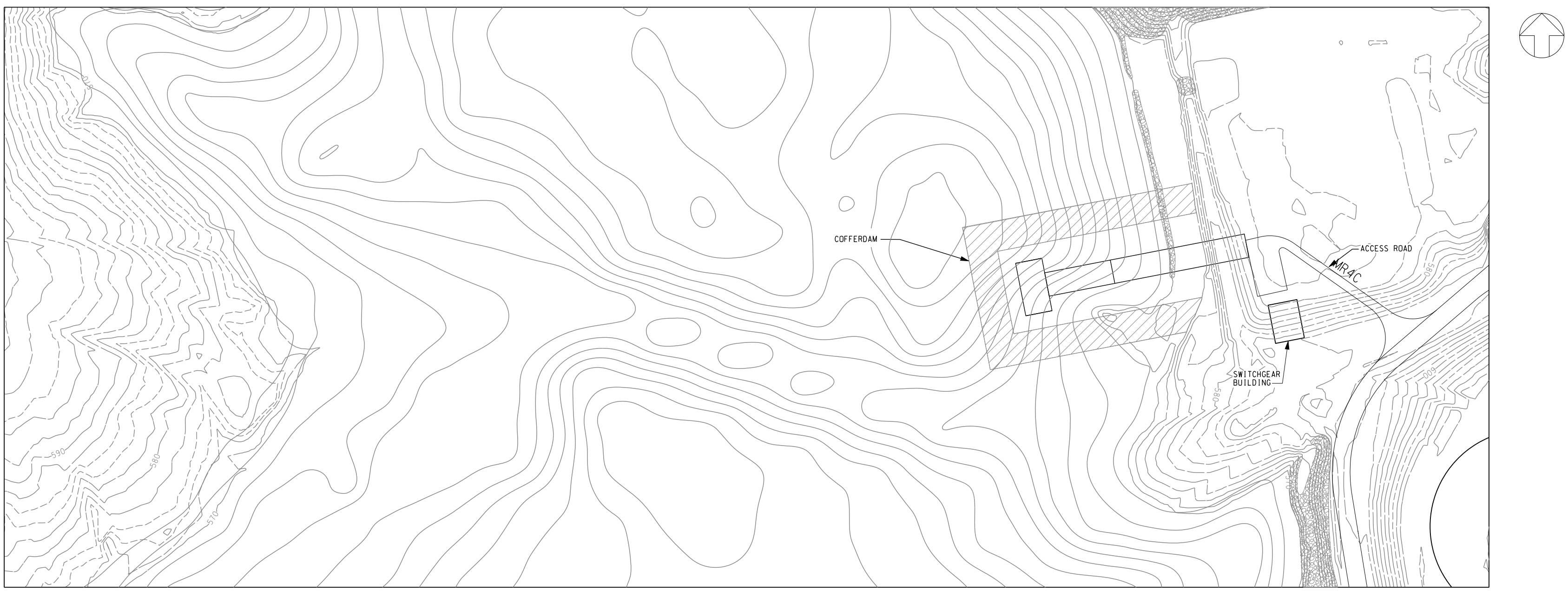


EXISTING CONDITION



MAKE-UP POND B INTAKE STRUCTURE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond B Intake Structure
Sheet 1 of 3
Figure A-19

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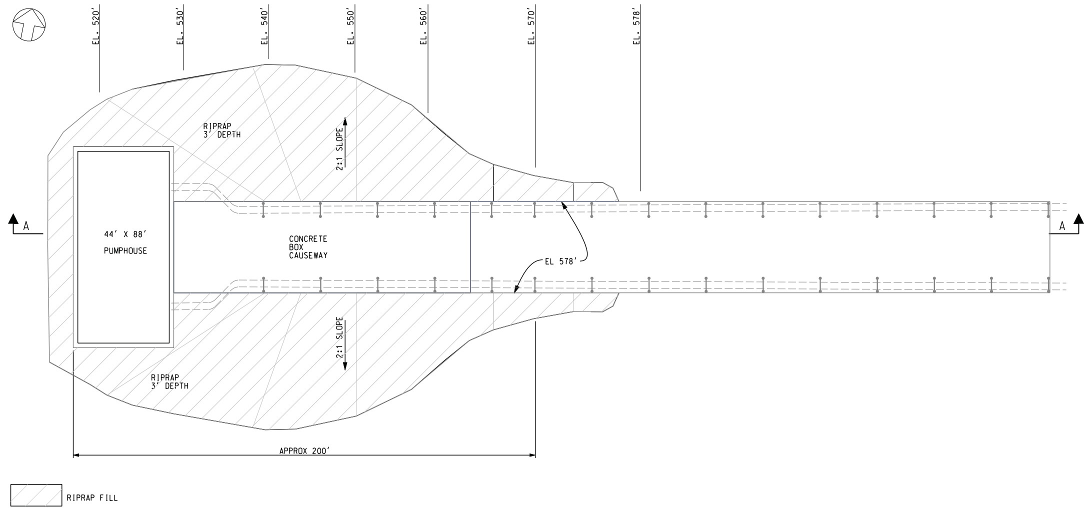
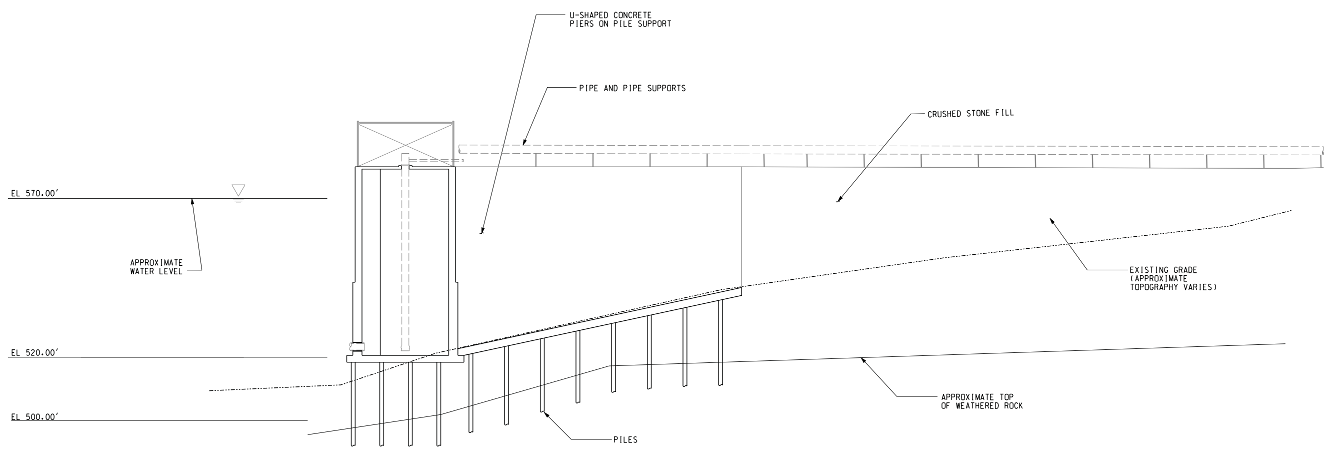


MAKE-UP POND B INTAKE STRUCTURE PLAN
PUMP AND PIPE OUTLINE ARE NOT TO SCALE



MAKE-UP POND B INTAKE STRUCTURE SECTION A-A
PUMP AND PIPE OUTLINE ARE NOT TO SCALE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond B Intake Structure
Sheet 2 of 3
Figure A-20

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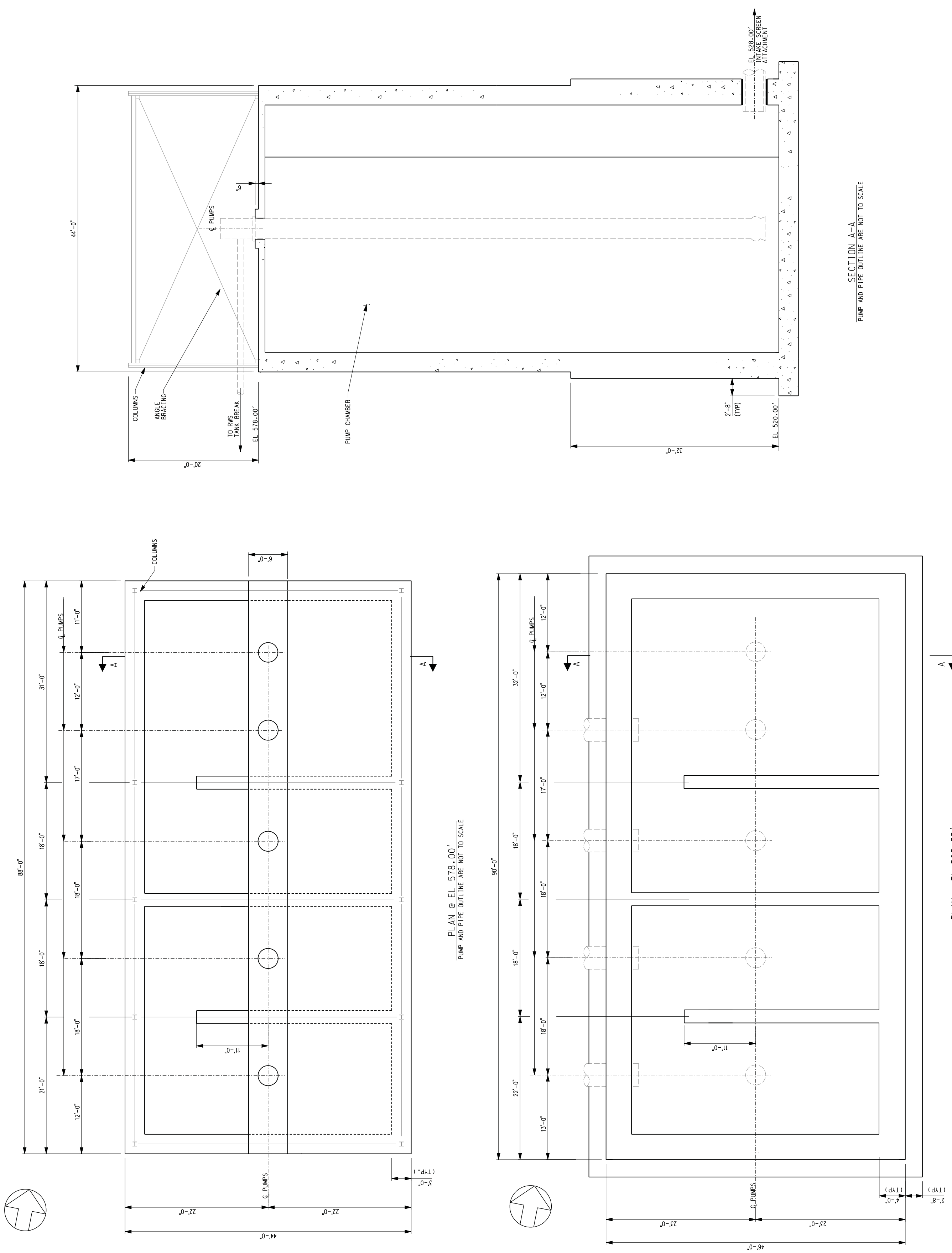

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond B Intake Structure
Sheet 3 of 3
Figure A-21

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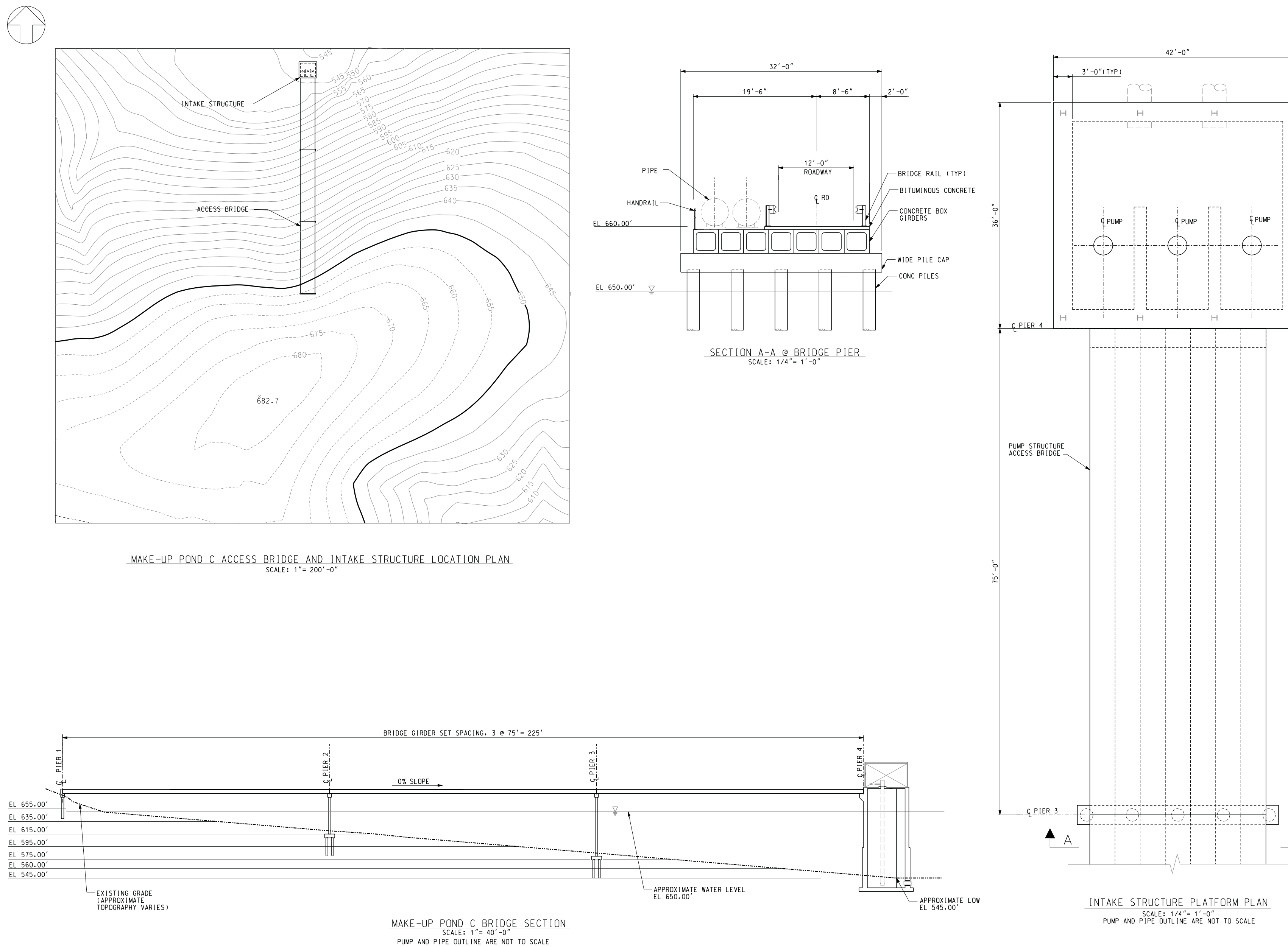

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond C Intake Structure
Sheet 1 of 2
Figure A-22

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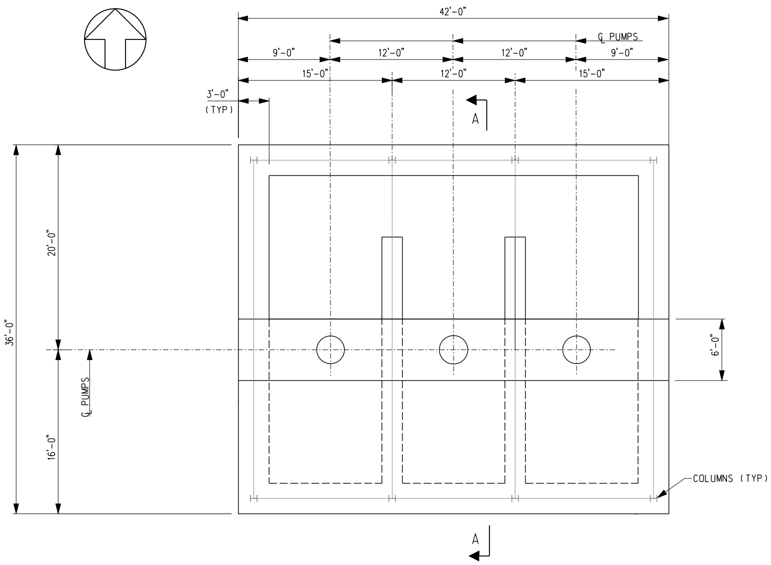
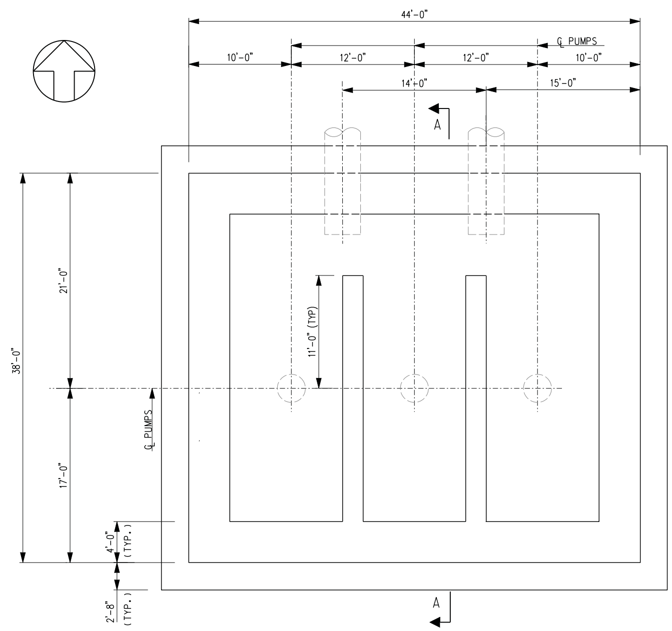


PLAN @ EL 660.00'
PUMP AND PIPE OUTLINE ARE NOT TO SCALE



PLAN @ EL 550.75'
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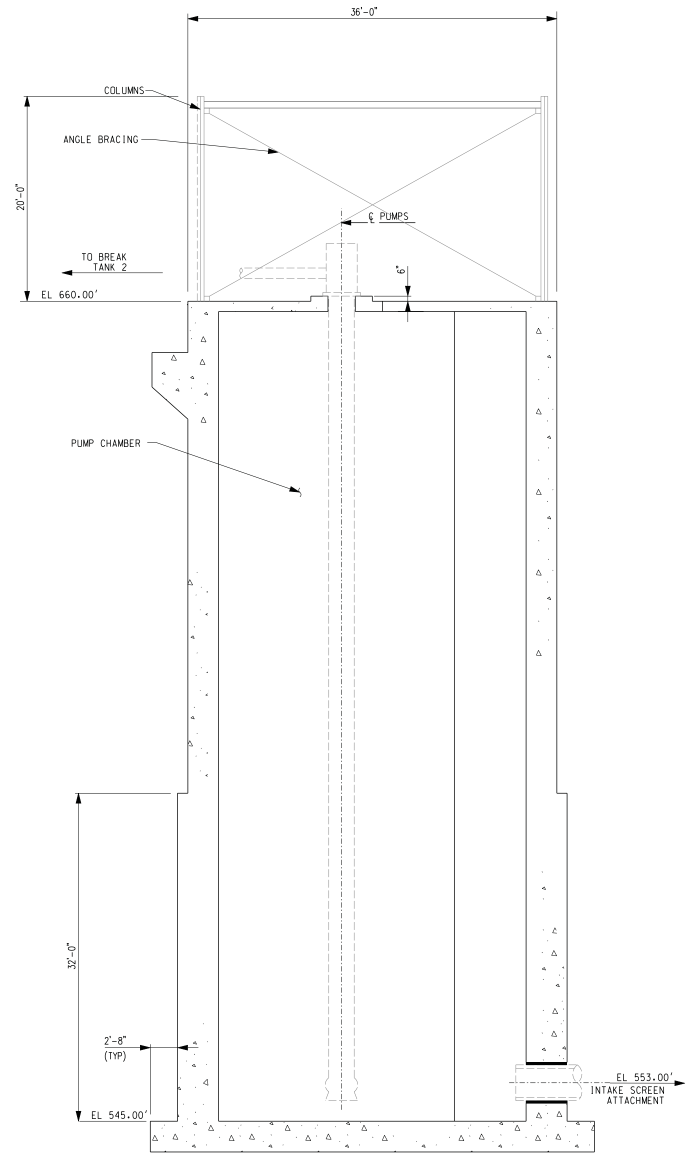

SECTION A-A
PUMP AND PIPE OUTLINE ARE NOT TO SCALE

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 AND 2

Pond C Intake Structure
Sheet 2 of 2
Figure A-23

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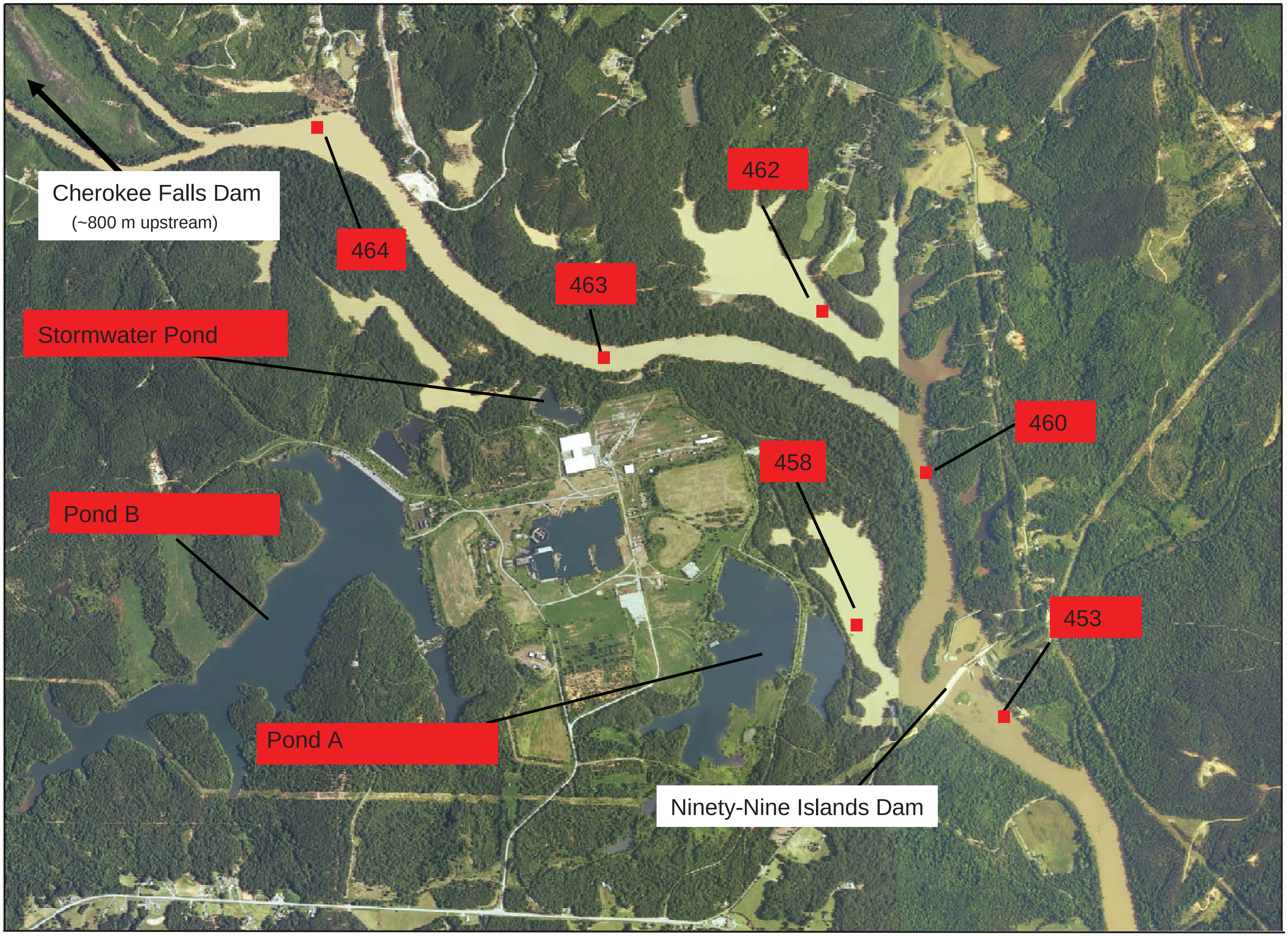
Figure A-24. Fishery Sampling Locations



Source: Barwick, D.H., D.J. Coughlan, G.E. Vaughan, B.K. Baker and W.R. Doby. 2006. Figure 1

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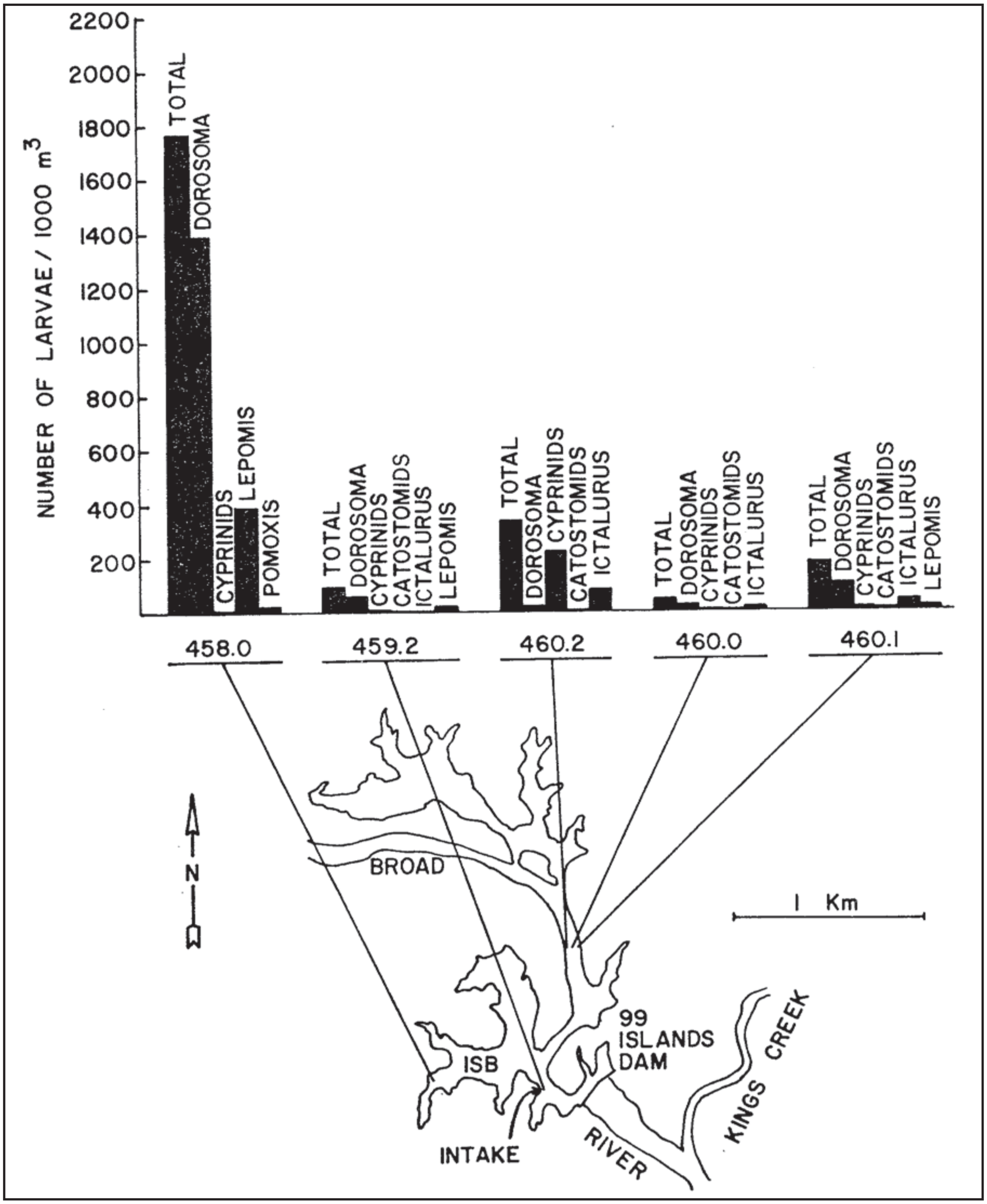
Figure A-25. Ichthyoplankton Sampling Locations, 1976



Source: Cloutman and Edwards, 1977. Figure 1.

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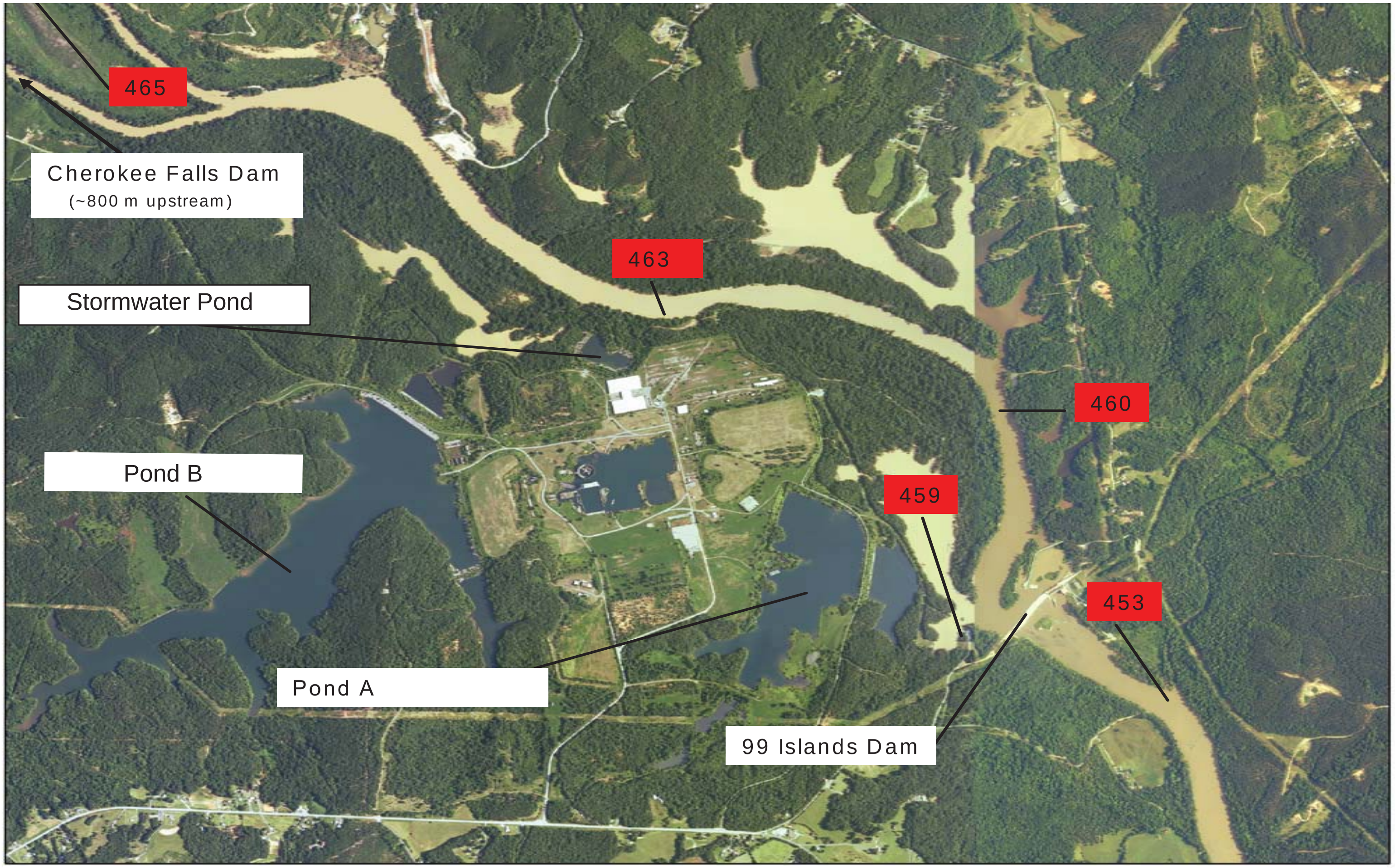
Figure A-26. Macroinvertebrate Sampling Locations



Source: Derwort, J.E. and S.F. McCorkle. 2006. Figure 1.

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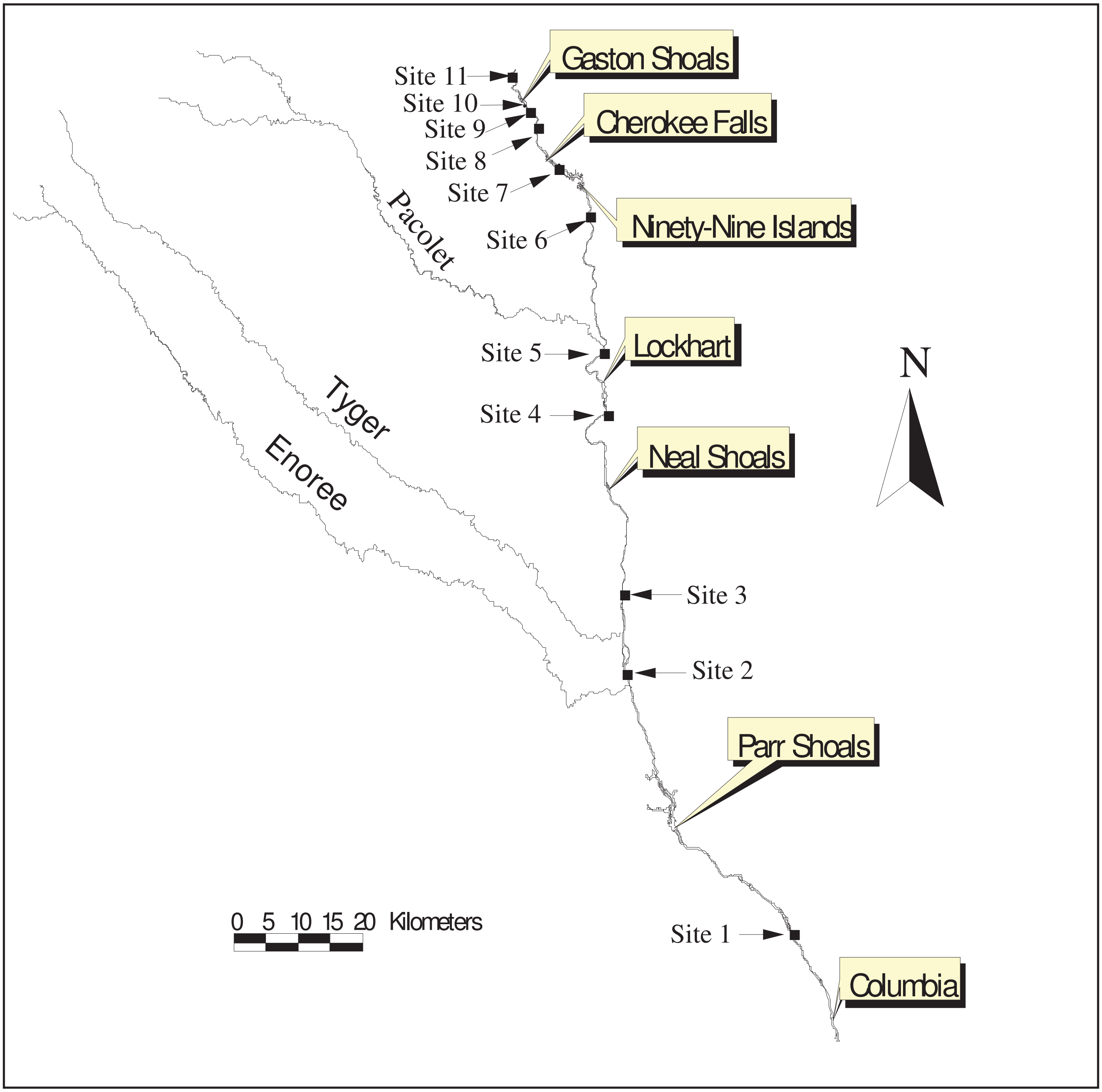
Figure A-27. Sites sampled during the Broad River fisheries inventory, October 2000- June 2002



Source: Bettinger et al. 2003. Figure 1

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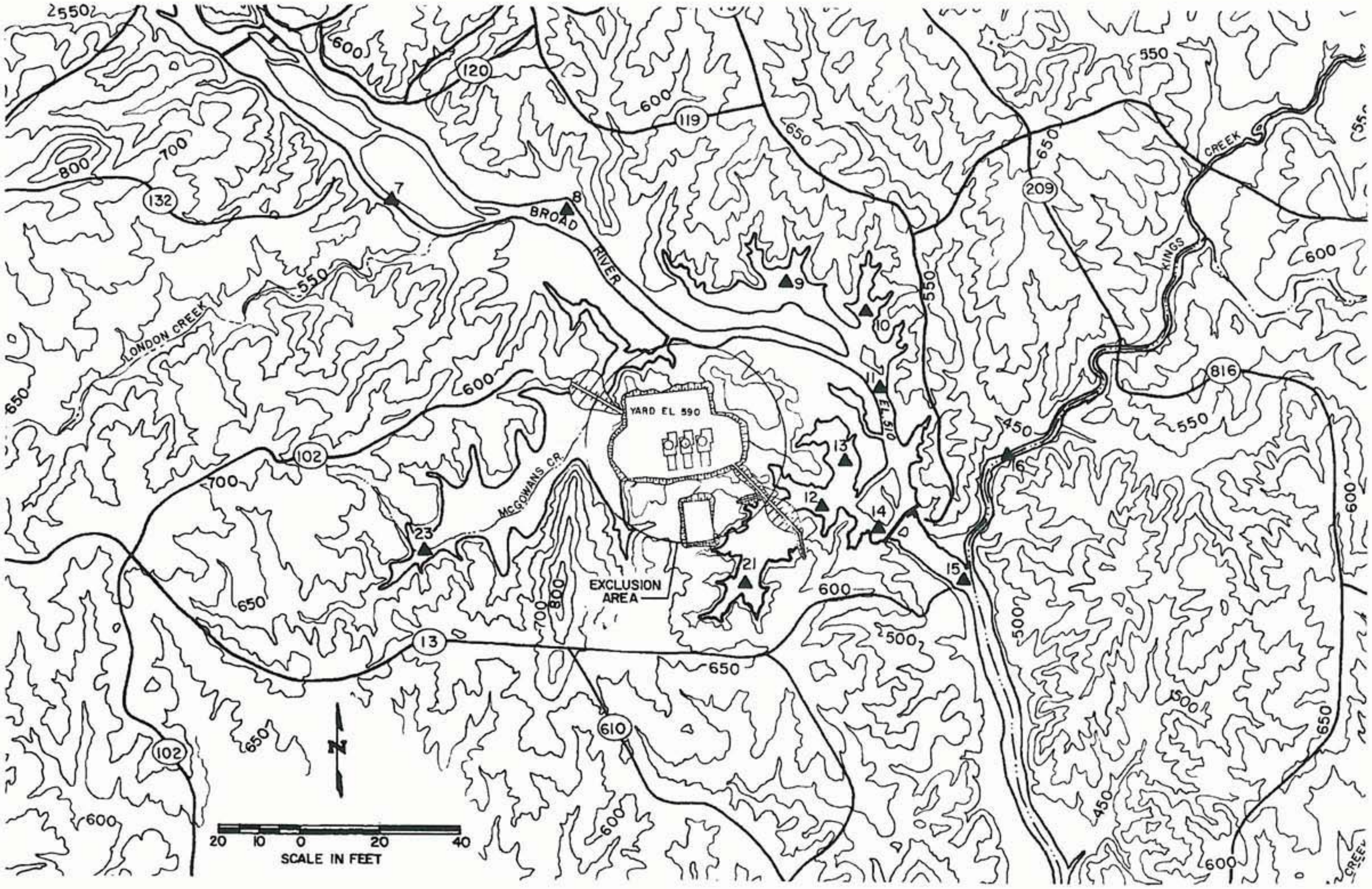
Figure A-28. Locations of Aquatic Sampling Stations in the Site Area



Source: Duke Power 1975. Figure 1.1-2

CHEROKEE NUCLEAR STATION

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Attachment A.1

Threatened and Endangered Species Correspondence

United States Department of the Interior

FISH AND WILDLIFE SERVICE
176 Croghan Spur Road, Suite 200
Charleston, South Carolina 29407

August 22, 2007

Mr. Theodore Bowling
Duke Energy
EC09D / P.O. Box 1006
Charlotte, NC 28201-1006

Re: Duke Energy, Cherokee Project
Cherokee, South Carolina
FWS Log No: 2006-I-0530

Dear Mr. Bowling:

The U.S. Fish and Wildlife Service (Service) has reviewed your letter requesting concurrence on your threatened and endangered species determination. The proposed project would involve construction and operation of a nuclear power generation facility in Cherokee County, South Carolina. The following comments are provided in accordance with section 7 of the Endangered Species Act (Act), as amended (16 U.S.C. 1531-1543).

Based on species occurrence records contained in the Heritage Trust database and Service files, and the information provided in your consultation request, we concur with your conclusion that there are no federally threatened or endangered species on the proposed site that would be impacted by the construction or operation of the Lee Nuclear Station. In view of this, the Service believes that the requirements of Section 7 of the Act have been fulfilled relative to the proposed action, and no further consultation is necessary at this time. However, obligations under Section 7 of the Act must be reconsidered if: (1) new information reveals that the proposed project may affect listed species in a manner or to an extent not previously considered, (2) the proposed project is subsequently modified to include activities which were not considered during this consultation; or (3) new species are listed or critical habitat designated that might be affected by the proposed project.

Your letter indicates an Environmental Report to evaluate the potential impacts to trust resources from project construction and operation is forthcoming. The Service looks forward to review and comment of the environmental analysis pursuant to the National Environmental Policy Act (42 U.S.C.§ 4321 et seq.). Until the issuance of the Environmental Report, we reserve the opportunity to submit comments regarding potential impacts to migratory fishes and aquatic

resources, in accordance with the Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661-667e).

Your interest in ensuring the protection of endangered species is appreciated. If you have further questions or require additional information, please contact Lora Zimmerman of this office at (843) 727-4707 ext. 226. In future correspondence concerning this project, please reference FWS Log No. 2006-I-0530.

Sincerely,

Timothy N. Hall
Field Supervisor

TNH/LLZ

NN 4000.35-05
000252

South Carolina Department of
Natural Resources

John E. Frampton
Director
Alfred H. Vang
Deputy Director for
Land, Water & Conservation Division

April 14, 2006

Mr. Theodore Bowling, Environmental Report Project Manager
Duke Energy
526 S. Church St.
Charlotte, NC 28202

RE: Duke Energy, Cherokee Project
Request for Information on Rare, Threatened, and Endangered Species (Response)

Dear Mr. Bowling,

Because our database does not represent a comprehensive biological inventory of the state, I can only verify the known occurrences in the vicinity of your project. There may be occurrences of species in the vicinity of your project area that have not been reported to us. Fieldwork remains the responsibility of the investigator.

I have checked our database, and there are no known occurrences of any federally or state listed species within a mile of the project site. As you indicated in your letter, the only federally or state listed species known to occur in Cherokee County is the federally threatened *Hexastylis naniflora* (Dwarf-flowered heartleaf). As a professional courtesy, we ask that you acknowledge S.C. Heritage Trust as a source of information whenever you use this data in reports.

If you need additional assistance, please contact me by phone at 803/734-3917 or by e-mail at HollingJ@dnr.sc.gov.

Sincerely,

Julie Holling

Julie Holling, Data Manager
SC Department of Natural Resources
Heritage Trust Program

Attachment A.2

Earlier Studies Used To Support The Baseline Biological Characterization 40 CFR § 122.21(r)(4)(viii)

PHASE I DEMONSTRATION
UNDER § 316(b) FOR
WILLIAM S. LEE III NUCLEAR STATION

ATTACHMENT A.2
EARLIER STUDIES USED TO SUPPORT THE BASELINE BIOLOGICAL CHARACTERIZATION
40 CFR § 122.21(r)(4)(viii)

Prepared for:

Duke Energy Carolinas, LLC
526 South Church Street
Charlotte, North Carolina 28202-1802

Prepared by:

AKRF, Inc.
7250 Parkway Drive
Hanover, Maryland 21076

July 31, 2010
(rev. February 10, 2011)

Contents

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ATTACHMENT A.2
EARLIER STUDIES USED TO SUPPORT THE BASELINE BIOLOGICAL CHARACTERIZATION
40 CFR 122.21(r)(4)(VIII)

I. CHEROKEE NUCLEAR STATION ENVIRONMENTAL REPORT, DUKE POWER, 1975

This document supplements the information presented in Appendix A, subsection 1.2.14, of Duke Energy Carolinas, LLC's (Duke Energy), William S. Lee III Nuclear Station (Lee Nuclear Station) Clean Water Act § 316(b) Compliance Demonstration. In particular it provides the detailed information required to be submitted pursuant to 40 CFR § 122.21(r)(4)(viii) for those studies conducted prior to 2006. They include:

- Cherokee Nuclear Station Environmental Report, Duke Power, 1975;
- Evaluation of potential entrainment at Cherokee Nuclear Station; and
- Broad River Aquatic Resources Inventory Completion Report. Comprehensive Entrainment Mitigation and Fisheries Resource Program.

Duke Energy conducted both macroinvertebrate and fish sampling in connection with the site assessment for its former Cherokee Nuclear Station.

A. Description of All Methods and Quality Assurance Procedures for Sampling and Data Analysis

Benthic macroinvertebrate sampling initially occurred at 23 stations from October 1973 through May 1974 (Duke Power 1975). However, six locations (9–14) (Figure A-8, Duke Energy 2009 [Figure 2.4-3]), sampled from October 1973 through March 1974, provide the background macroinvertebrate data for the Ninety-Nine Islands Reservoir. In addition, background macro-invertebrate data were collected at locations upstream and downstream of the Ninety-Nine Islands Reservoir by sampling locations 8 and 15, respectively (Figure A-8, Duke Energy 2009 [Figure 2.4-3]). Monthly sampling was also performed from September 1974 through November 1975, followed by quarterly sampling from winter 1976 to spring 1977 (Duke Power 1978). Four sampling devices were used in the sampling of benthos. Two modifications of the Ekman grab were employed in soft substrates: a 9-inch model for deep water and a 6-inch, pole-mounted version in shallow water. A heavier Ponar grab was used on hard-packed sand and in fast-flow stream conditions. Shallow riffles with rock or gravel substrates were sampled with a Surber square-foot sampler. A detailed description of each device can be found in Edmondson and Winberg (1971).

Samples retained by the Surber net were removed and preserved directly in 70 percent ethanol. Grab samples were washed through a Model 190 wash bucket (Wildlife Supply Company), which has a 0.516-millimeter mesh opening. Screened water was used in washing to prevent the introduction of extra organisms. Finally, water and materials that passed through the wash bucket were retained and sieved a second time. The concentrated samples were then preserved in 70 percent ethanol. In the laboratory, the preserved specimens were transferred to trays and the macroinvertebrates in them were hand-picked. The samples were then sorted to major taxa and stored again in 70 percent ethanol in labeled vials. Biomass was estimated by weighing blot-dried preserved specimens that had been rehydrated in water (Duke Power 1975). The firm of Midwest Aquatic Enterprises was retained by Duke Power Company to check several samples to confirm or revise the identifications made by Environmental Consultants, Inc. (Duke Power 1975).

Fish sampling occurred in 1973 through 1974 at 14 locations (Duke Power 1975, Table 6.1.1-1). Four different methods were used in these studies: sampling with 12- and 30-foot seines, electro fishing using a 110-volt portable electro shocker, sampling with a 300-foot trammel net, and sampling with a 15-foot hoop net. Because each method has its own sampling bias, a combination of two or more methods was used at each station. Laboratory analysis of the 1973–1974 data included species identification using several keys established in scientific literature. Trophic relations, growth, and population structure were studied by examining stomach contents of selected fishes and length-frequency distributions of specimens. Determinations of growth and population age structure were made by scale reading techniques. Sex ratios and maturity were determined by examination of gonads in selected specimens and the use of a maturity index to quantify the maturity of specimens (Duke Power 1975). Final identification of the more-difficult fish species were confirmed by Dr. E.F. Menhinick of the University of North Carolina at Charlotte.

Though specifics on the quality assurance procedures for this study are not available, Duke Energy (and its predecessors) have maintained and operated a biological laboratory employing standard operating procedures (SOPs) and rigorous quality assurance/quality control methods employed by highly trained scientists (Duke Energy 2010). The biological and chemical laboratories have been certified by both the North Carolina Department of Environment and Natural Resources (NCDENR) and South Carolina Department of Health and Environmental Control (SCDHEC) to conduct biological investigations and perform water quality analyses for as long as each agency has implemented a certification program. All biological programs conducted by Duke Energy discussed in this section have been implemented in accordance with these procedures.

B. Description of the Study Area

Six benthic macroinvertebrate locations (9–14) were sampled from October 1973 to March 1974 to provide the background data for the Ninety-Nine Islands Reservoir (Figure A-8, Duke Energy 2009 [Figure 2.4-3]). In addition, benthic macroinvertebrates were sampled at locations in the Broad

River upstream and downstream of the Ninety-Nine Islands Reservoir, which were locations 8 and 15, respectively (Figure A-8, Duke Energy 2009 [Figure 2.4-3]).

The 14 fish sampling locations (2, 4–6, 9–16, 22, and 23; Duke Power 1975, Table 6.1.1-1) ranged on the Broad River from upstream location 2 near the South Carolina Route 18 crossing over the river to location 15 below the Ninety-Nine Islands Dam at the confluence of the river with Kings Creek, and included the area of the river intake.

C. Taxonomic Identification of Sampled and Evaluated Biological Assemblages

Benthic macroinvertebrate identifications were made with standard taxonomic keys (Duke Power 1975). At least 140 species of benthic macroinvertebrates were collected; however, many of the taxa collected could not be reliably identified to the species level (Duke Power 1975, 2.7-48). For instance, 29 genera of chironomids (midges) and all the other orders of insects had individuals that could not be indentified beyond the genus level. Two abundant phyla, the Oligochaeta and Nematoda, were not taken beyond that taxonomic level. In addition, the firm of Midwest Aquatic Enterprises was retained by Duke Power Company to prepare a faunistic key to the benthic macroinvertebrates of the Piedmont Carolinas.

Fish collected were identified using keys of Eddy (1969), Moore (1968), Hubbs and Lagler (1947), Trautman (1957), and Smith-Vaniz (1968). The species collected in both the macroinvertebrate and fish collections are presented in Appendix A, subsection1.2.8 of the § 316(b) Compliance Demonstration document.

D. Sampling and Data Analysis Methods

Estimated benthic macroinvertebrate densities (in numbers per square meter) for all species (or higher taxa) sampled at each location for each time period was determined (Duke Power 1975, Table 2.7.2-14). In addition, the percent composition for all the major taxa was summarized by number and biomass (Duke Power 1975, Table 2.7.2-15). Using these data, the species composition, density, and biomass at different locations could be compared to each other and through time (i.e., different seasons).

The fish studies provided information on the seasonal patterns of abundance, distribution, and migration of fish. In addition, the average age, length and weight were presented on each sex for nine important or common fish collected from the Broad River. Also, the breeding behavior of most of the species sampled during the study was presented (Duke Power 1975, Table 2.7.2-23).

II. EVALUATION OF POTENTIAL ENTRAINMENT AT CHEROKEE NUCLEAR STATION

Ichthyoplankton sampling was conducted to evaluate the potential for entrainment.

A. Description of All Methods and Quality Assurance Procedures for Sampling and Data Analysis

Ichthyoplankton were collected with Nitex nets (560-micrometer (µm) square mesh) attached to square frames (0.5 meter on each side), which were mounted on poles 2.6 meters long. A frame designed to hold three nets simultaneously was mounted to the bow of a 4.9-meter aluminum boat. Duplicate and triplicate samples were taken at locations 458.0 and 459.2, respectively. Because of shallow water, drift samples were taken at locations, 460.0, 460.1, and 460.2. A General Oceanics flowmeter suspended across the net mouth allowed calculation of the volume of water filtered in each sample. Samples were collected during the 1976 spawning season (April through September). Surface samples were collected on an approximate weekly basis from April 7, 1976, to August 2, 1976. From August 3, 1976, to September 21, 1976, samples were taken biweekly. Sampling time was 5 minutes for each sample, and all the samples were collected at night. All samples were preserved in the field with 10 percent formalin and rose bengal dye was added to facilitate the subsequent sorting of the specimens in the laboratory.

At the laboratory, formalin and excess dye were rinsed out of each sample jar through 560 µm mesh net inserted in the jar lid. The samples were sorted in white enamel pans, fish larvae were identified, and then preserved in 40 percent isopropanol. Larval densities were extrapolated to number per 1,000 cubic meters based on the volume of water filtered in each sample.

On May 13, 1976, a diel study was conducted at all locations, except 458.0, to determine the larval fish densities over a 24-hour period. Samples were collected at 3:00 a.m. (0300 hours), 9:00 a.m. (0900), 3:00 p.m. (1500), and 9:00 p.m. (2100). Six 5-minute replicates were collected at each location during each time period.

Though specifics on the quality assurance procedures for this study are not available, Duke Energy (and its predecessors) have maintained and operated a biological laboratory employing SOPs and rigorous quality assurance/quality control methods employed by highly trained scientists (Duke Energy 2010). The biological and chemical laboratories have been certified by both the NCDENR and SCDHEC to conduct biological investigations and perform water quality analyses for as long as each agency has implemented a certification program. All biological programs conducted by Duke Energy discussed in this section have been implemented in accordance with these procedures.

B. Description of the Study Area

Five locations were sampled for ichthyoplankton (Cloutman and Edwards 1977, Figure 1; Figure A-25). Location 459.2 (proposed intake site) was located in the Broad River approximately 200 meters upstream from the Ninety-Nine Islands Dam. Locations 460.0 (mid-channel), 460.1 (left bank facing downstream), and 460.2 (right bank facing downstream) were located approximately 0.6 mile (0.9 kilometer) upstream from location 459.2. Location 458.0 was in the west backwater of the Ninety-Nine Islands Reservoir.

C. Taxonomic Identification of Sampled and Evaluated Biological Assemblages

Fish larvae were identified to the lowest practicable taxon. Carp, largemouth bass, and Piedmont darter were identified to species, while shad and crappie were identified to genus, and minnows excluding carp, suckers, and sunfish were identified to family.

D. Sampling and Data Analysis Methods

Friedman's randomized block analysis of variance of ranks was used to determine whether significant differences in larval fish densities occurred among the different locations throughout the spawning season or time of day for the diel samples. A non-parametric Student-Newman Keuls multiple range test was performed to determine at which times the densities were significantly different.

III. BROAD RIVER AQUATIC RESOURCES INVENTORY COMPLETION REPORT: COMPREHENSIVE ENTRAINMENT MITIGATION AND FISHERIES RESOURCE PROGRAM

A. Description of All Methods and Quality Assurance Procedures for Sampling and Data Analysis

Two years of fish community data were collected in the Broad River between winter 2001 and spring 2002. Boat electrofishing consisted of sampling at least three transects at each location: at least one transect along each bank in pool habitat and one mid-channel transect in glide/run habitat. During the winter, each shoreline transect received 10 minutes of continuous electrofishing effort in a downstream direction. During other seasons, the length of shoreline was fixed at 150 meters and shocked in an upstream direction. Electrofishing was performed at 60 pulses per second and varying the voltage to obtain 3.5–4.0 amps of output.

Otoliths were collected during the spring to assess the age and growth of representative species (largemouth bass, smallmouth bass, redbreast sunfish, and redear sunfish).

Data collected from boat electrofishing were used to calculate relative abundance, relative biomass by family, species diversity (Simpson's diversity index, D), and species richness at each location during each season. Mean catch per unit effort (CPUE) was calculated as the number per meter for each location during each season and year.

Backpack electrofishing was conducted during fall 2000, spring and fall 2001, and spring 2002. A modification of the Tennessee index of biotic integrity protocol (TDEC 1995) was used for sampling complex habitat. Riffles and runs were sampled until three consecutive efforts produced no additional species for that habitat. Each unit of effort consisted of sampling 30-square-meter plot (e.g., 6 x 5 meters). A 6-meter seine was positioned perpendicular to current; one person outfitted with a backpack electrofishing unit began shocking 5 meters upstream of the seine and shocked downstream into the seine. At each location, shoreline habitat was also sampled by backpack electrofishing a single pass along a 100-meter wadeable transect.

Each species collected was assigned to one of three pollution tolerance levels (tolerant, moderately tolerant, or intolerant) and one of five trophic levels (piscivore, insectivore, omnivore, specialized insectivore, or herbivore) (Barbour et al. 1999; NCDENR 2001).

Data collected from backpack electrofishing were used to calculate relative abundance, species diversity (Simpson's diversity index, D), and species richness (total number of species) at each location during each season. Mean CPUE was calculated as the number per riffle and run plot for each location during each season and year.

Though specifics on the quality assurance procedures for this study are not available, Duke Energy (and its predecessors) have maintained and operated a biological laboratory employing SOPs and rigorous quality assurance/quality control methods employed by highly trained scientists (Duke Energy 2010). The biological and chemical laboratories have been certified by both the NCDENR and SCDHEC to conduct biological investigations and perform water quality analyses for as long as each agency has implemented a certification program. All biological programs conducted by Duke Energy discussed in this section have been implemented in accordance with these procedures.

B. Description of the Study Area

Eleven locations along the Broad River were sampled for fish. Two locations are relevant to the proposed Lee Nuclear Station: location 7 is 2 kilometers below the Cherokee Falls Dam and upstream of the Ninety-Nine Islands Reservoir and location 6 is located downstream of the Ninety-Nine Islands Dam (Bettinger et al. 2003, Figure 1).

C. Taxonomic Identification of Sampled and Evaluated Biological Assemblages

Each fish collected during sampling was identified to species, and when practical, measured to the nearest millimeter total length and weighed to the nearest gram. In some instances, the number of species were too numerous to measure and weigh individually. In these cases, the individuals were enumerated, lengths were recorded for 25 randomly selected individuals, and a total batch weight was recorded. A reference collection of each species was maintained. Species identifications were verified by Fritz Rohde of the North Carolina Division of Marine Fisheries.

D. Sampling and Data Analysis Methods

For boat electrofishing, differences in species richness were investigated using a two-way analysis of variance (ANOVA) by location and season. Differences in species diversity and CPUE among locations and seasons were evaluated with independent Kruskal-Wallis tests.

For backpack electrofishing, differences in mean species richness and diversity among locations and seasons were evaluated with independent Kruskal-Wallis tests. Differences in mean CPUE were investigated using a two-way ANOVA by location and season. Chi-square analysis was used to evaluate differences in trophic composition and pollution tolerance among locations.

IV. REFERENCES

Barbour, M.T., Gerritsen, J., Snyder, B.D. and Stribling, J.B. (1999) Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington.

Bettinger, J., J. Crane, and J. Bulak. 2003. Broad River Aquatic Resources Inventory Completion Report. Broad River Comprehensive Entrainment Mitigation and Fisheries Resource Program. South Carolina Department of Natural Resources.

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Appendix B

Hydraulic Zone of Influence

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COOLING WATER INTAKE STRUCTURES HYDRAULIC ZONE OF INFLUENCE WILLIAM STATES LEE III NUCLEAR STATION CHEROKEE COUNTY, SOUTH CAROLINA

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ATTACHMENTS

1. INTRODUCTION

Lee Nuclear Station will use as its primary cooling water source waterbody, an existing impoundment on the Broad River created by the Ninety-Nine Islands Hydroelectric Project. The Ninety-Nine Islands Reservoir covers about 430 acres and has a total storage capacity of about 2,300 acre-feet (ac-ft) [Reference 1; Chapter 2]. Ninety-Nine Islands Reservoir is characterized by three hydrographic areas, the main river channel and two backwater areas that have developed because of sedimentation patterns since impoundment of the reservoir. The two backwater regions exhibit very little circulation during non-flood periods. Therefore, the average transit time is conservatively estimated from the volume of the main channel excluding the backwater areas. Consequently, a storage volume of 570 ac-ft along the main channel results in an average hydraulic retention time of about 3 hours under annual average flow conditions [Reference 1; Chapter 2].

The cooling water intake structure on the Broad River (river intake) will be located within the Federal Energy Regulatory Commission (FERC) project boundary for the Ninety-Nine Islands Reservoir. The river intake will have two sections: the primary intake, and the drought contingency intake. At this point, the width of the river is 240 ft [Reference 1; Chapter 2].

As a 2,200 megawatt facility, Lee Nuclear Station will require approximately 78 cubic feet per second (cfs) or 35,030 gallons per minute (gpm) of cooling water withdrawal from the Broad River for station operations. Approximately 71 percent (55 cfs or 24,800 gpm) of the withdrawal will be consumptive due to evaporative and drift losses from the cooling towers, with 5 cfs (2,000 gpm) returned to the river as screen wash water and about 18 cfs (8,200 gpm) returned to the river as cooling tower blowdown and smaller process-related waste streams.

The design and capacity of cooling water intake structures are regulated under the National Pollutant Discharge Elimination System (NPDES) permitting program. The South Carolina Department of Health and Environmental Control (SCDHEC) administers this program under delegated authority from the U.S. Environmental Protection Agency (EPA). EPA has promulgated rules pursuant to Clean Water Act Section (§) 316(b) that requires new facilities with cooling water intake structures to apply "Best Technology Available" (BTA) to reduce "adverse environmental impact"

associated with entrainment and impingement of fish and shellfish. SCDHEC has adopted EPA's regulations.

The §316(b) regulations at §122.21(r)(2) specify the submittal of "Source Water Physical Data" upon application for an NPDES permit for new facilities with regulated cooling water intake structures. Among other data, the applicant is required to identify and characterize the source waterbody's hydrological and geomorphologic features, "*as well as the methods you used to conduct any physical studies to determine your intake's area of influence within the waterbody and the results of such studies*".

In addition to the river intake, Lee Nuclear Station will require additional intake structures on other ponds, one sedimentation pond (Pond A) and two drought contingency ponds (Pond B and the proposed Pond C).

Geosyntec was contracted by Duke Energy to conduct the necessary calculations/modeling to determine the hydraulic zone of influence (HZI) for the Lee Nuclear Station intake structures to support the NPDES permit application for this new facility. To accomplish this task, Geosyntec employed Computational Fluid Dynamics (CFD) modeling to simulate the flows induced by the intakes, with the results from these simulations providing the basis for the HZI determination.

2. COOLING WATER OPERATION AND MODELING SCENARIOS

The modeled scenarios approximate normal and worst-case operating conditions of the intakes in order to provide a conservative assessment of the HZI. Under normal operating conditions, 35,030 gpm (78 cfs) will be withdrawn from the Broad River via the primary section of the river intake: 33,030 gpm (73 cfs) as plant make-up water and 2,000 gpm (5 cfs) as screen wash water returned to the Broad River at the intake (maximum withdrawal approximately 43,960 gpm (98 cfs)) [Reference 1; Chapter 3 – Figure 3.3-1]. This raw water from the primary section will be pumped directly to Pond A, which will be used on a daily basis as a settlement/equalization basin. Under normal operating conditions, Drought Contingency Ponds B and C will not be used. However, during low flow conditions on the Broad River, consumptive water will be supplied by Ponds B and/or C rather than the Broad River. When supported by higher flows in the Broad River, water may be pumped for Lee Nuclear Station operations via the primary section of the intake (two pumps (20,980 gpm (46.8 cfs) each) and screen wash (2,000 gpm (4.5 cfs)), at a total rate of approximately 43,960 gpm (98 cfs). The drought

contingency section will have four additional refill and screen wash pumps, with a total rate of approximately 92,500 gpm (206 cfs) [Reference 2 and 3]. After periods of extreme drought, when the flows in the Broad River return to normal, Duke Energy will operate both the primary and drought contingency sections of the river in order to meet the operating requirements of Lee Nuclear Station while at the same time refilling the drought contingency ponds.

2.1 Intake Structure Specifications

In addition to the Environmental Report (Rev. 1) associated with the Duke Energy Combined Construction and Operating License Application for the facility [Reference 1], specifications, and maximum and normal operational parameters for each Lee Nuclear Station intake structure, were obtained from the following documents:

- Duke Energy Response to NRC Request for Additional Information (RAI) No.: 190 – "Site Layout and Plant Description" dated 22 July 2010 [Reference 3]

- Duke Energy Response to NRC RAI No.: 210 Supplement – "Ecology – Aquatic" dated 12 November 2010 [Reference 4]

- Shaw Group Response to Duke Energy Request for Information (RFI) No.: WLG-XXER-GF-018 related to NRC RAI No.: 210 dated 30 September 2010 [Reference 5]

- Duke Energy Response to NRC RAI No.: 210 – "Ecology – Aquatic" dated 14 October 2010 [Reference 6]

- Shaw Nuclear Calculation WLG-RWS-M3C-012 Rev. E, *Standard RWS Traveling Screen Calculation*, dated July, 2011 [Reference 11]

- Shaw Nuclear Calculation WLG-RWS-M3C-013 Rev. E, *Standard RWS Passive Screen Calculation*, dated July, 2011 [Reference 12]

River Intake

The river intake will consist of two subsystems: 1) the primary section, and 2) the drought contingency section; both will be fitted with traveling screens.

Primary Section

This section will have four intake bays open to the Broad River aligned parallel to shore and flow. Each bay will be 11 feet (ft) 9 inches (in) wide, by 11 ft high fully submerged at river elevation, 511 ft above mean sea level (msl) (elevation at annual mean flow). There will be one variable-speed pump in each bay, rated at 20,980 gpm (46.8 cfs) each, for a total of four pumps. Two pumps will support Unit 1 and two pumps will support Unit 2; one pump for each Unit will be a back-up pump. Pump arrangement based on designated Unit will be: 1-1-2-2. This section will also have screen wash pumps rated at approximately 2,000 gpm (4.5 cfs).

Drought Contingency Refill Section

This section will also have four intake bays open to the Broad River, aligned parallel to shore and flow. Each bay will be 11 ft 9 in wide, by 11 ft high fully submerged at elevation 511 ft msl. There will be one variable-speed pump in each bay, rated at 22,500 gpm (50 cfs) each, for a total of four pumps. Though total pumping capacity will be 90,000 gpm (200 cfs), normal refill operation will be 45,000 gpm (100 cfs). Pump arrangement based on Unit will be: R1-R1-R2-R2. This section will also have screen wash pumps rated at approximately 2,500 gpm (5.5 cfs).

Pond A – Raw Water Supply Intake

Cooling water from the primary intake will be fed into Pond A where the Lee Nuclear Station Raw Water Intake will be located (the river water feed into Pond A is subsequently referred to as the “refill” flow in the pond). This intake structure will be aligned parallel to shore, and will have six intake bays open to the pond that will be fitted with traveling screens; each bay will be 11 ft 9 in wide by 11 ft high and fully submerged at normal full pond elevation of 547 ft msl. The presence of a sediment seal extending 2 ft 6 in up from the intake bay floor is accounted for in the intake bay dimensions modeled [Reference 4].

There will be one pump in each bay rated at approximately 15,000 gpm (33 cfs) each; for a total of six pumps (two pumps will be back-up), at a maximum capacity of 60,000 gpm (134 cfs). Three pumps will support Unit 1 and three pumps will support Unit 2. Current planned operation calls for each pump to be fixed-speed and operated at full pump capacity with system flow controlled via a flow control return loop. However, the use of variable-speed pumps is under consideration for this intake. Dual-flow vertical traveling screens will be fitted to each intake bay opening. A range of screen mesh sizes; from 0.236 in (6.0 millimeter (mm)) to 0.079 in (2.0 mm) yielding a percent open area of 65.9 percent to 56.3 percent, is being considered by Duke Energy for Pond A [References 5 and 11]. As the smaller mesh size would be expected to produce a larger HZI, the CFD modeling was performed using the conservative 2.0 mm mesh size with an assumed 25 percent blockage due to debris buildup on the screen. Raw Water Intake pump arrangement based on Unit served is: 1-1-1-2-2-2. This subsystem will also have screen wash pumps rated at approximately 2,000 gpm (4.5 cfs).

Drought Contingency Pond B Intake

This intake structure will support five pumps positioned within two pump bays/wet wells [Reference 4]. One wet well will contain three pumps: two main pumps each rated at 10,000 gpm (22 cfs) and one ancillary pump rated at 6,000 gpm (13 cfs). The second wet well will contain two main pumps rated at 10,000 gpm (22 cfs) each. One 10,000 gpm pump will be a back-up pump. The ancillary pump will deliver water from Pond B to Pond C and will not be operated concurrent with the primary 10,000 gpm pumps. Normal summer operation will consist of three pumps delivering an effective flow rate of 30,000 gpm (67 cfs).

Pond B intake structure will be configured with four passive wedge-wire drum-type screens with each screen designed to handle the capacity of one 10,000 gpm (22 cfs) pump. A range of wedge-wire screen diameters and lengths, and screen slot sizes are being considered for Pond B. Screens will be 5 ft to 5.83 ft in diameter and 6.44 ft to 8.13 ft in length, extending out into the pond parallel with the intake pump structure causeway. The screens will be separated by a distance of 17 ft to 18 ft. The wedge-wire screens will have 0.394 in (10 mm) to 0.079 in (2 mm) slot openings yielding a percent open area of 71.36 percent to 45.85 percent, respectively [References 5, 6 and 12]. Expected to produce a larger HZI, the CFD modeling was performed using the conservative 2.0 mm slot size with an assumed 25 percent blockage due to debris

buildup on the screen. As dictated by the smaller slot size, the greater screen diameter (5.83 ft) and length (8.13 ft) were also input to the model accordingly.

Elevation of the centerline of the cylindrical wedge wire drum-screen will be: 528 ft msl.

Drought Contingency Pond C Intake

This intake structure will support three pumps rated at 10,000 gpm (22 cfs) each; all configured in one common pump bay/wet well. These pumps will deliver water from Pond C to Pond B. Normal summer operation will consist of all three pumps delivering an effective flow rate of 30,000 gpm (67 cfs). The Pond C intake will also use wedge-wire drum-screens. In this case, two wedge wire drum-type screens will be fitted to the single wet well. Screens will be 5 ft to 5.83 ft in diameter and 6.44 ft to 8.13 ft in length, extending out into the pond parallel with the intake pump structure causeway. The screens will be separated by a distance of 14 ft. The wedge wire screens have 0.394 in (10 mm) to 0.079 in (2 mm) slot openings, yielding a percent open area of 71.36 percent to 45.85 percent, respectively [References 5, 6 and 12]. As the wedge-wire screen and slot size specifications for Pond C are the same as for Pond B, the CFD model inputs used were the same.

Elevation of the centerline of the cylindrical wedge wire drum-screen will be: 553 ft msl.

2.2 Intake Pumping Scenarios Modeled

Considering the above intake specifications and possible operating regimes, the following scenarios were selected for the conservative determination of respective hydraulic zones of influence using CFD modeling techniques:

- For the **River Intake**, three pumping scenarios were evaluated:

  1. Withdrawal of approximately 43,960 gpm (98 cfs)[1] via the primary section to support normal operations under the Broad River mean annual flow

[1] Two pumps at 20,980 gpm (47 cfs) each plus screen wash pumpage of 2,000 gpm (5 cfs).

conditions[2] (1,956 cfs at 511 ft msl reservoir/river surface elevation) [Reference 7]. Two adjacent pumps were selected for the HZI determination under this scenario: 1-**1**-**2**-2.

2. Withdrawal of 35,030 gpm (78 cfs) via the primary section to support normal operations prior to invoking the low flow protocol using the drought contingency ponds (river flow set to 538 cfs, accounting for both the FERC minimum release[3] of 483 cfs and the 55 cfs consumptive withdrawal). Additionally, the Ninety-Nine Islands impoundment elevation is set to 2 ft below normal pool elevation of 511 ft msl in accordance with the conditions of the FERC license. Two adjacent pumps were selected for the HZI determination under this scenario: 1-**1**-**2**-2.

3. Maximum withdrawal of approximately 92,500 gpm (206 cfs)[4] through the drought contingency section, plus approximately 43,960 gpm (98 cfs)[5] through the primary section under conditions representative of high flows in the Broad River. This high flow condition has been determined by Duke Energy as an average flow of 2,260 cfs, which is a high flow during the refill period for the ponds (July to February) [Reference 2]. The surface elevation is set at 511 ft msl. Primary and drought contingency pumps selected for the HZI determination under this scenario were: **R1-R1-R2-R2** | **1** 1 **2** 2 , operating a River Water Subsystem pump adjacent to the Refill Water Subsystem pumps to maximize the zone of hydraulic influence.

- For the **intake on Pond A**, two pumping scenarios were evaluated:

1. Operation of four variable-speed pumps plus screen wash (2,000 gpm (5 cfs)) for a total flow rate of 35,030 gpm (78 cfs) at a normal/full pond water level elevation of 547 ft msl (Pond A water level is maintained at a constant elevation). Pumps selected for the HZI determination under this scenario

[2] Mean annual flow is based on 2001-2010 in accordance with §316(b) guidance for determining mean annual flow.
[3] The FERC requires a 483 cfs minimum release from the Ninety-Nine Islands Hydroelectric Station as part of the FERC license for the project.
[4] Four pumps at 22,500 gpm (50 cfs) each plus screen wash pumpage of 2,500 gpm (6 cfs).
[5] Two pumps at 20,980 gpm (47 cfs) each plus screen wash pumpage of 2,000 gpm (5 cfs)

were: 1-**<u>1-1-2-2</u>**-2, operating adjacent pumps for each Unit to maximize the zone of hydraulic influence.

2. Operation of four fixed-speed pumps at full capacity of 60,000 gpm (134 cfs) plus screen wash of 2,000 cfs for total flow rate of 62,000 gpm (139 cfs) with 26,970 gpm (61 cfs) plus screen wash returned to the pond. The four pumps selected for the HZI determination under this scenario were: <u>1-**1-1-2-2-**2</u>.

- For the intake structure on **Pond B**, one pumping scenario was evaluated:

1. Normal operation of three pumps at a combined flow rate of 30,000 gpm (67 cfs) at the maximum estimated drawdown elevation of 540 ft msl (30 ft below full pond elevation). The maximum drawdown elevation during severe drought conditions was used, as the reduced volume will result in a conservative value for the HZI. Based on configuration of the wedge wire drum screens, it was conservatively assumed that a single pump will pump water through the open area of one screen. [Reference 4].

- For the intake structure on **Pond C**, two pumping scenarios were evaluated:

1. Normal operation of all three pumps at a combined flow rate of 30,000 gpm (67 cfs) at the maximum estimated drawdown elevation of 620 ft msl (30 ft below full pond elevation). Pumps selected for the HZI determination under this scenario were: **<u>1-2-3</u>**. Based on configuration of the wedge wire drum screens, it was assumed that all three pumps will pump water through the open area of two screens [Reference 4].

2. Normal operation of all three pumps at a combined flow rate of 30,000 gpm (67 cfs) at the maximum estimated drawdown elevation of 605 ft msl (45 ft below full pond elevation). The maximum drawdown elevation during severe drought conditions was used for the same reason given for Pond B. Pumps selected for the HZI determination under this scenario were: **<u>1-2-3</u>**. Based on configuration of the wedge wire drum screens, it was assumed that all three pumps will pump water through the open area of two screens [Reference 4].

3. MODELING METHODOLOGY

Computational Fluid Dynamics modeling was applied to the above scenarios. The use of CFD is appropriate as the flows in the river and ponds are complex and cannot be modeled as accurately using simpler techniques which, by necessity, make broad assumptions regarding the nature of the flow (e.g., velocity profiles). By contrast, CFD solves the fundamental fluid flow equations (Navier-Stokes equations) with no assumptions regarding flow profiles or other broad generalizations.

3.1 Generation of the Computational Model

To model the intake flows in the river and ponds, a three-dimensional geometry was defined based on elevation data from various sources [References: 3, 4, 5, 6, 8, 9, 10, 11, and 12]. For the river simulations, a large section of the Broad River was modeled, including the section containing the river intake. On the upstream face of the modeled river section, the appropriate flow rate was input for each Scenario of interest. The upstream section of the model allowed the flows in the river to develop realistic, complex profiles in the vicinity of the river intake. The river intake design and location were based on information and drawings in References 3 and 8, with the primary and drought contingency section pump bays represented as rectangular faces on the intake structure. Figures 1 and 2 show the modeled section of Broad River and the intake structure in the CFD model. For the pond models, a similar approach was taken to the generation of the geometry and mesh.

Further technical details regarding the CFD model are given in Attachment B.1.

3.2 Definition of the Hydraulic Zone of Influence

The §316(b) regulations at §125.82 define the HZI broadly as: "*that portion of the source waterbody hydraulically affected by the cooling water intake structure withdrawal of water.*" A more quantitative definition is not provided. Due to the physical differences between the flows in the river and the ponds, separate definitions of the HZI were used in each case evaluated. For the river scenarios, a location was included in the HZI if the flow vector at that location pointed directly towards the intake structure – in other words, if a particle were to follow the direction of the flow at that point, and did not change direction, then it would be drawn toward the intakes. For the pond scenarios, this definition was not practical, as the flow vector may well point

towards the intake structure, but the flow velocity at that point may be so low that it is impractical to consider it within the HZI. As such, a location was included in the HZI for the pond intakes if the velocity at that point was greater than 0.1 foot per second (ft/s), irrespective of the flow vector.

4. RESULTS & DISCUSSION

The results from the CFD modeling are discussed below. An overview of the results for the dimensions of the HZI for each scenario is provided in Section 5.

4.1 River Scenarios

Figure 3 shows velocity contours on the river surface for **River Scenario 1** (mean annual flow and approximately 43,960 gpm [98 cfs] through the primary section) for the modeled section of the Broad River. The variation in velocity is due to the three-dimensional nature of the model, which reflects the effect of bends and undulating river bed (see Figure 1) on velocity. Figure 4 provides river flow direction (vector ►) and velocities (vector color) for ambient river conditions near the river intake absent any pumping activity. Ambient flows show considerable variation in both velocity and direction, and large recirculation regions are shown by the velocity vectors (Figure 4). Notably, ambient river flows unaffected by the primary section withdrawal naturally exceed 0.5 ft/s.

It can be seen from Figure 4 that although approximately 43,960 gpm (98 cfs) is removed from the river at the primary section intake pump bays, the flow vectors in general remain aligned with the river flow direction. The streamlines on Figure 5 show that, the flow directed into the primary section intake bays is in fact from the southern edge of the river, and the angle of the flow does not turn perpendicular to the pump bays but is more aligned with the river flow direction. As such, the HZI as defined in Section 3.2 is relatively small, and does not protrude far into the river. A visualization of the HZI for Scenario 1 is shown on Figure 6. The volume of the HZI under these flow conditions is 0.129 ac-ft and it extends into the Broad River a maximum of 9.2 ft perpendicular to the intake structure.

The velocity vectors for **River Scenario 2** (538 cfs flow and 35,030 gpm [78 cfs] through the primary section) are shown on Figure 7, with the blue coloration indicative of the lower velocities (< 0.5 ft/s) associated with the low flow condition. Figure 8

shows the HZI, and as expected it is slightly larger than the previous case due to the lower river flow rate – the HZI volume is 0.200 ac-ft and it extends 14.4 ft into the Broad River from the cooling water intake structure.

The final scenario (**River Scenario 3**) considered for the river intake is the high river flow condition of 2,260 cfs and total withdrawal capacity of 136,460 gpm through the primary and drought contingency sections (approximately 43,960 gpm (98 cfs) through the primary section and 92,500 gpm (206 cfs) through the drought contingency section). Similar to the mean annual flow model (River Scenario 1), ambient river flows unaffected by the river intake withdrawal naturally exceed 0.5 ft/s under conditions of high river flow (Figure 9).

The velocity vectors on the river surface near to the river intake for this case are also shown on Figure 9, while the HZI can be seen on Figure 10. Notice that the HZI is much larger than the previous two scenarios, as the drought contingency section of the river intake contributes to the HZI, whereas for the previous two scenarios it did not. The HZI volume in this case is 0.316 ac-ft while extending into the Broad River is 15.4 ft.

4.2 Pond Scenarios

The computational model for the two **Pond A** scenarios [(1) withdrawal of 35,030 gpm (78 cfs) and (2) withdrawal of 62,000 gpm (139 cfs) with 26,970 gpm (61 cfs) returned to the pond] is shown on Figures 11-16. The model assumes the future removal of the temporary cofferdam that is indicated by the current bathymetry data. The intake structure is shown, as is the location of the refill inlet from the river intake subsystem on the Broad River into Pond A. A closer view of the intake structure is shown on Figure 12. A contour plot of velocity magnitude for the flows for **Scenario 1** in Pond A is shown on Figure 13 with the contours “clipped” to 0.1 ft/s (i.e., the red areas show velocities at, or greater than, 0.1 ft/s). This scale (velocity greater or equal to 0.1 ft/s) was used as the definition of the HZI for the pond simulations. Although it appears that the flow through Pond A is very large, in fact the flows are almost entirely induced by the refill flow from the primary section intake to Pond A and, *not* caused by the withdrawal of water via intake for Pond A. Although there are large areas within Pond A (see Figure 13) where the model predicts velocities greater than 0.1 ft/sec, as shown

in Figure 14, the HZI is localized and small; the volume is 0.054 ac-ft and it extends 3.7 ft outward of the intake bays.

For **Pond A-Scenario 2**, four pumps/bays are operational, and the flow rate withdrawn from the pond is increased to 62,000 gpm[6] (139 cfs). The maximum refill flow rate into the pond from the the primary section intake structure remains at 38,400 gpm (86 cfs); and 26,970 gpm (61 cfs) is returned to the Pond A via a flow control return loop from the pond intake structure. This return flow has not been included in the model so that the hydraulic zone of influence of the intake structure can be isolated. Mesh size for the dual-flow vertical traveling screens was set at 2.0 mm with an assumed 25 percent blockage due to debris buildup on the screen. The velocity contours for this scenario are shown on Figure 15, and are similar to those for Scenario 1 as the refill flow (the primary influence on flows in the pond) has not changed. However, as is shown on Figure 16, the HZI of the Pond A intake structure is greater due to the increase in the withdrawal flow rate, with a volume of 0.150 ac-ft, extending outward 9.2 ft into the pond.

Figure 17 shows the computational model for **Pond B**, while the intake structure is shown on Figure 18. The model considers the breaching of the temporary cofferdam indicated by the bathymetry data [Reference 10]. In this case, the Pond B intake structure is 90 ft wide and has two pump bays [Reference 4]. The intake design for Pond B includes four cylindrical wedge-wire screens, two for each bay [Reference 4] – depicted as yellow areas on Figure 18. Modeling was performed based on a screen diameter of 5.83 ft and length of 8.13 ft. Screen slot size was set at 2.0 mm with an assumed 25 percent blockage due to debris buildup on the screen. The velocity contours on the bottom of the pond (Figure 19) show that velocities greater than 0.1 ft/s (red areas) exist only very close to the intake screens (Figure 20). The total HZI for Pond B (all four screens collectively) is 0.039 ac-ft in volume, and the HZI only extends a distance of 7.2 ft from the intake structure.

The model for **Pond C** is shown on Figure 21. Notice the dam in the upper right section of the figure. The intake structure, shown on Figure 22, is similar to that of Pond B, but in this case, it extends about 180 ft into the pond (at a water surface elevation of 620 ft msl) and is 44 ft wide [Reference 4]. The two intakes to the single

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[6] Includes 2,000 gpm (5 cfs) screen wash pumpage.

pump bay are cylindrical wedge-wire screens of the same dimensions as those for Pond B [Reference 4], and are highlighted yellow in Figure 22. As the wedge-wire screen and slot size specifications for Pond C are the same as for Pond B, the CFD model inputs used were the same. Figure 23 shows that the HZI (red areas on the contour plot) is again very local to the intakes, and is barely discernable on the scale shown on the figure. A close-up view of the intake structure reveals the HZI for the 30 ft drawdown model (red areas in Figure 24); the total volume of the HZI (both wedge-wire screens collectively) is 0.062 ac-ft and it extends 9.2 ft from the intake structure. At the lower water surface elevation of the 45 ft drawdown model, the total volume of the HZI is 0.061 ac-ft and it also extends 9.2 ft from the intake structure. Figure 25 shows that the HZI (red areas on the contour plot) is again very local to the intakes, and is barely discernable on the scale shown on the figure. A close-up view of the intake structure reveals the HZI from the 45 ft drawdown model (red areas in Figure 26). The similarity between the two results, even though the water surface elevation is different, is due to the fact that the HZI in both cases is well below the water surface and the flow is relatively unaffected by changes in surface elevation in the range considered

5. RESULTS SUMMARY

5.1 River Intake Scenarios - Primary and Drought Contingency Sections

	Scenario 1	Scenario 2	Scenario 3
Intake flow	43,960 gpm *Primary Section at normal pumping capacity*	35,030 gpm *Primary Section at normal pumping capacity*	136,460 gpm *43,960* gpm *Primary Section plus* *92,500* gpm *Drought Contingency Section*
River flow	1,956 cfs *Mean annual flow*	538 cfs *483 cfs FERC flow plus 55 cfs consumptive*	2,260 cfs *High flow during refill period (Sept-Dec)*
Surface Elevation	511 ft msl	509 ft msl	511 ft msl
	Hydraulic Zone of Influence		
- **Volume**	0.129 ac-ft	0.200 ac-ft	0.316 ac-ft
- **Surface area**	0.004 acre	0.013 acre	0.025 acre
- **Extending Distance**	9.2 ft	14.4 ft	15.4 ft

5.2 Pond Scenarios

	Pond A-Scenario 1	Pond A-Scenario 2	Pond B	Pond C	Pond C
Intake Flow	35,030 gpm *Normal 4-pump capacity* *(variable speed)*	62,000 gpm *Normal 4-pump capacity* *(fixed speed)*	30,000 gpm *Normal 3-pump capacity*	30,000 gpm *Normal 3-pump capacity*	30,000 gpm *Normal 3-pump capacity*
Pond Elevation	547 ft msl *Full Pond*	547 ft msl *Full Pond*	540 ft msl *30 ft drawdown*	620 ft msl *30 ft drawdown*	605 ft msl *45 ft drawdown*
	Hydraulic Zone of Influence				
- **Volume**	0.054 ac-ft	0.150 ac-ft	0.039 ac-ft	0.062 ac-ft	0.061 ac-ft
- **Surface area**	0.004 acre	0.011 acre	0.004 acre	0.005 acre	0.005 acre
- **Extending Distance**	3.7 ft	9.2 ft	7.2 ft	9.2 ft	9.2 ft

6. CONCLUSIONS

A series of CFD simulations were run to support the NPDES application for the Lee Nuclear Station located in Cherokee County, South Carolina. The purpose of the simulations was to determine the hydraulic zone of influence for the cooling water intake structures located on the Broad River and in the ponds under several operational and flow conditions. In all cases the HZI remained localized to the intake structures and did not extend significantly into the Broad River or affect the flows greatly within the ponds. Full details of the HZI dimensions for each scenario considered have been given in the preceding pages.

7. REFERENCES

[1] *Duke Energy Combined Construction and Operating License Application for William States III Nuclear Station; Environmental Report (Rev.1).* http://adamswebsearch2.nrc.gov/idmws/ViewDocByAccession.asp?AccessionNumber=ML090990348

[2] *E-mail correspondence dated February 4, 2010* from T. Bowling (Duke Energy) to T. Cheek (Geosyntec Consultants).

[3] Duke Energy Response to NRC Request for Additional Information (RAI) No.: 190 – "Site Layout and Plant Description" dated 22 July 2010.

[4] Duke Energy Response to NRC RAI No.: 210 Supplement – "Ecology – Aquatic" dated 12 November 2010.

[5] Shaw Group Response to Duke Energy Request for Information (RFI) No.: WLG-XXER-GF-018 related to NRC RAI No.: 210 dated 30 September 2010.

[6] Duke Energy Response to NRC RAI No.: 210 – "Ecology – Aquatic" dated 14 October 2010.

[7] *William S. Lee III Nuclear Station Hydrology Report* prepared by HDR Engineering, Inc. Of The Carolinas, dated July, 2011.

[8] *Conceptual Design Package for RWS*, Report prepared by Shaw Nuclear, Document Ref. 11887902-F-RWS-CDP-0, 2009.

[9] *Site Plan – East Lee Nuclear Station Units 1 & 2*, Drawing Ref. WLG-0000-X2-005 Rev. C, 2009.

[10] *Lee Nuclear Station Reservoirs Bathymetry Report*, Report prepared by Devine Tarbell and Associates for Duke Energy Carolinas LLC, 2007.

[11] Shaw Nuclear, Calculation WLG-RWS-M3C-012 Rev. E, *Standard RWS Traveling Screen Calculation*, dated July, 2011.

[12] Shaw Nuclear, Calculation WLG-RWS-M3C-013 Rev. E, *Standard RWS Passive Screen Calculation*, dated July, 2011.

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FIGURES

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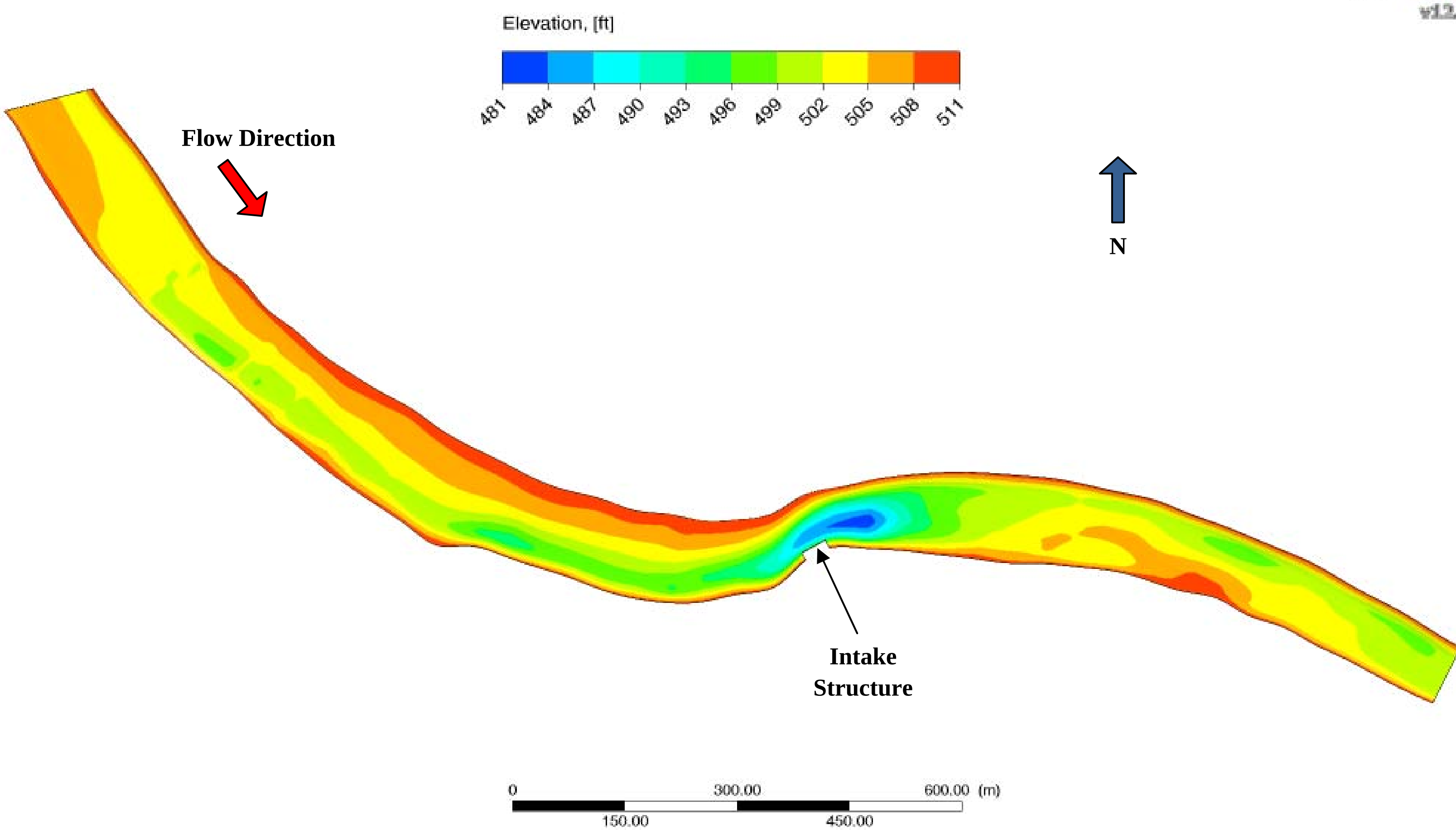

Figure 1 – Plan view of modeled section of the Broad River showing the river intake location

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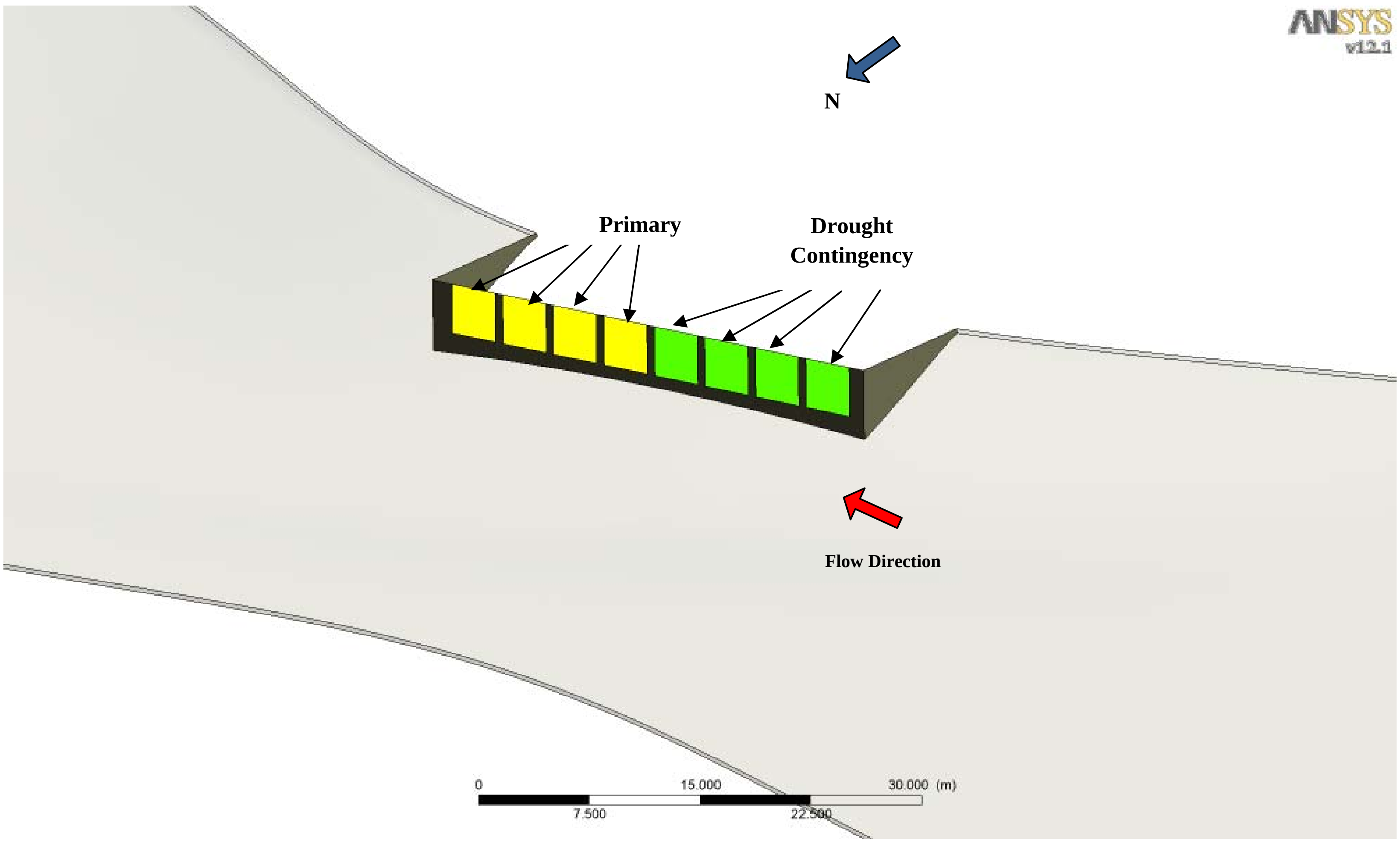

Figure 2 –View of the river intake structure showing four primary (yellow) and four drought contingency (green) intakes.

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ANSYS v12.1

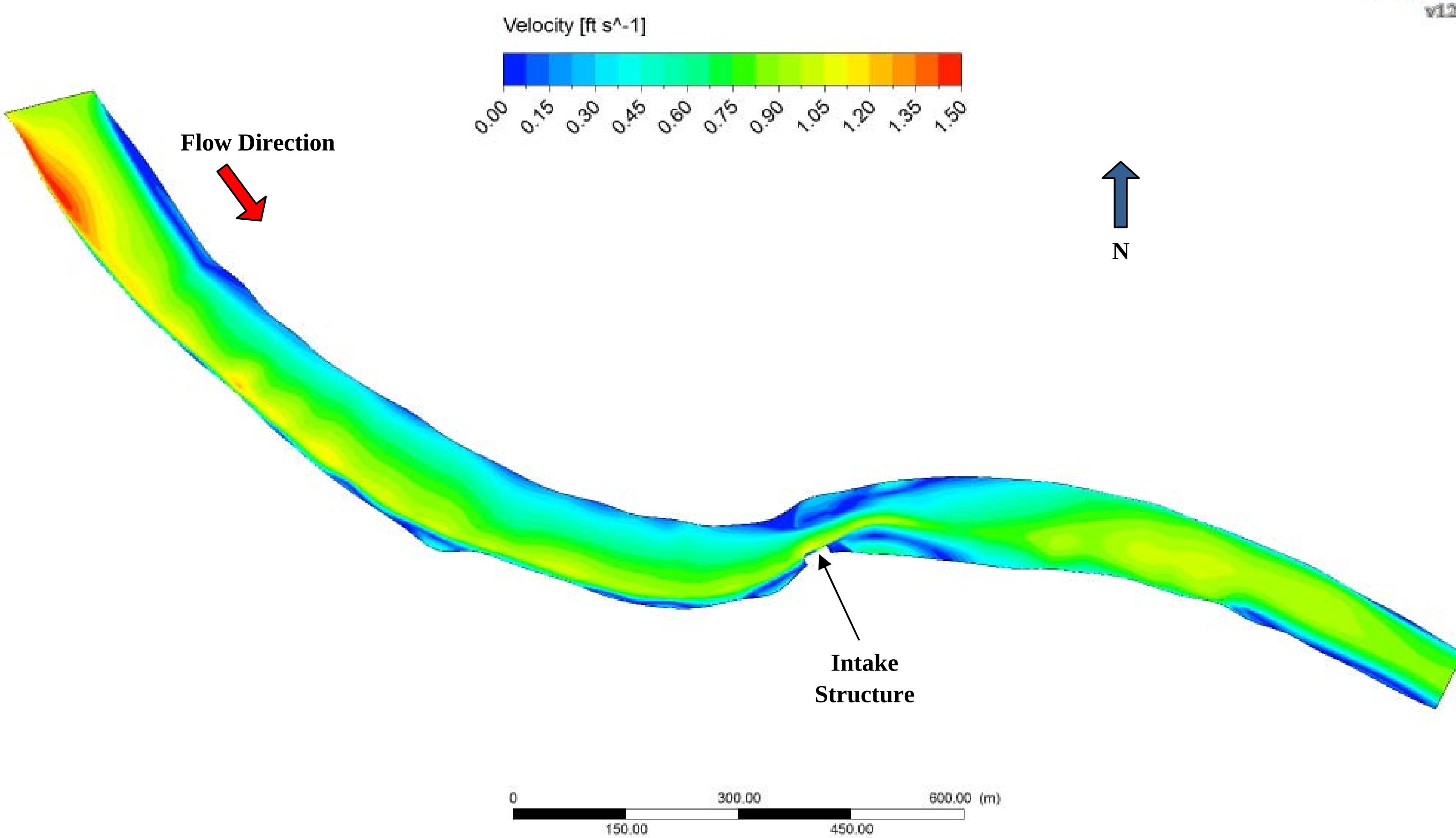

Figure 3 – Contour plot of velocity magnitude, Scenario 1.

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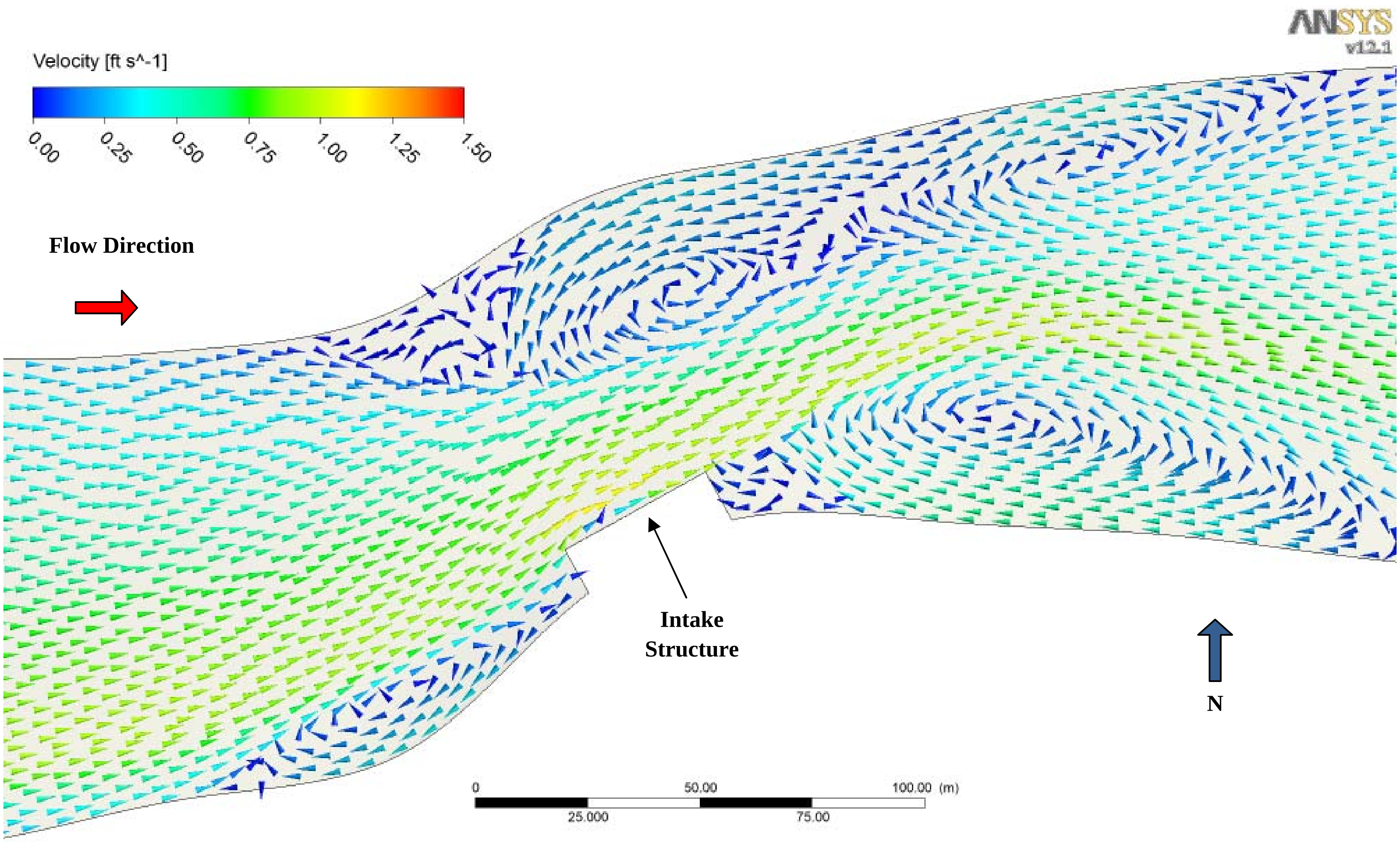

Figure 4 – Velocity vectors near the river intake structure, Scenario 1.

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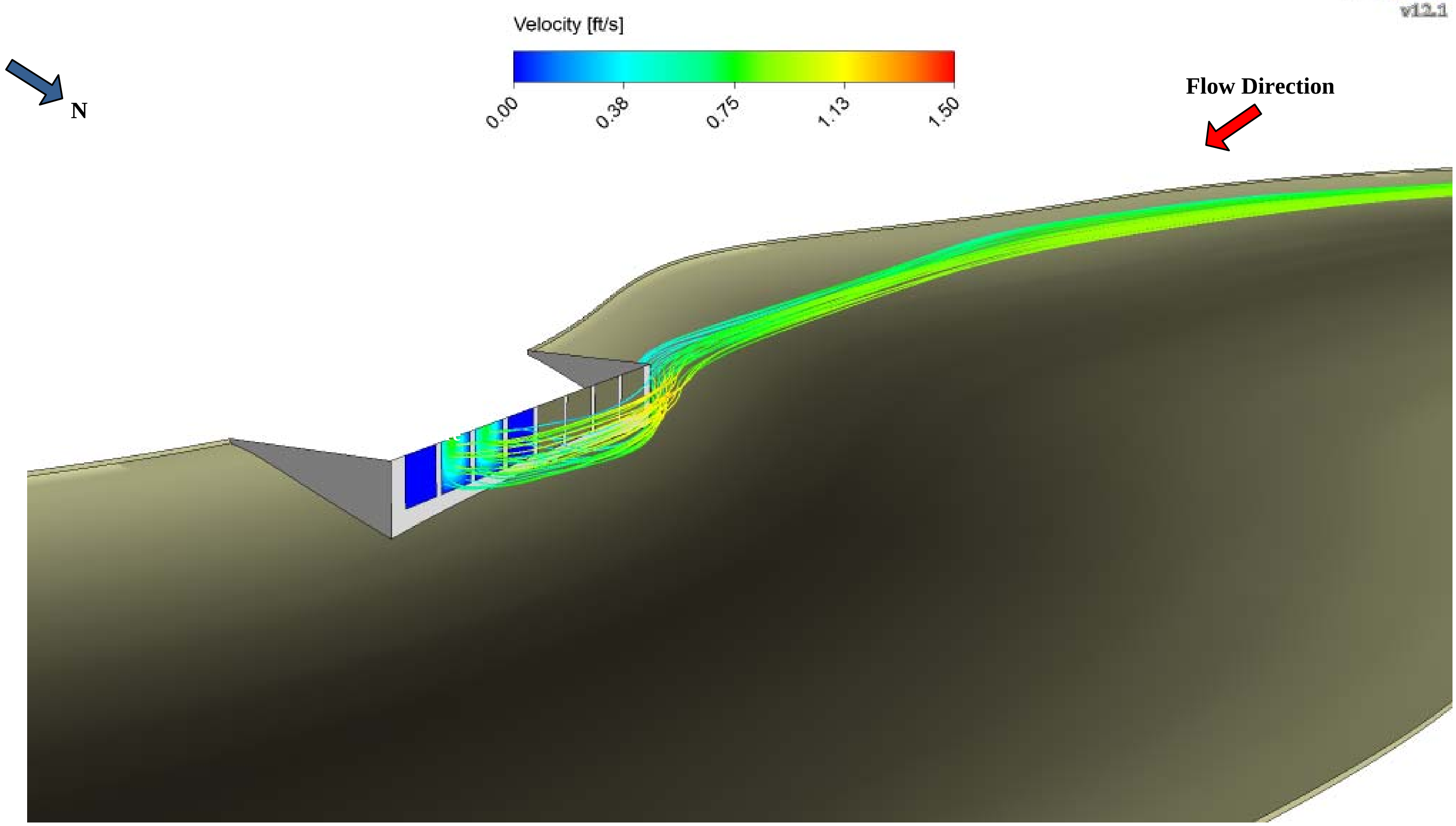

Figure 5 – Streamlines into the primary section intakes, Scenario 1.

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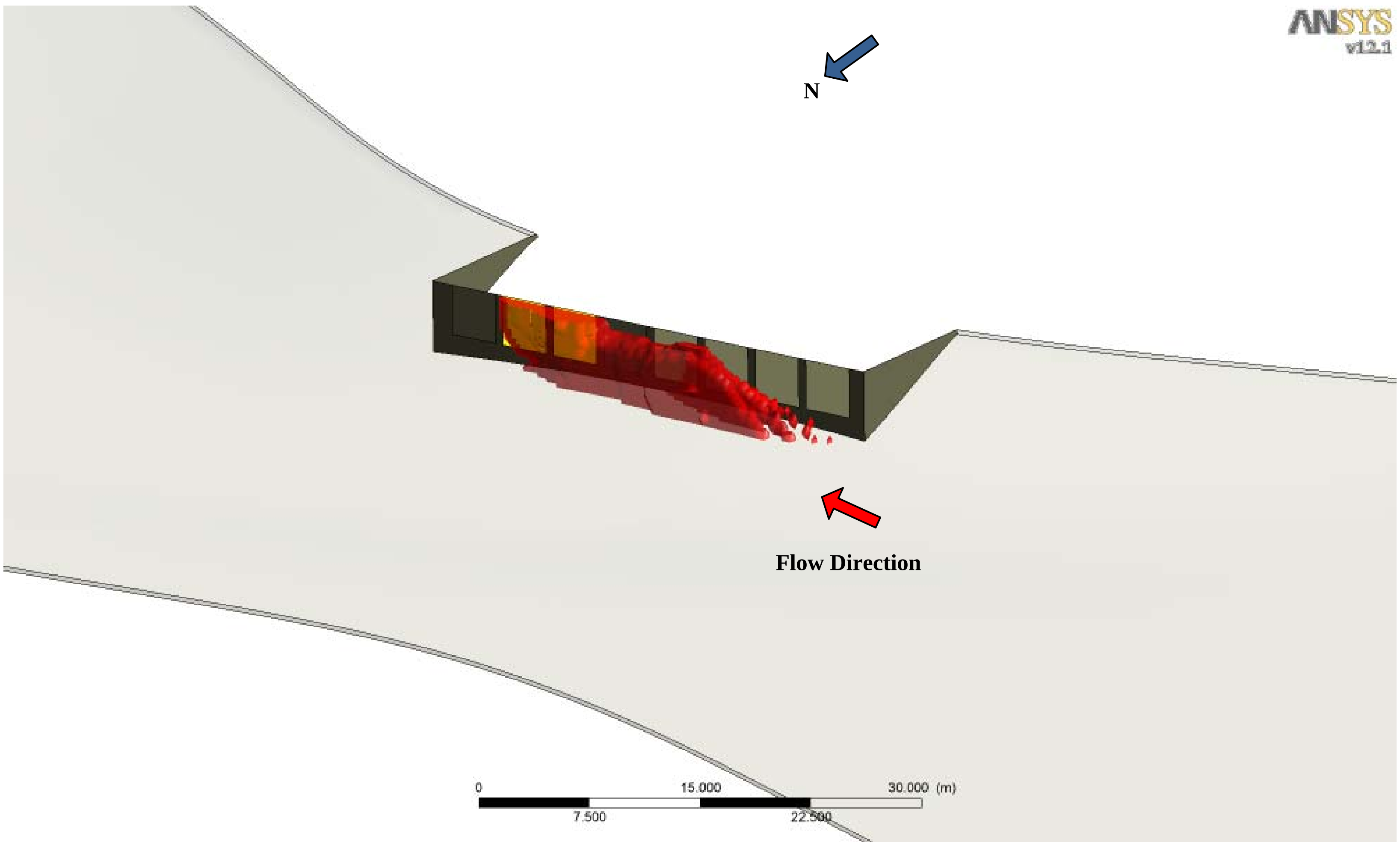

Figure 6 – Hydraulic zone of influence (indicated in red) for Scenario 1.

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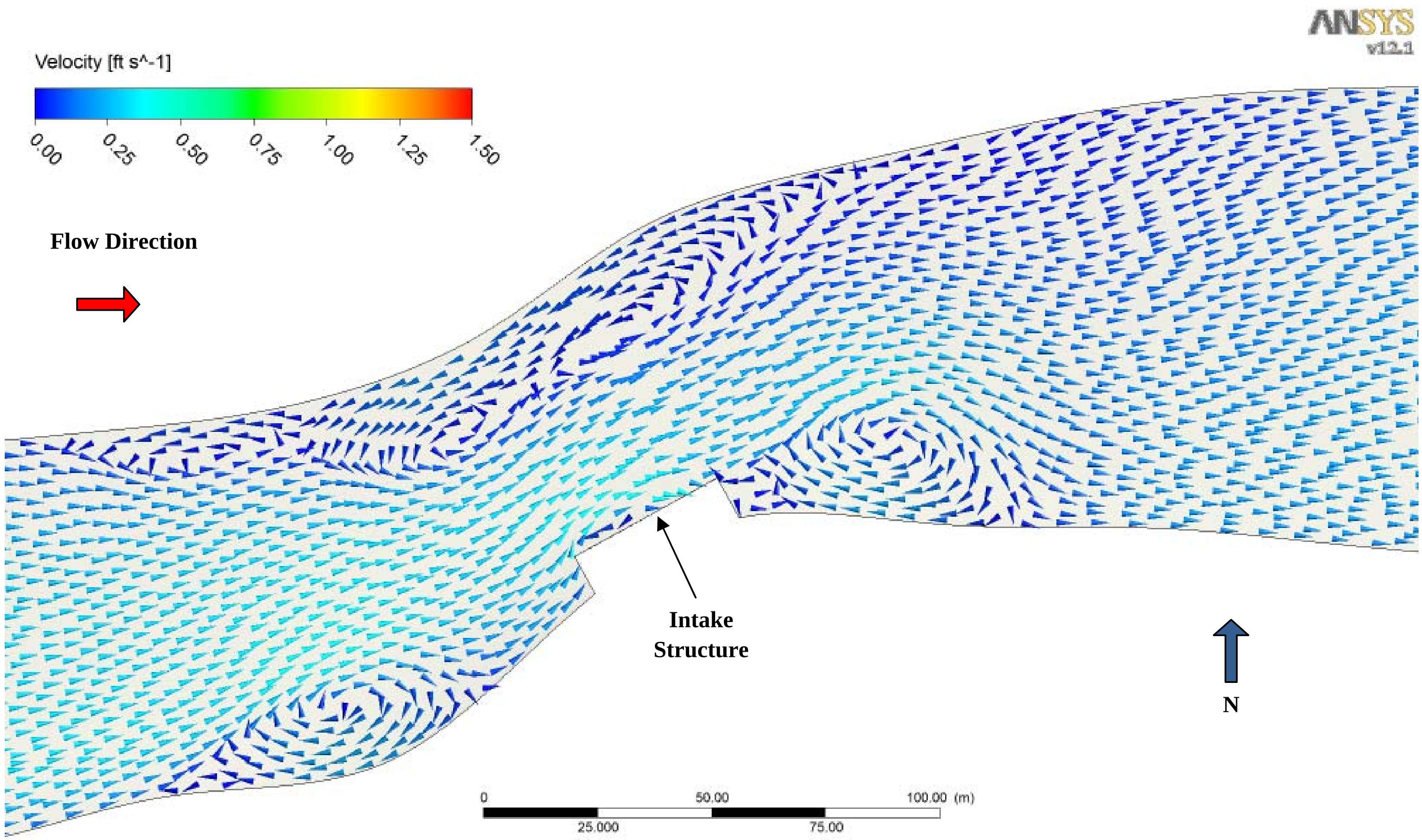

Figure 7 – Velocity vectors near the river intake, Scenario 2.

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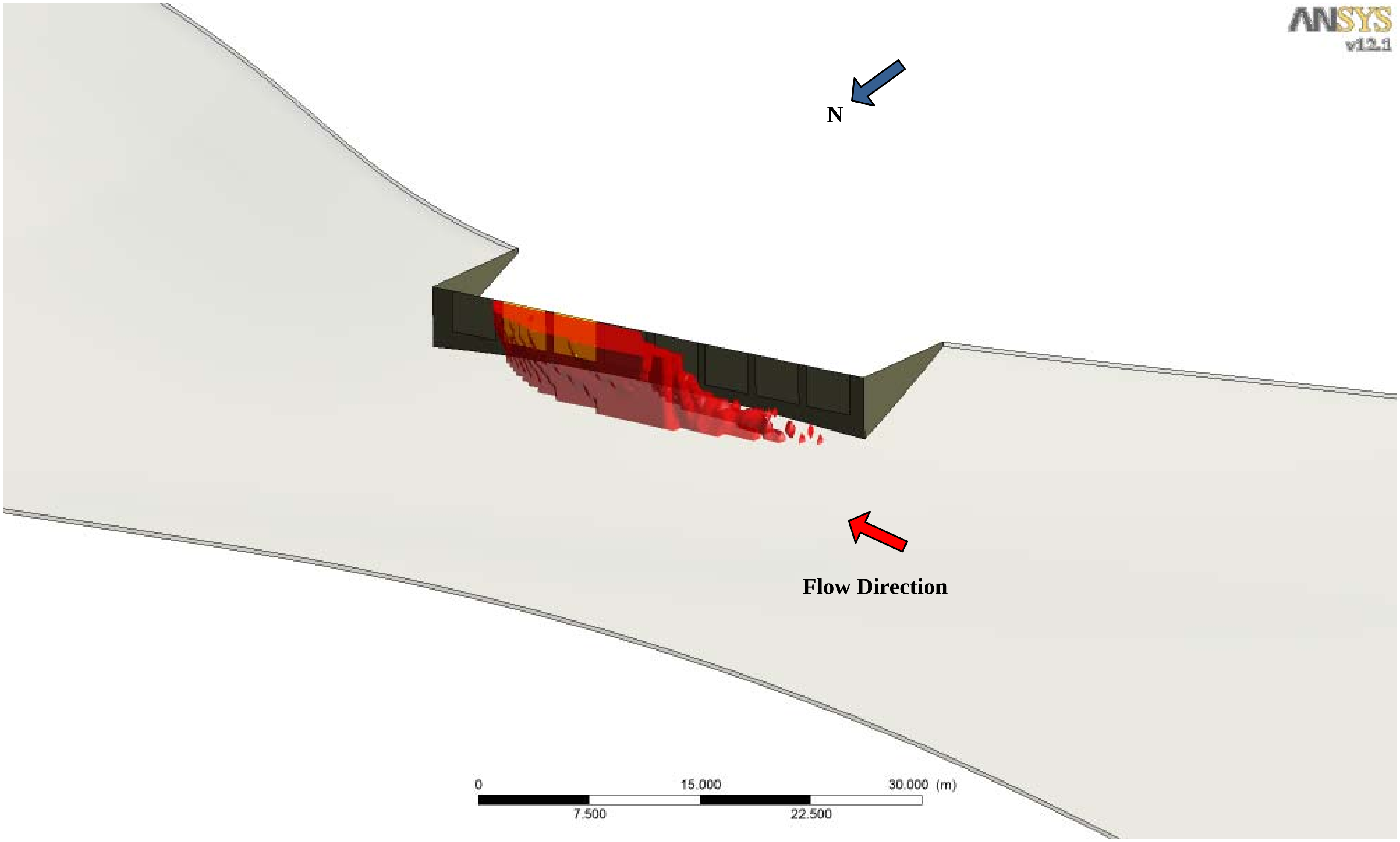

Figure 8 – Hydraulic zone of influence (indicated in red) for Scenario 2.

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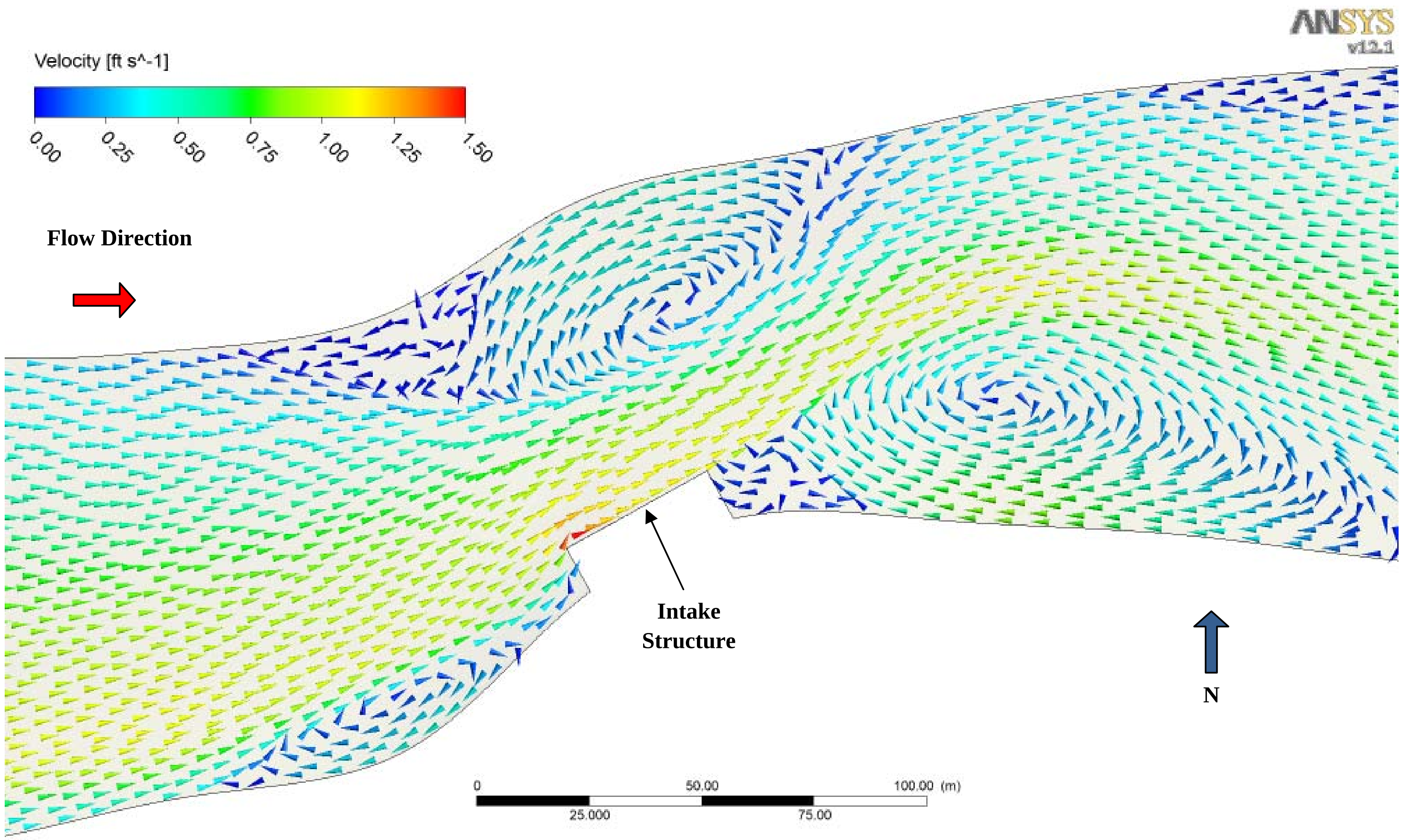

Figure 9 – Velocity vectors near the river intake, Scenario 3.

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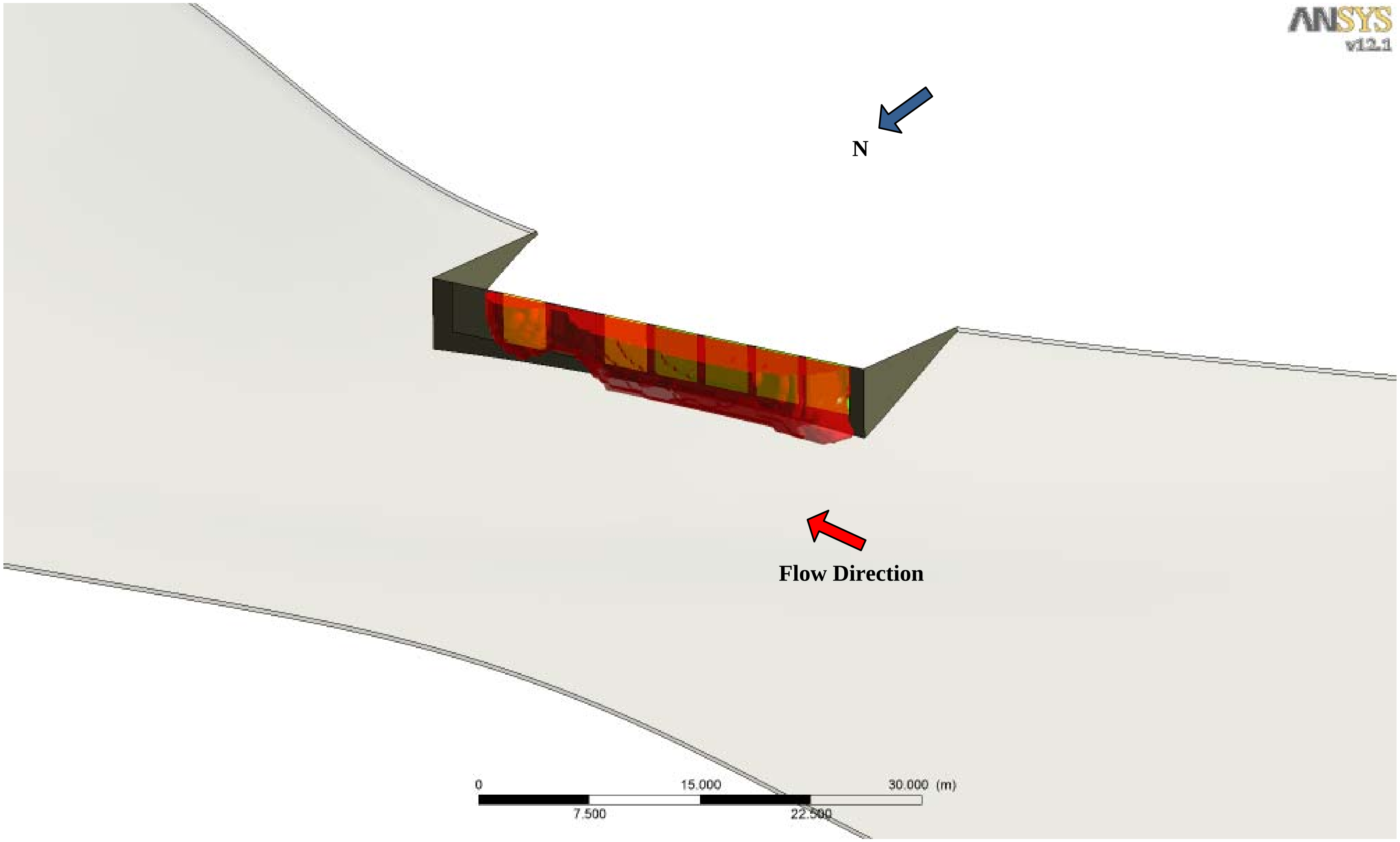

Figure 10 – Hydraulic zone of influence (indicated in red) for Scenario 3.

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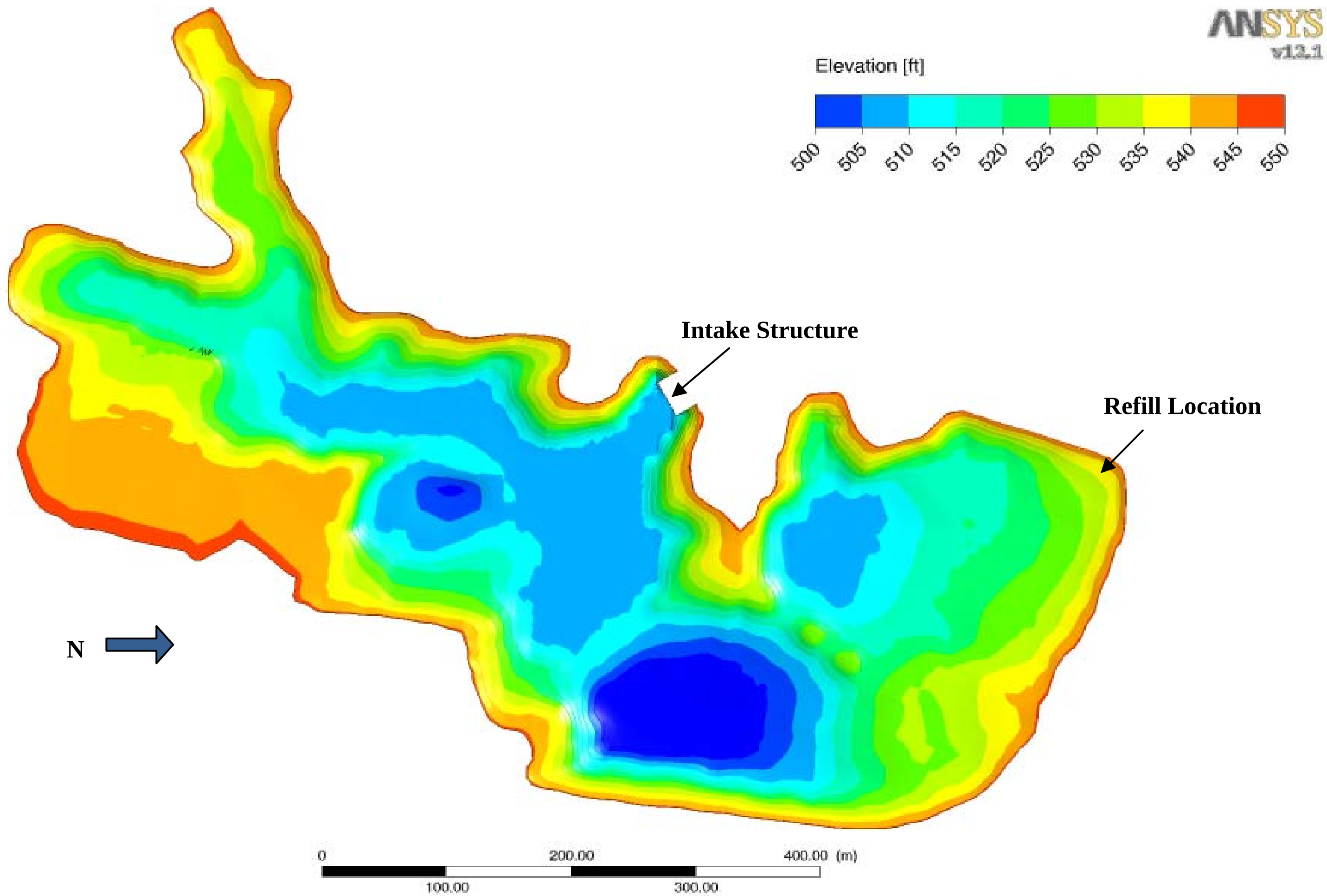

Figure 11 – Model of Pond A showing surface elevations and intake and refill locations.

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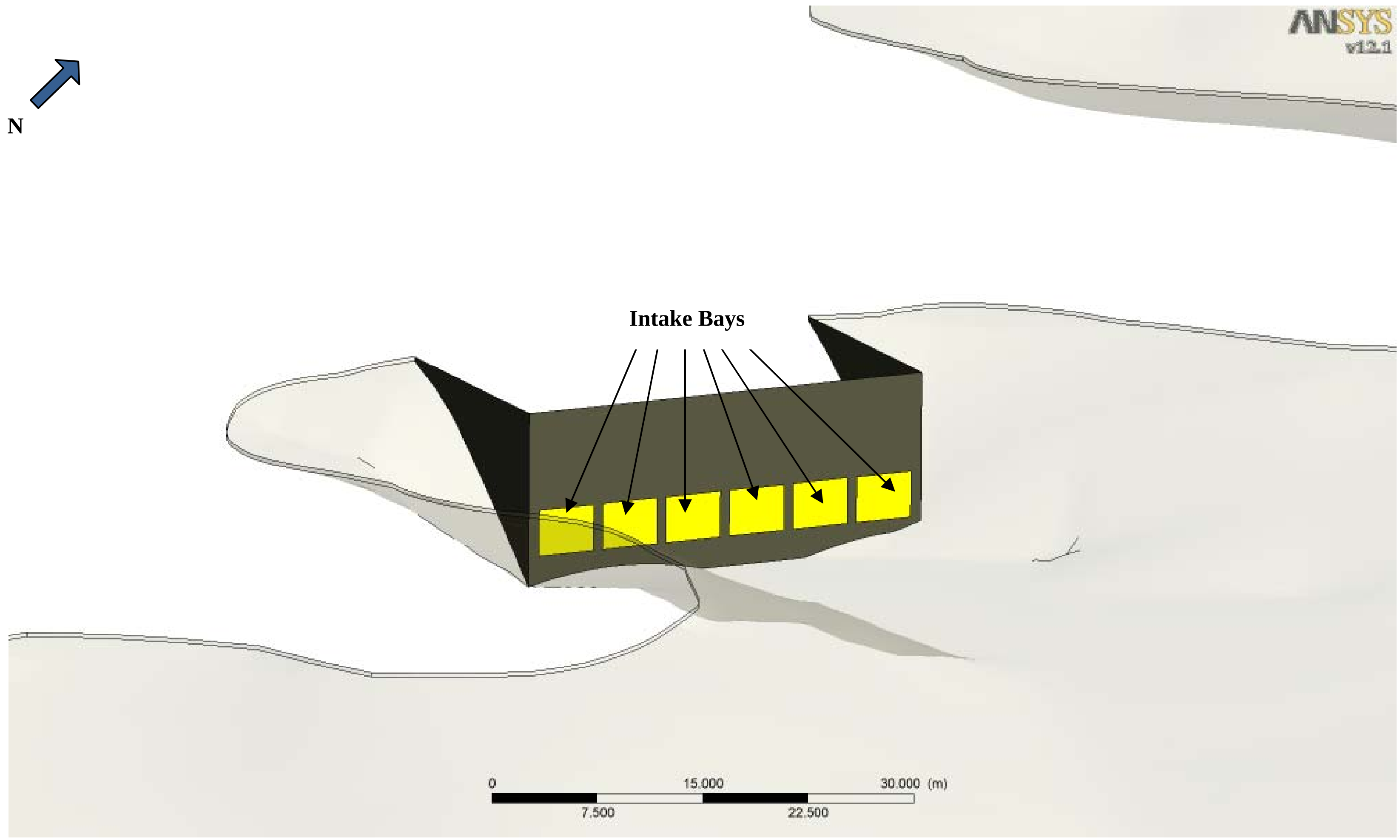

Figure 12 – Pond A intake structure showing six pump bays (yellow).

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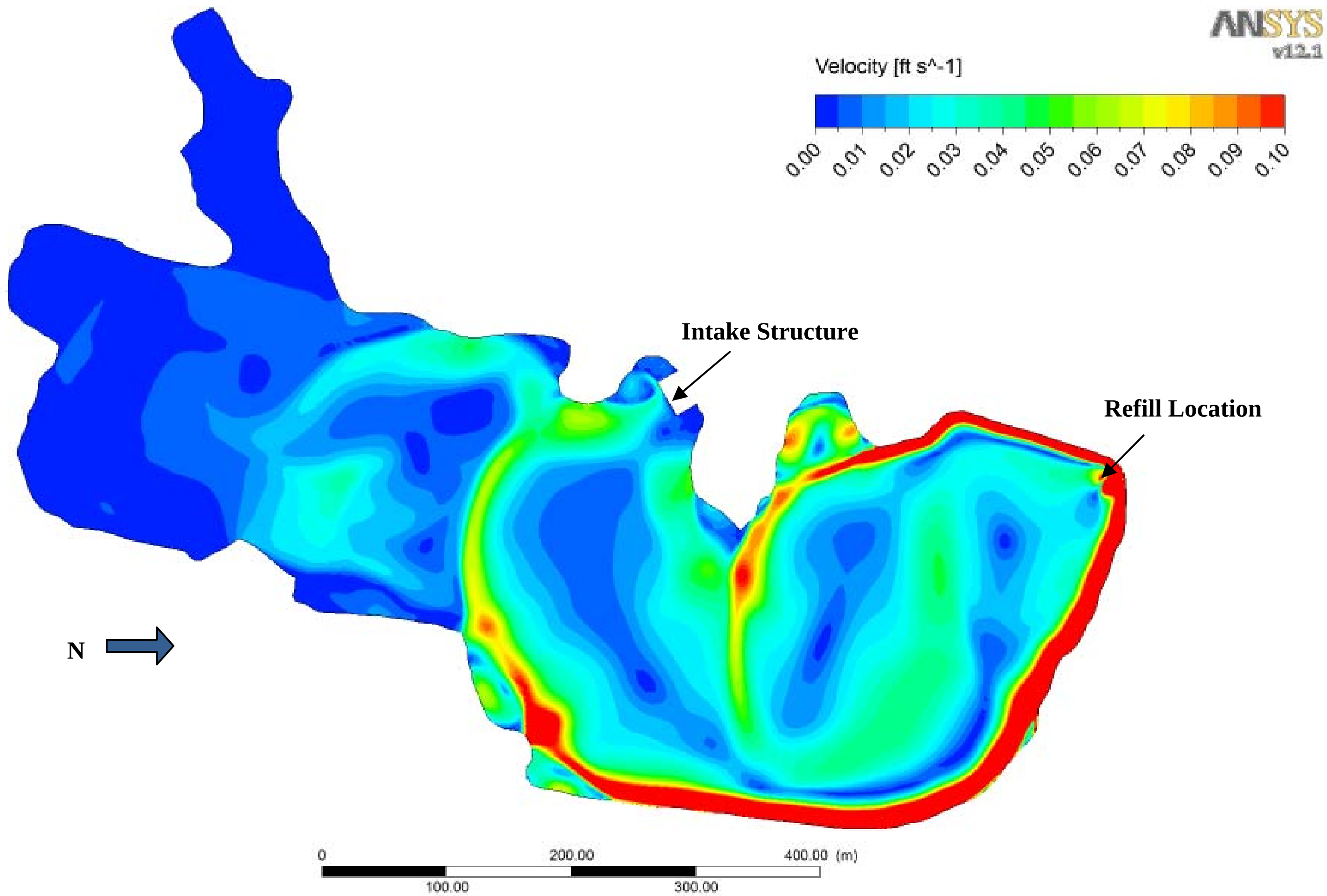

Figure 13 – Velocity contours for Pond A, Scenario 1.

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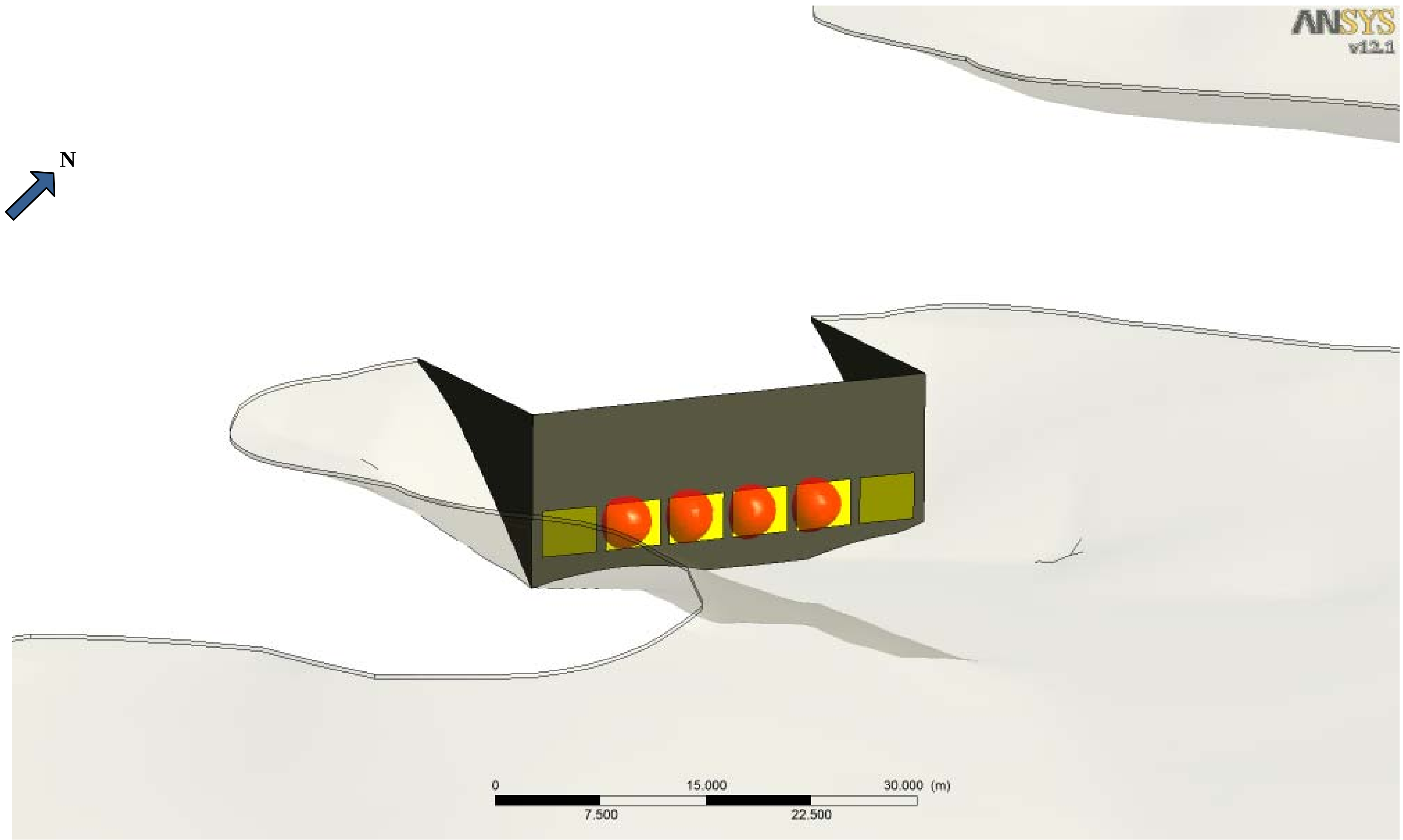

Figure 14 – Pond A hydraulic zone of influence (indicated in red) for Scenario 1; four middle bays active.

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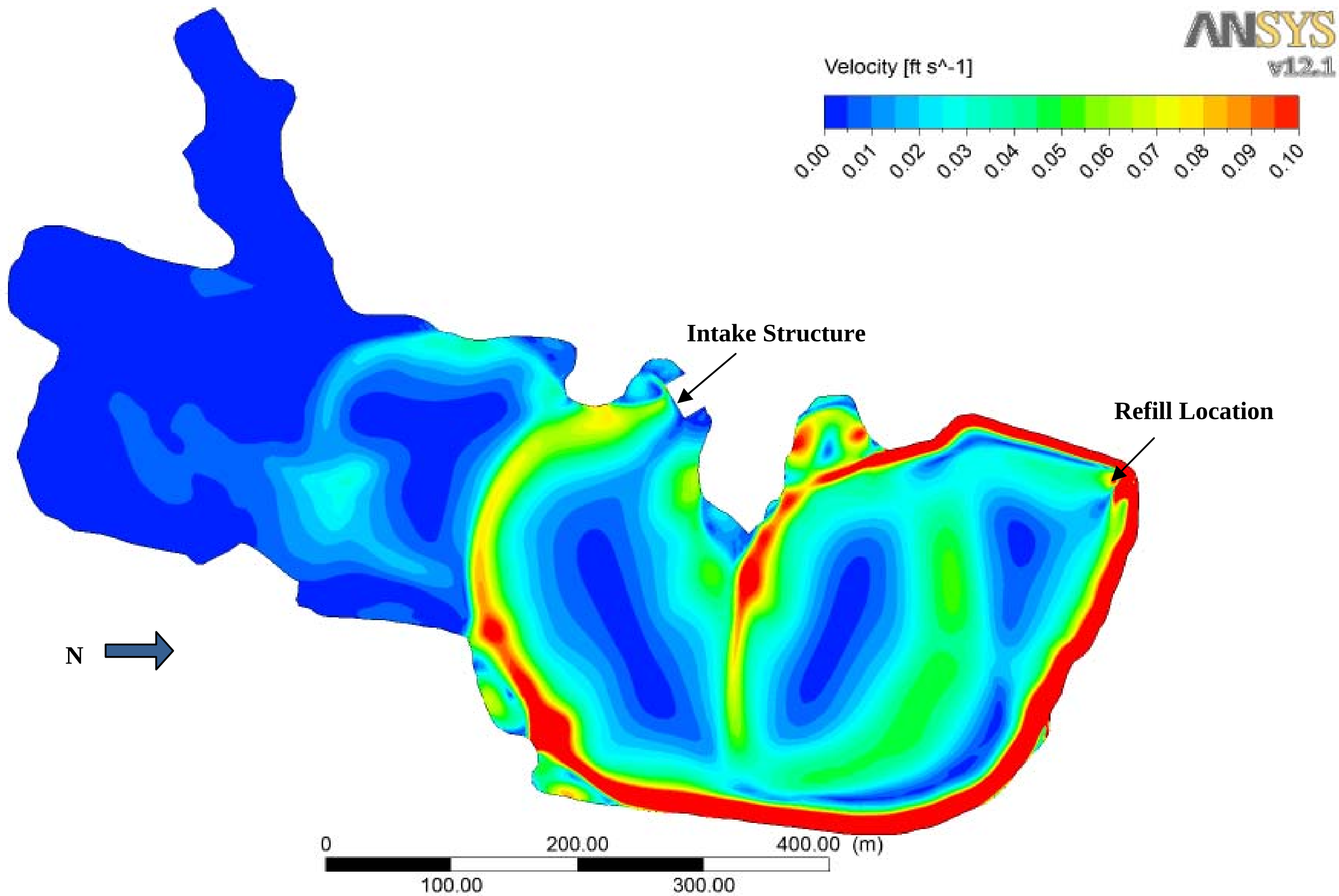

Figure 15– Velocity contours for Pond A, Scenario 2.

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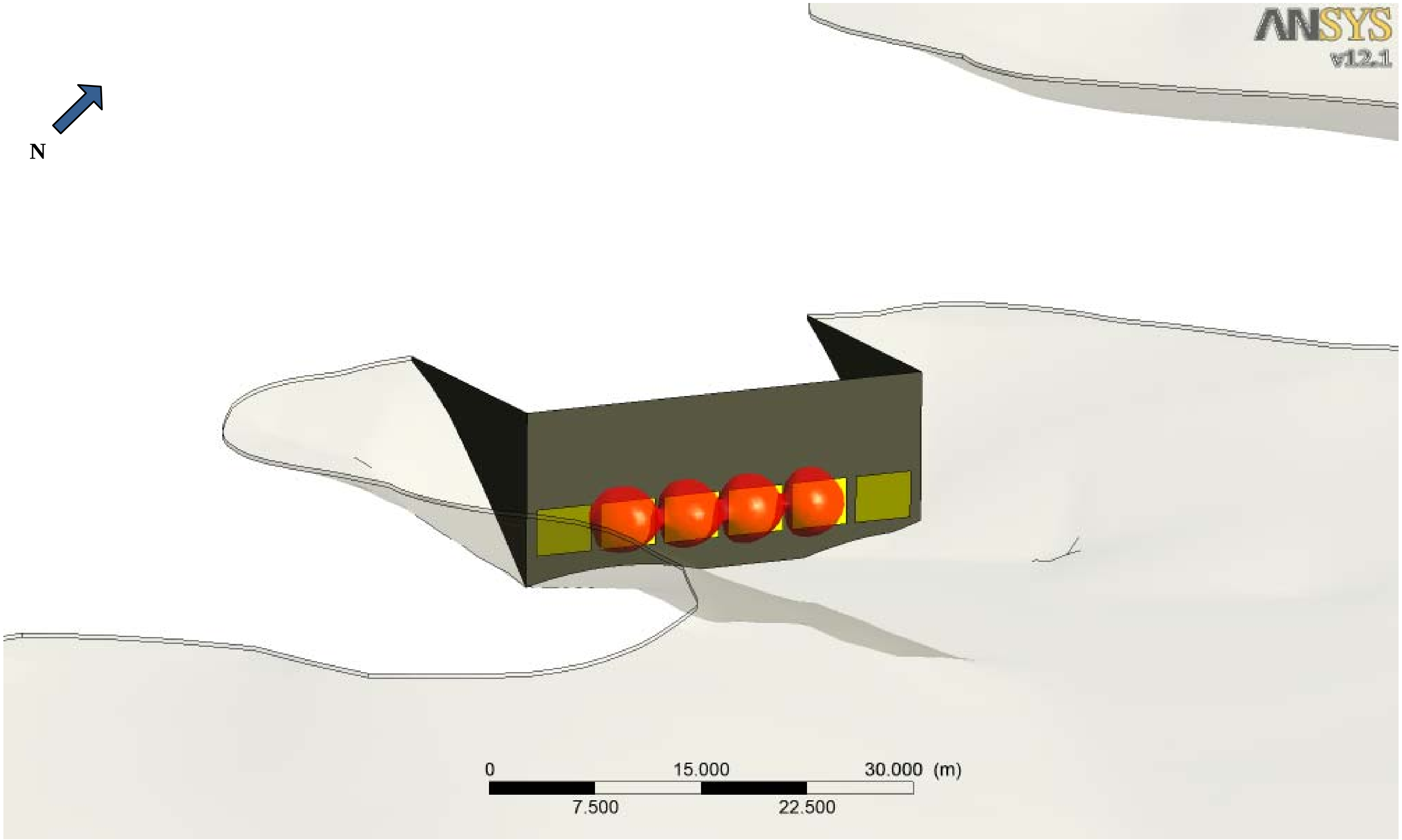

Figure 16 – Pond A hydraulic zone of influence (indicated in red) for Scenario 2; four middle bays active.

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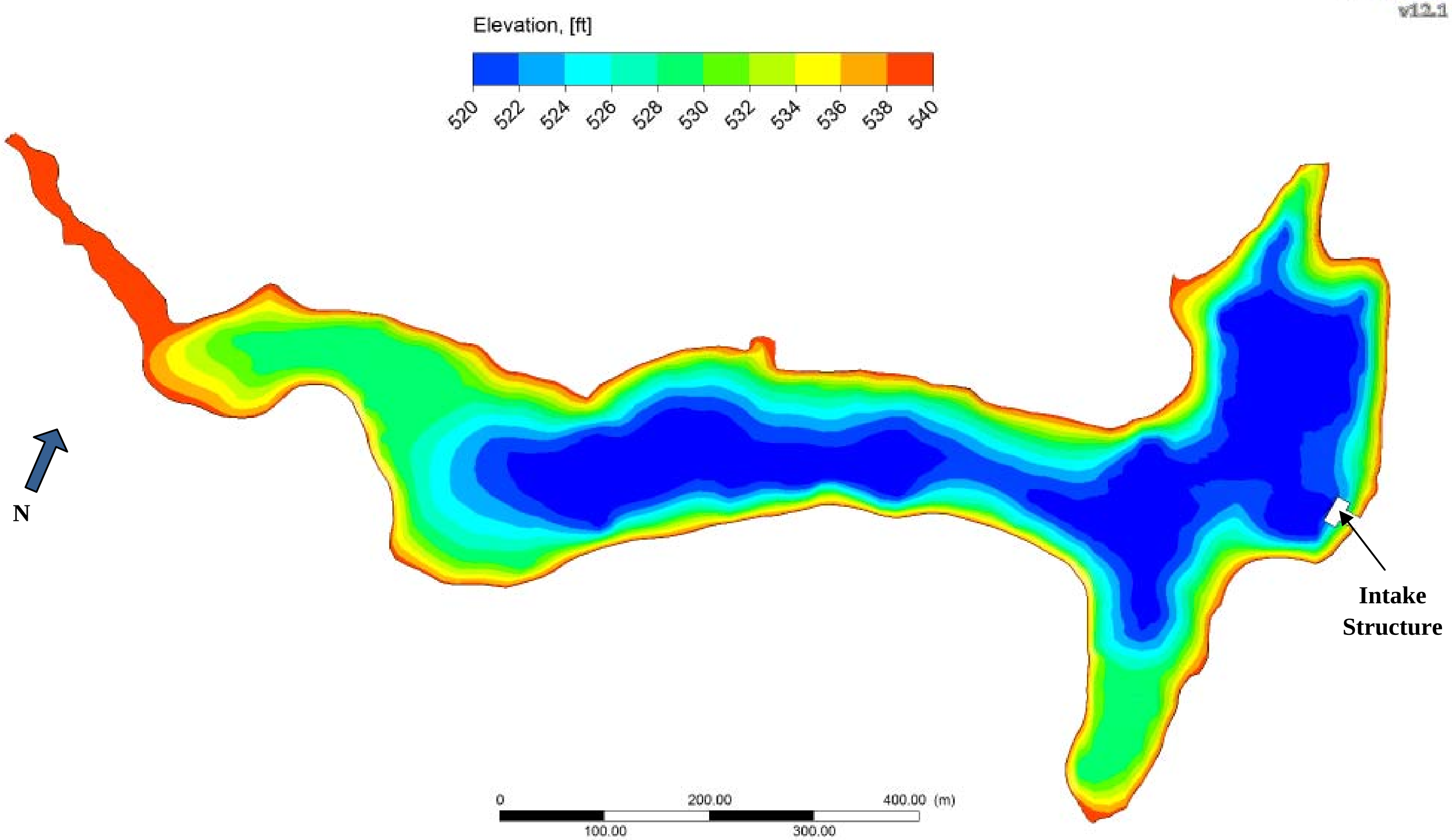

Figure 17 – Model of Pond B showing surface elevations and intake location.

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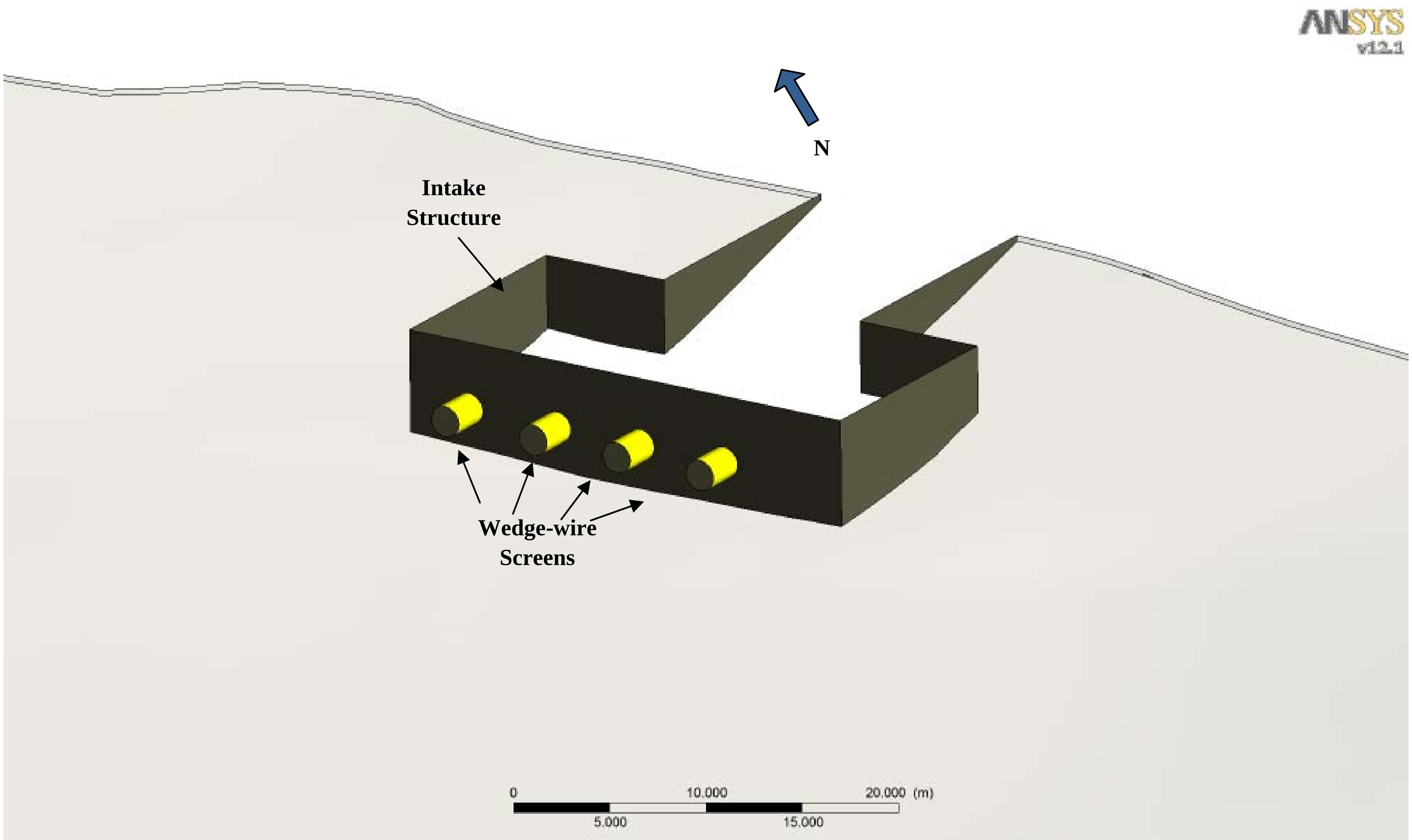

Figure 18 – Pond B intake structure showing intakes in yellow.

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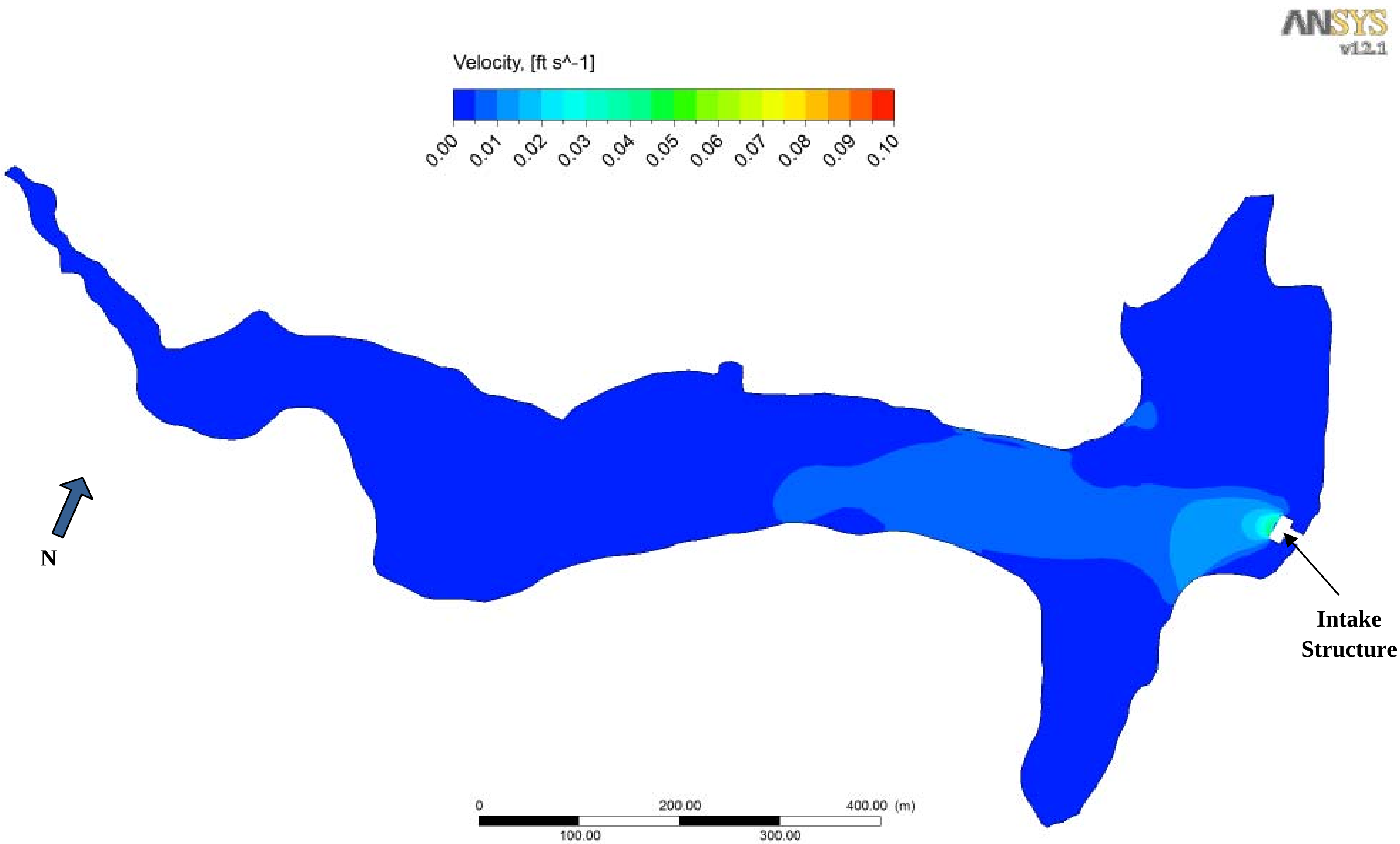

Figure 19 – Pond B velocity contours.

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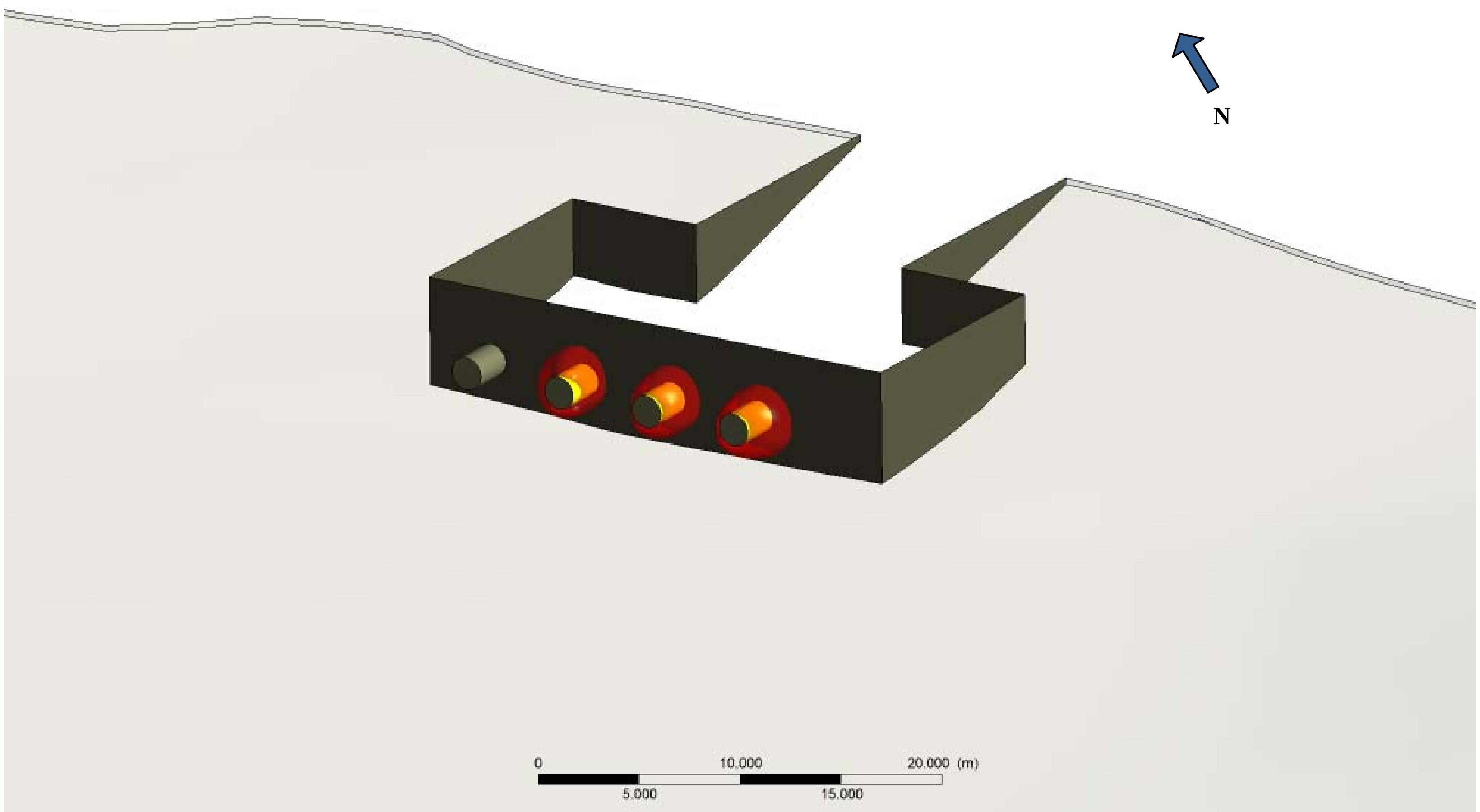

Figure 20 – Pond B hydraulic zone of influence (indicated in red) for the two intake structure pump bays.

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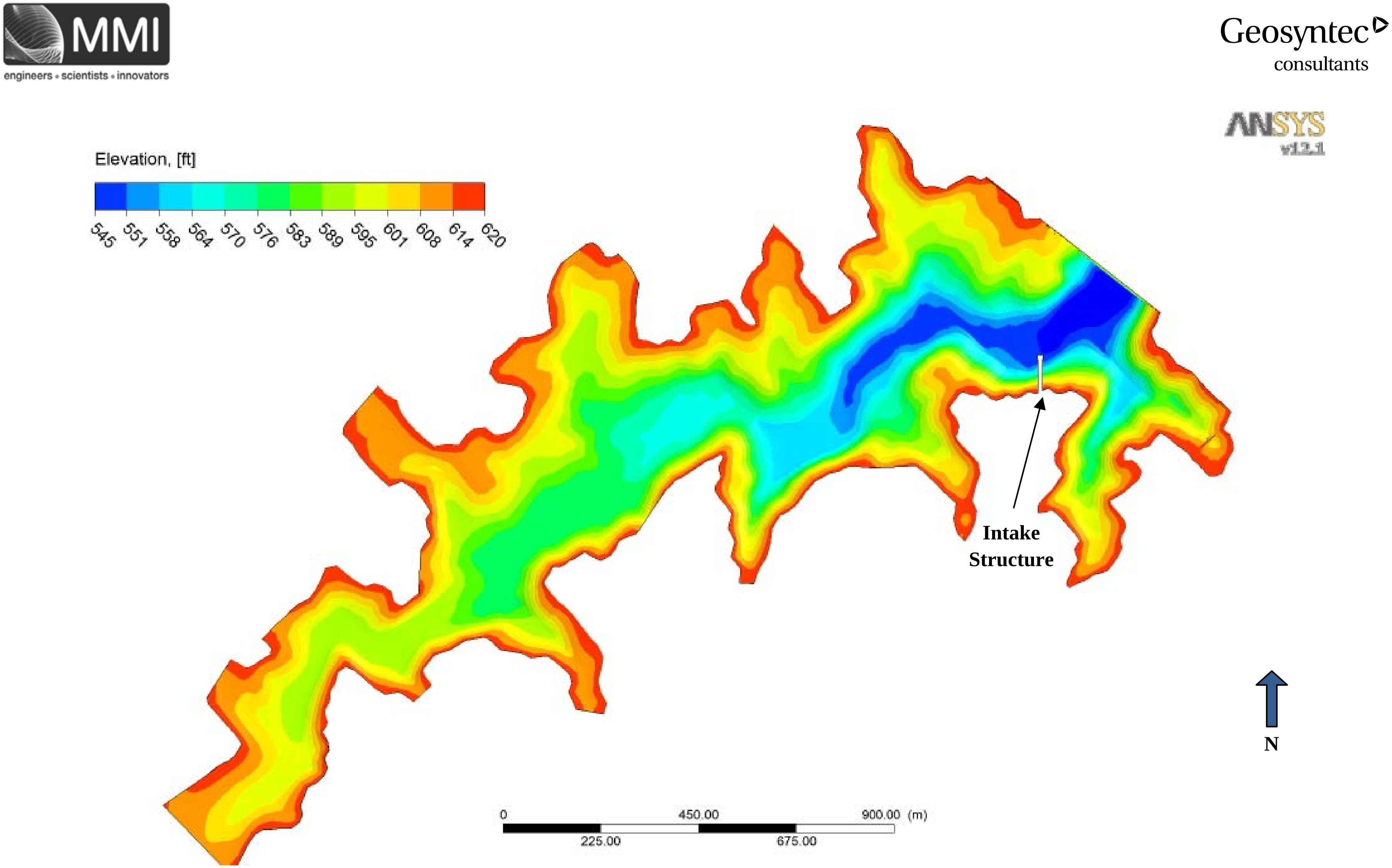

Figure 21 – Model of Pond C (30 ft drawdown) showing surface elevations and intake location.

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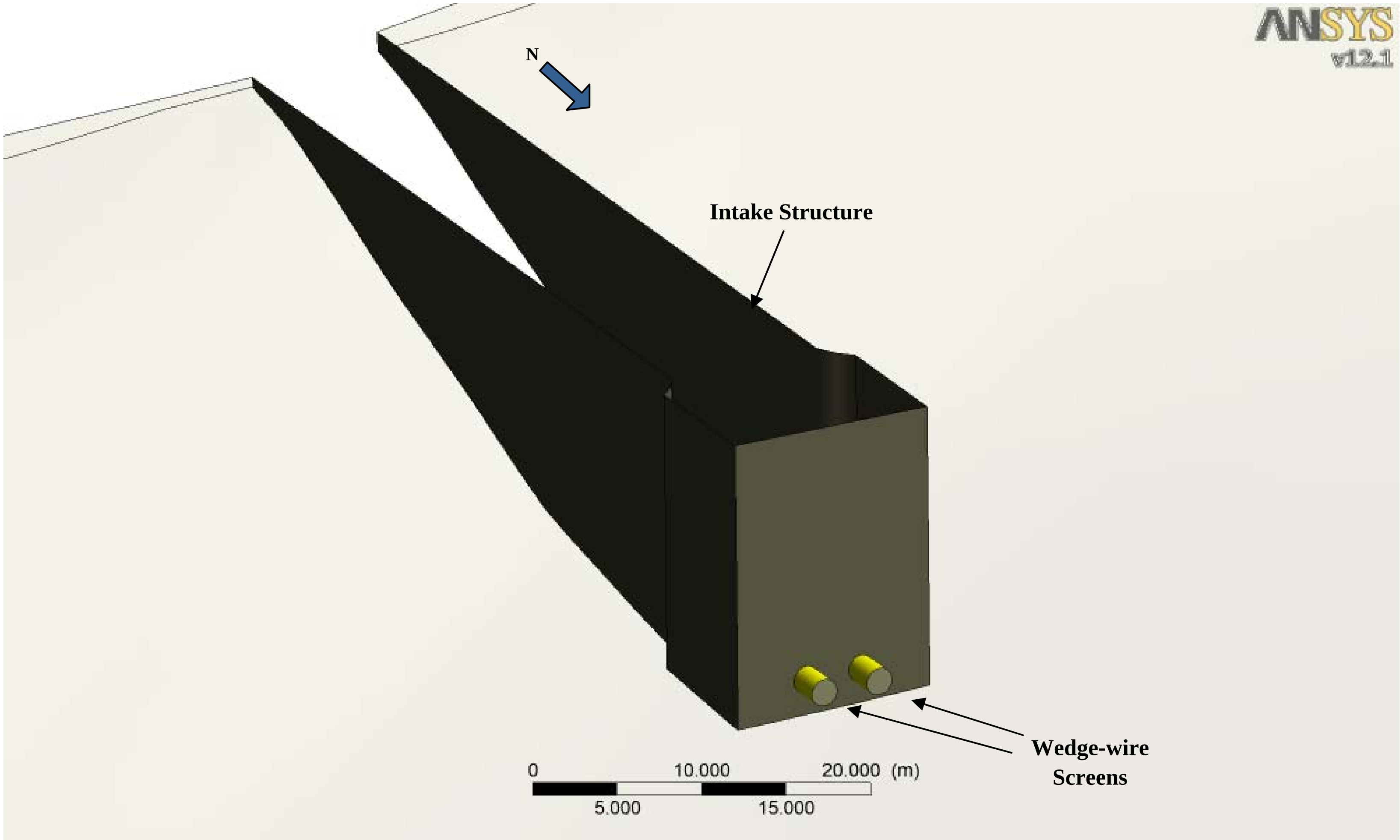

Figure 22 – Pond C intake structure showing pump bay intakes (wedge-wire screens).

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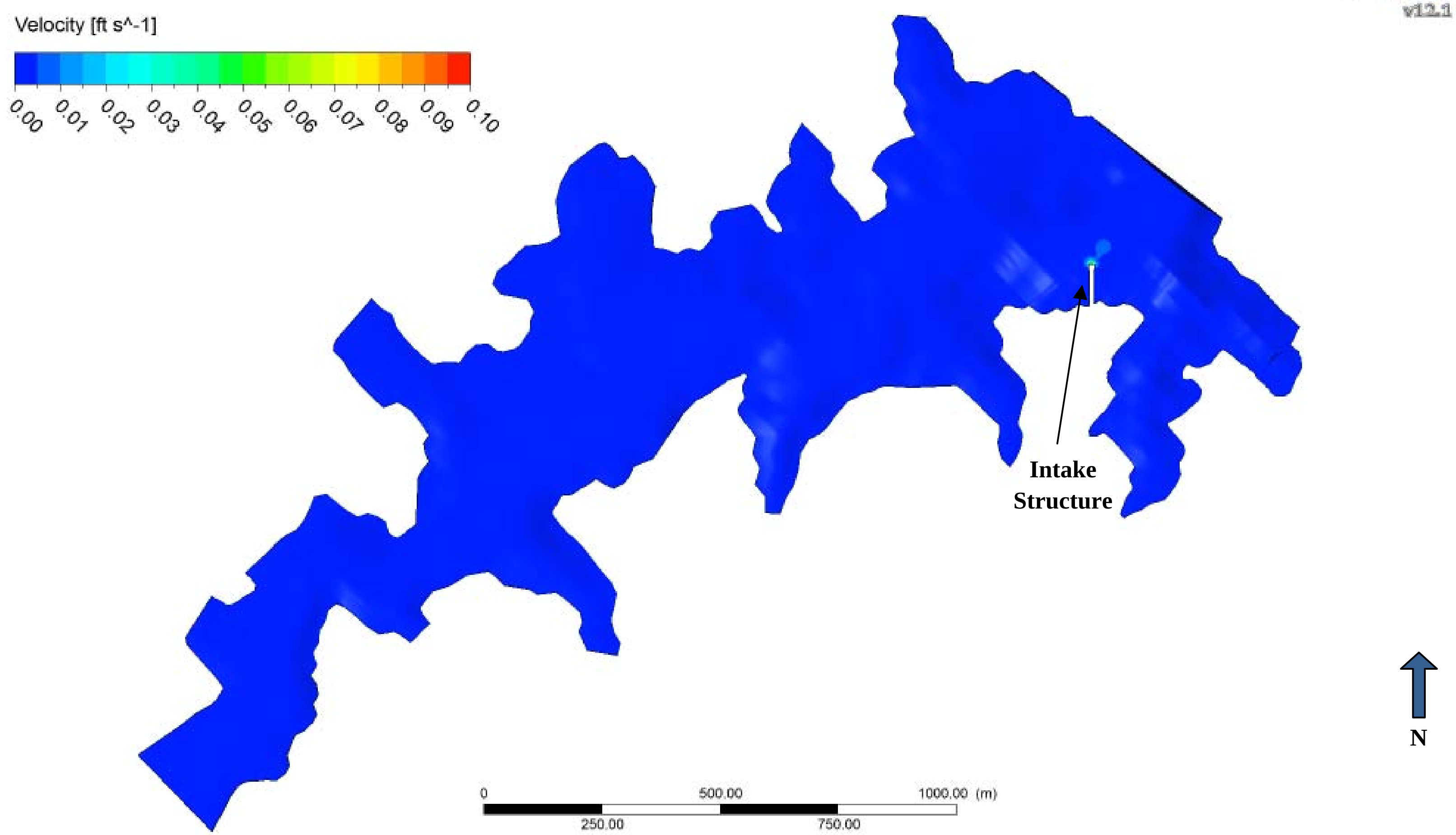

Figure 23 – Pond C velocity contours, 30 ft drawdown.

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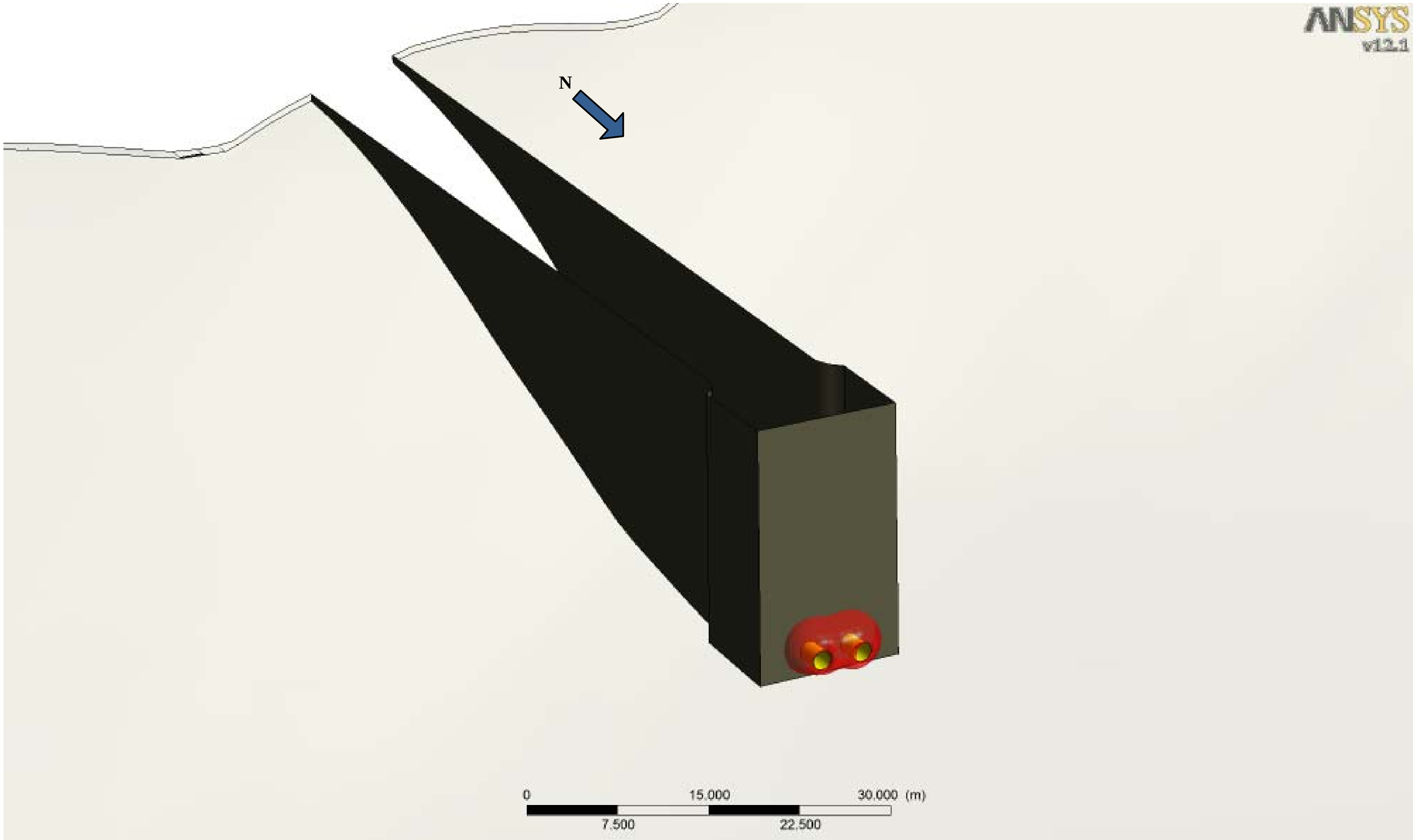

Figure 24 – Pond C hydraulic zone of influence (indicated in red) for the single intake structure pump bay, 30 ft drawdown.

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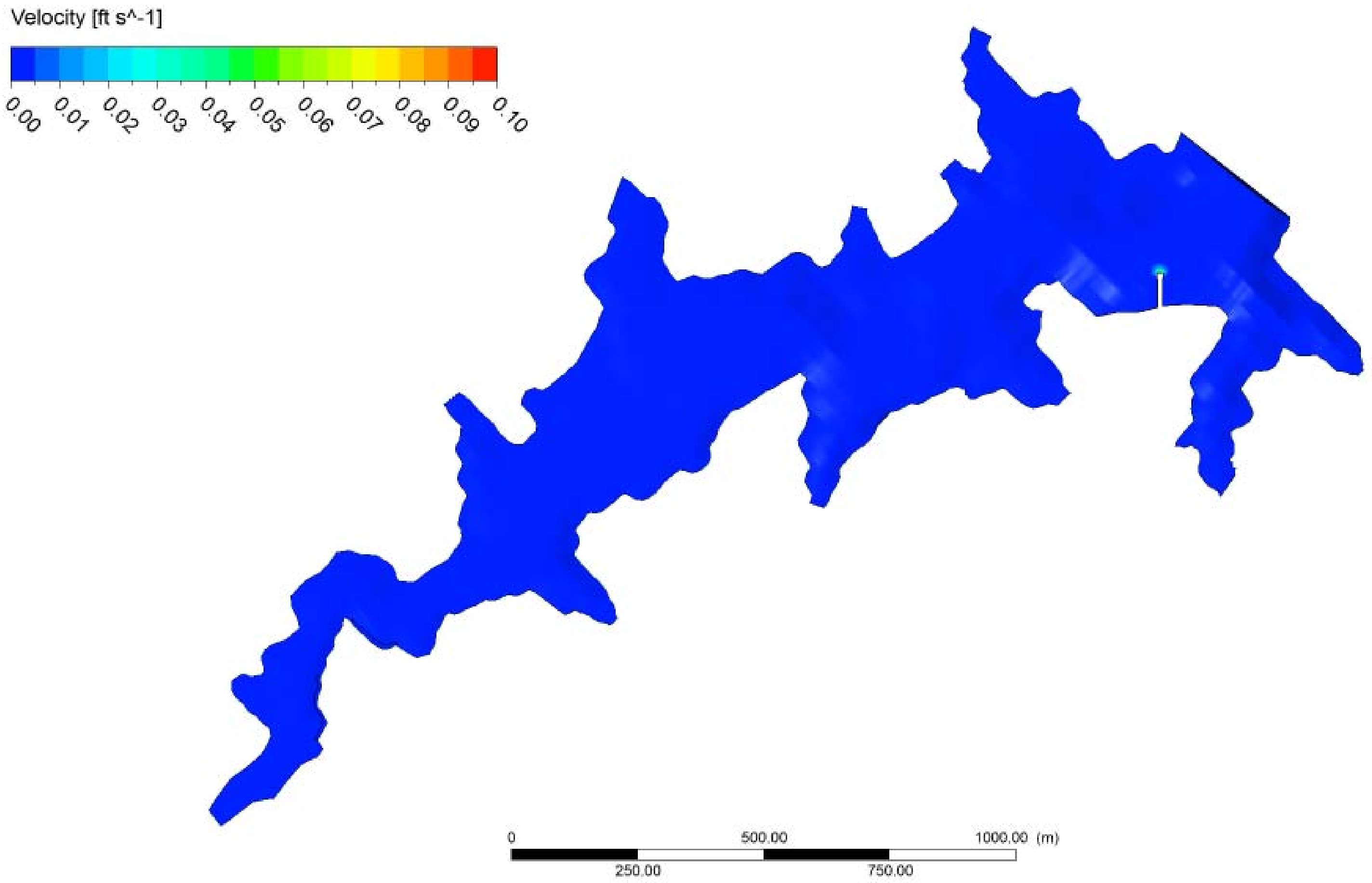

Figure 25 – Pond C velocity contours, 45 ft drawdown.

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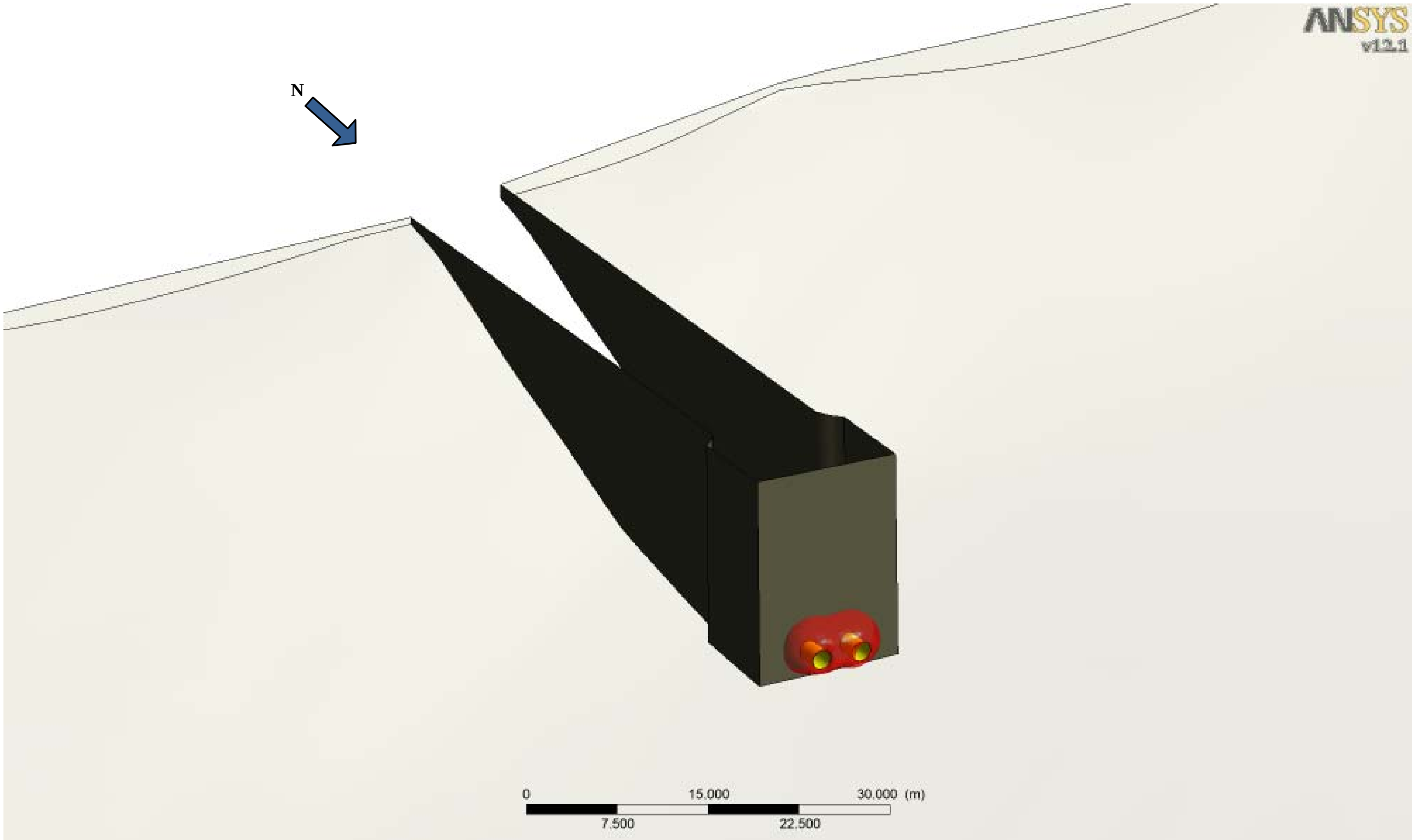

Figure 26 – Pond C hydraulic zone of influence (indicated in red) for the single intake structure pump bay, 45 ft drawdown.

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ATTACHMENT B.1

Details of the CFD Model

DETAILS OF THE CFD MODEL

1. GEOMETRY AND MESH

The elevation data required to describe the bottom surfaces for the river and pond simulations were digitized from bathymetry data in References [B.1, B.2, and B.3]. The exception was the model for Pond C, where the bottom surface was interpreted from digital elevation data for existing land contours. In all models the surface of the river or pond was set to the correct height; thus, two separate meshes were created for the river scenarios, as two surface elevations were used.

The number of cells in the models ranged from around 500,000 cells in the river scenarios to nearly 1,000,000 cells for Pond C. In all cases a mesh resolution of approximately one-tenth of the size of the intakes was used around the intake structure, with considerably larger cells in regions in the far-field. In all cases, the mesh was 10-15 cells deep (i.e., 10-15 control volumes from the surface to the bottom at any one point). The velocity gradients in the vertical direction were small enough so that this resolution is appropriate, and typical for CFD models. In the vicinity of the intake structures, the cells have been refined by a factor of 3 (30-45 control volumes in the vertical direction) to provide additional resolution.

Please refer to Figures B.1-1 through B.1-6 in this Attachment for graphical depictions of the CFD geometry and computational mesh for the river and pond models.

2. BOUNDARY CONDITIONS

2.1 <u>River Simulations</u>

On the upstream face of the river section, perpendicular to the river flow, an inlet boundary condition was employed. A mass flow condition was set at this inlet. On the downstream face, a zero-pressure opening boundary condition was set, with zero-gradient for all variables. The bottom and sides of the river were set as no-slip walls, while the surface was set to a free-slip wall.

The intake structure was set to a no-slip wall boundary condition, while the intakes were set to outlets. A mass flow was set at each intake, which was equivalent to the flow rate withdrawn through the intake by the pump in the pump bay. The velocity at the intakes is therefore part of the solution (the CFD code does not constrain the velocity to be perpendicular to the intake face), which is a more realistic boundary

condition than the alternative of specifying a uniform perpendicular velocity; as the flow is unlikely to enter the intakes at a uniform angle perpendicular to the intake structure, due to the ambient flow direction of the river.

2.2 Pond Simulations

A no-slip wall boundary condition was used on the bottom and sides of the ponds, as well as the intake structure, while a free-slip boundary condition was used on the water surface. The bay intakes (for Pond A) and wedge-wire screen intakes (for Ponds B and C) were set to outlets with the mass flow divided equally between all intakes/ screens. For Pond A, inlet boundary at the refill pipe outlet was used to represent the refill flow from the primary section of the river intake. However, for Ponds B and C the only boundary conditions were walls and outlets, a situation that would inevitably end with the model crashing due to the intractability of the pressure (if flow can only go out of the domain without being replaced, the negative fluid imbalance causes the pressure to drop unrealistically and eventually causing out-of-bounds errors). To account for this, a mass source equal to the intake was set equally over all cells of the computational domain, purely to keep the pressure to a sensible value while causing no other impact to the flow (i.e., this would not result in a net momentum source). While this is an unusual approach, it was considered the best alternative. For example, if an inlet is placed at some point in the domain, this will induce spurious flows in the pond that do not reflect the physical reality. A free-surface or a deforming mesh (surface compression) approach was possible, although highly computationally expensive especially considering that the very low reduction in surface velocity (typically on the order of 1 inch per hour) would not cause significant flow velocities that would change the flow patterns in the lake or would affect the size of the HZI.

3. COMPUTATIONAL MODELS

3.1 Thermodynamic

A constant density was set for the water fluid in the domain of 998 kg/m^3.

3.2 Turbulence

The shear-stress transport model (SST) was used for all simulations, which is a blend of the well-recognized k-ε and k-ω turbulence models [Reference B.4].

4. NUMERICS

4.1 Model

All simulations were performed using Ansys-CFX 12.0, a widely recognized industrial CFD software package. For the river simulations, the model was run in transient mode as transient instabilities in the flow field were observed in the CFD calculation – the results described in this report, and used to obtain the hydraulic zones of influence (HZI), are time-averages. For the pond models the model was run in steady-state mode as similar transient instabilities were not observed.

4.2 Discretization

For the river simulations, “High Resolution” spatial discretization was used, which is second-order except where the numerical restriction of boundeness is violated, in which case a blend of first- and second-order is used (including pure first-order if required) for numerical stability. Second-order time discretization was employed for the transient river simulations. First-order spatial discretization was required for the pond simulations for numerical stability. Although this results in greater numerical diffusion (i.e. gradients are leveled because of the reduced order representation) the spatial gradients are generally so low in this case that the source of numerical error is not significant.

4.3 Convergence

The transient CFD simulations (rivers) were set to a convergence criterion of 1e-04 on the RMS normalized residuals, which was obtained in all cases. A convergence criterion of 1e-05 was used for the steady-state pond simulations. These criteria comply with the guidelines for the ANSYS-CFX solver.

5. REFERENCES

[B.1] *Conceptual Design Package for RWS*, Report prepared by Shaw Nuclear, Document Ref. 11887902-F-RWS-CDP-0, 2009.

[B.2] *Site Plan – East Lee Nuclear Station Units 1 & 2*, Drawing Ref. WLG-0000-X2-005 Rev. C, 2009.

[B.3] *Lee Nuclear Station Reservoirs Bathymetry Report*, Report prepared by Devine Tarbell and Associates for Duke Energy Carolinas LLC, 2007.

[B.4] *Two-equation eddy-viscosity turbulence models for engineering applications*, Menter, F. R., AIAA Journal 32(8), pp. 1598-1605, 1994.

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6. FIGURES

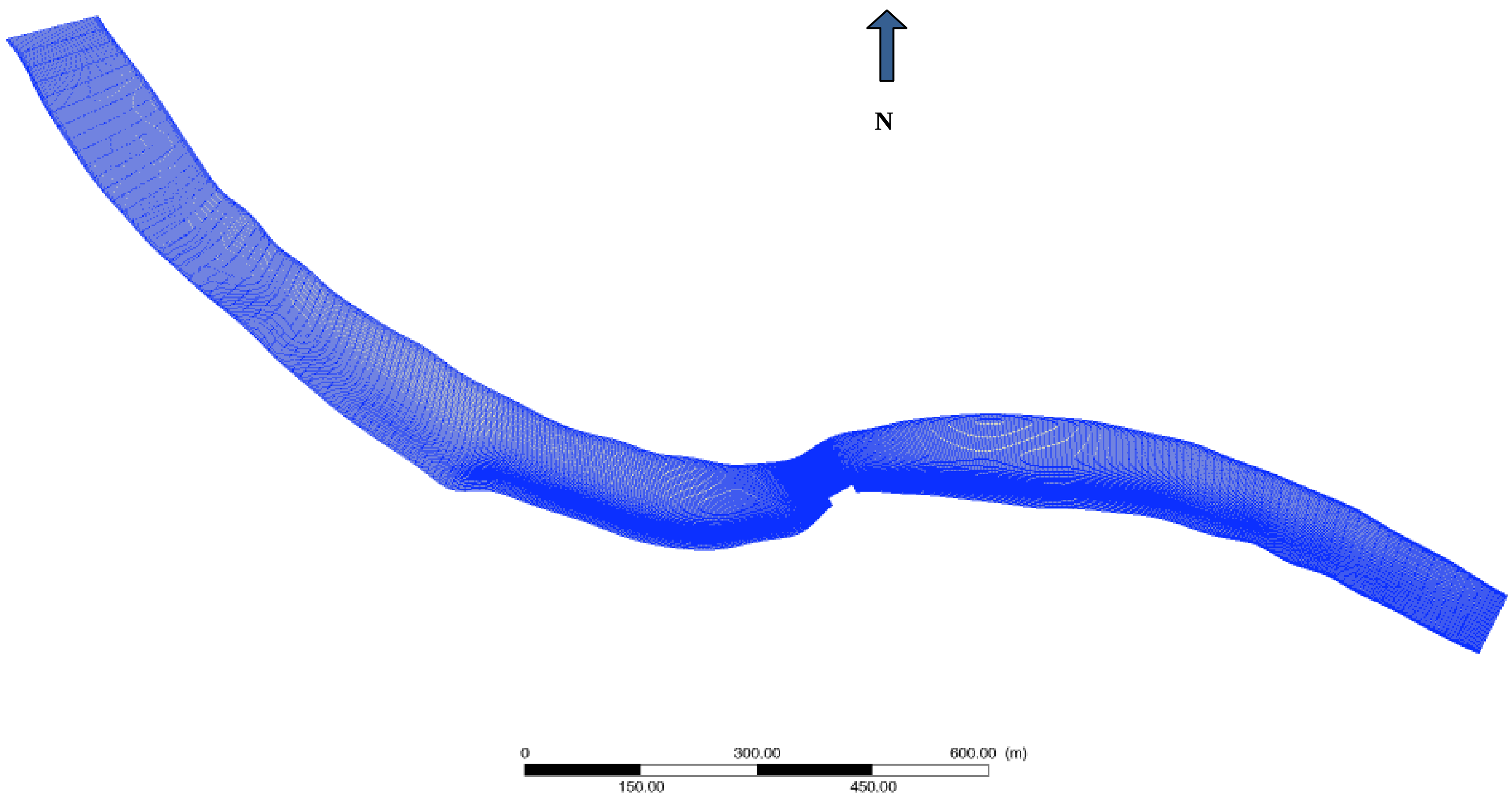

Figure B.1-1 – Computational mesh for the river scenarios

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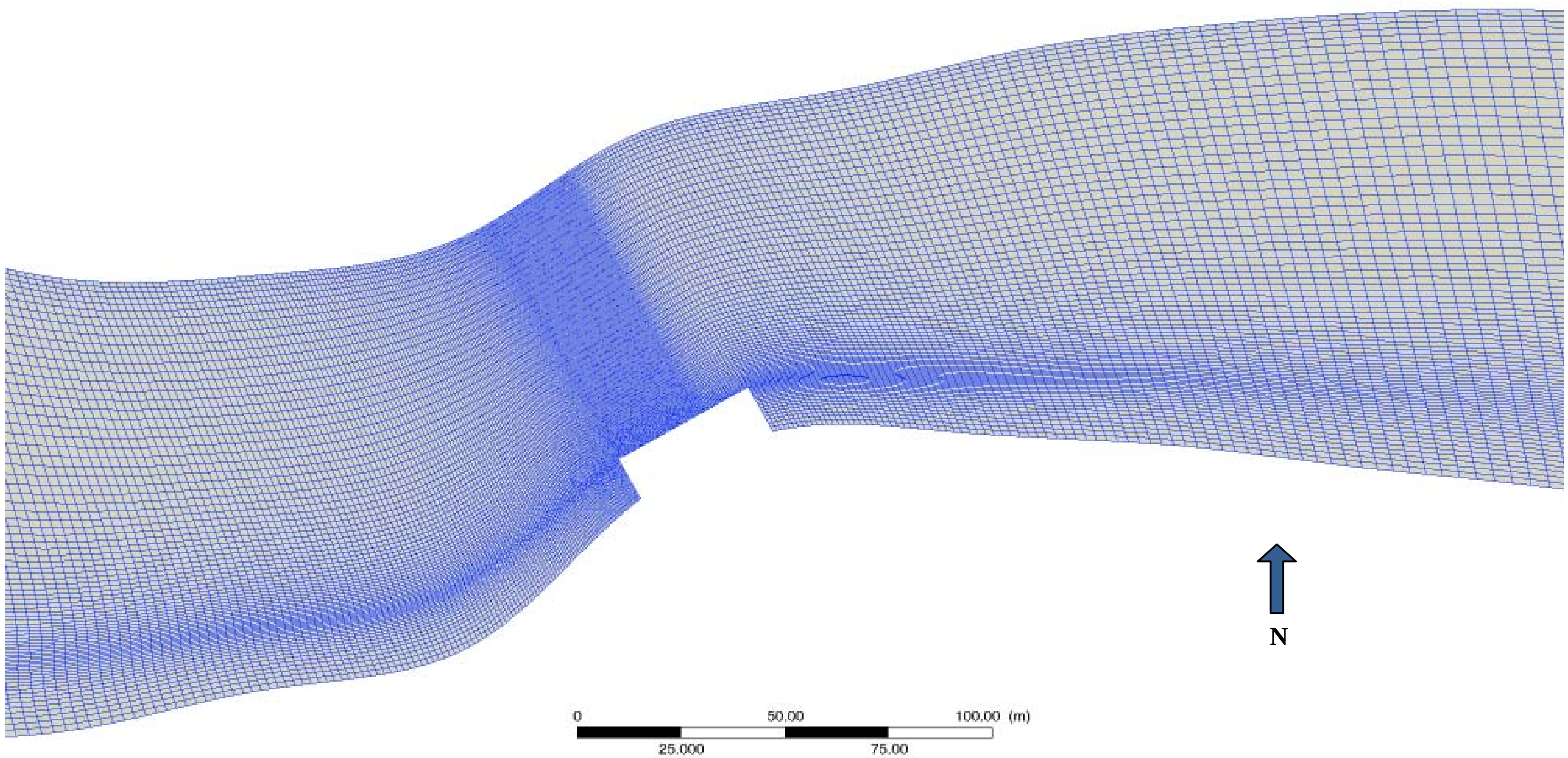

Figure B.1-2 – Close view of Computational mesh showing refinement around the primary cooling water intake structure.

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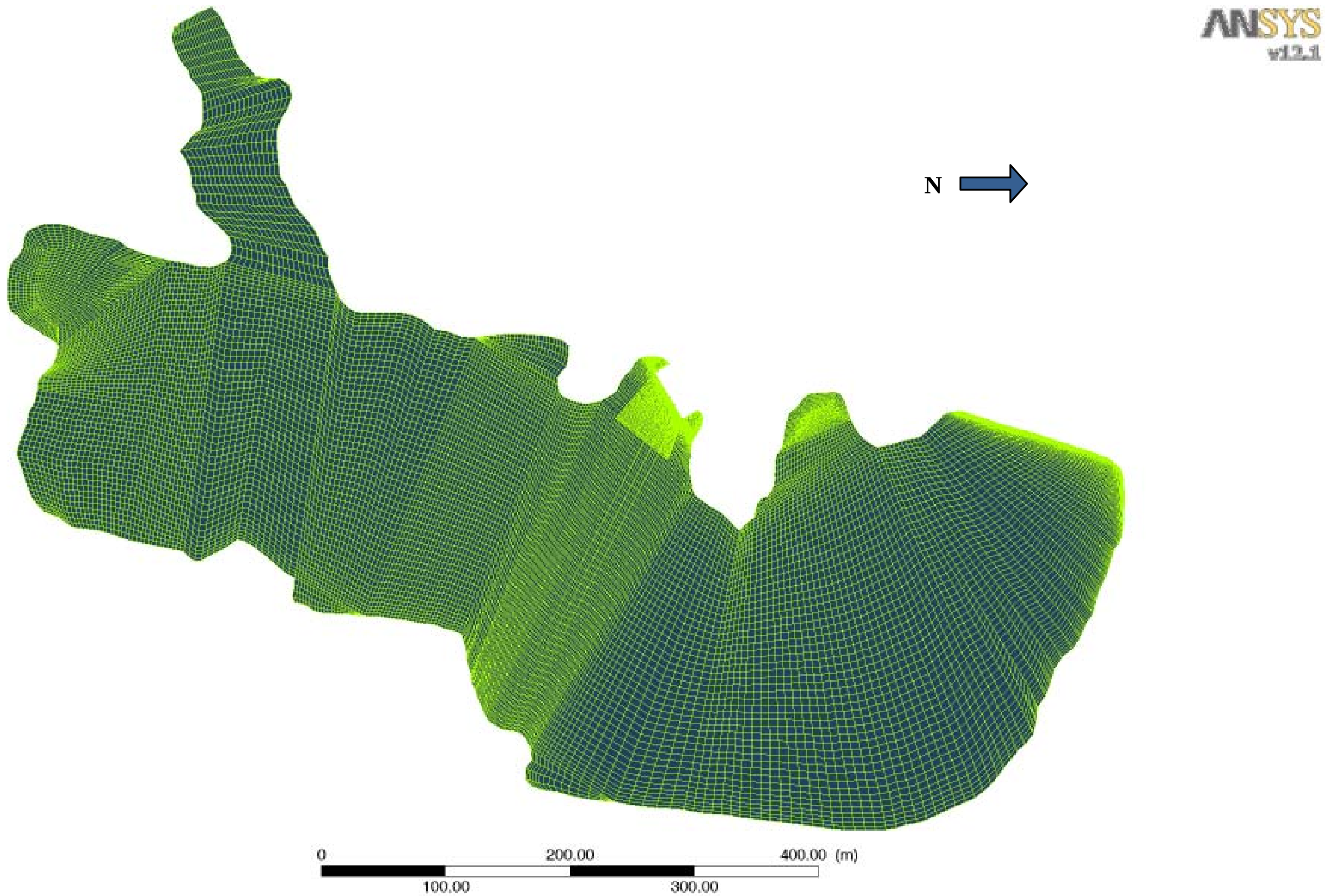

Figure B.1-3 – Computational mesh Pond A.

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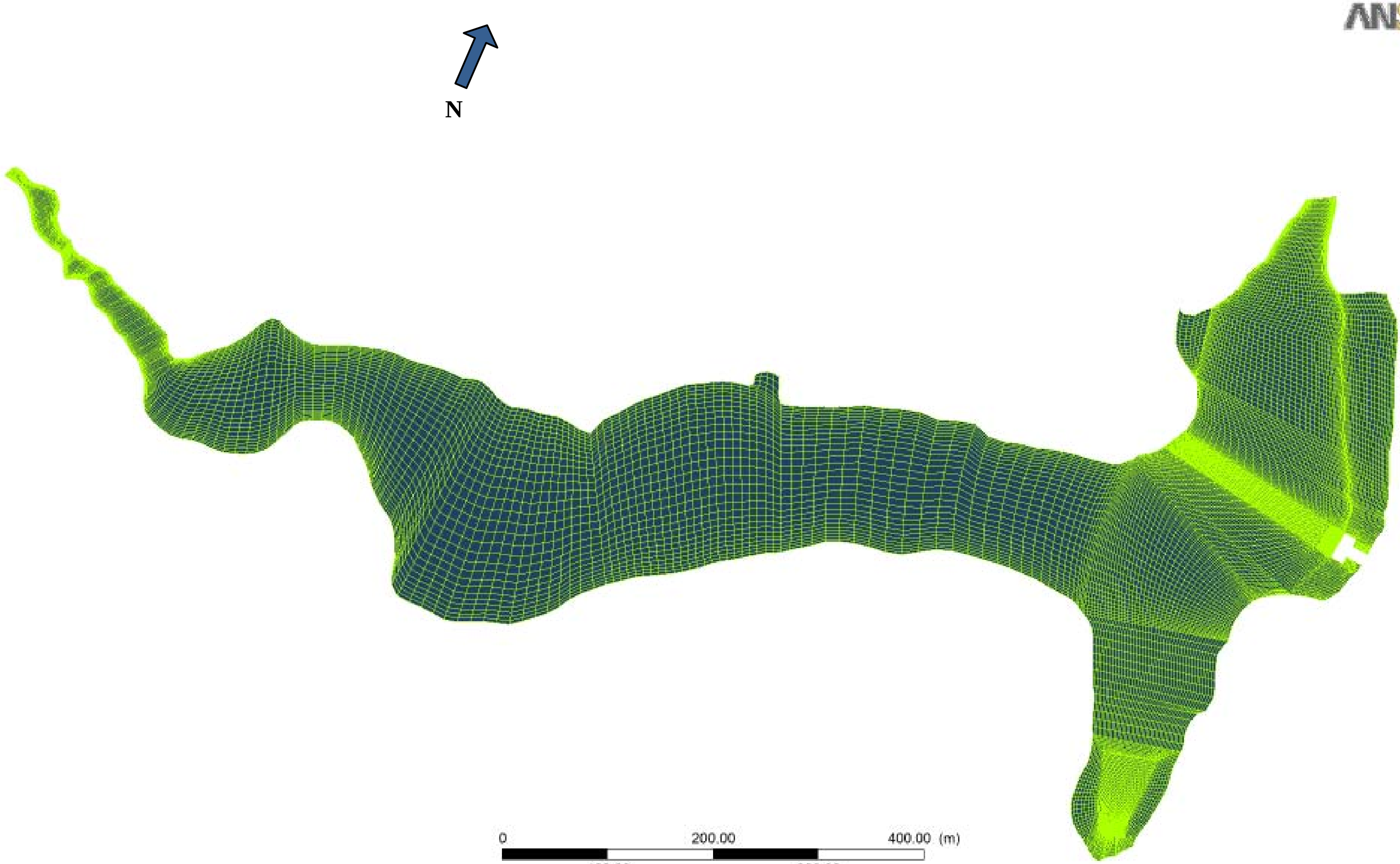

Figure B.1-4 – Computational mesh for Pond B.

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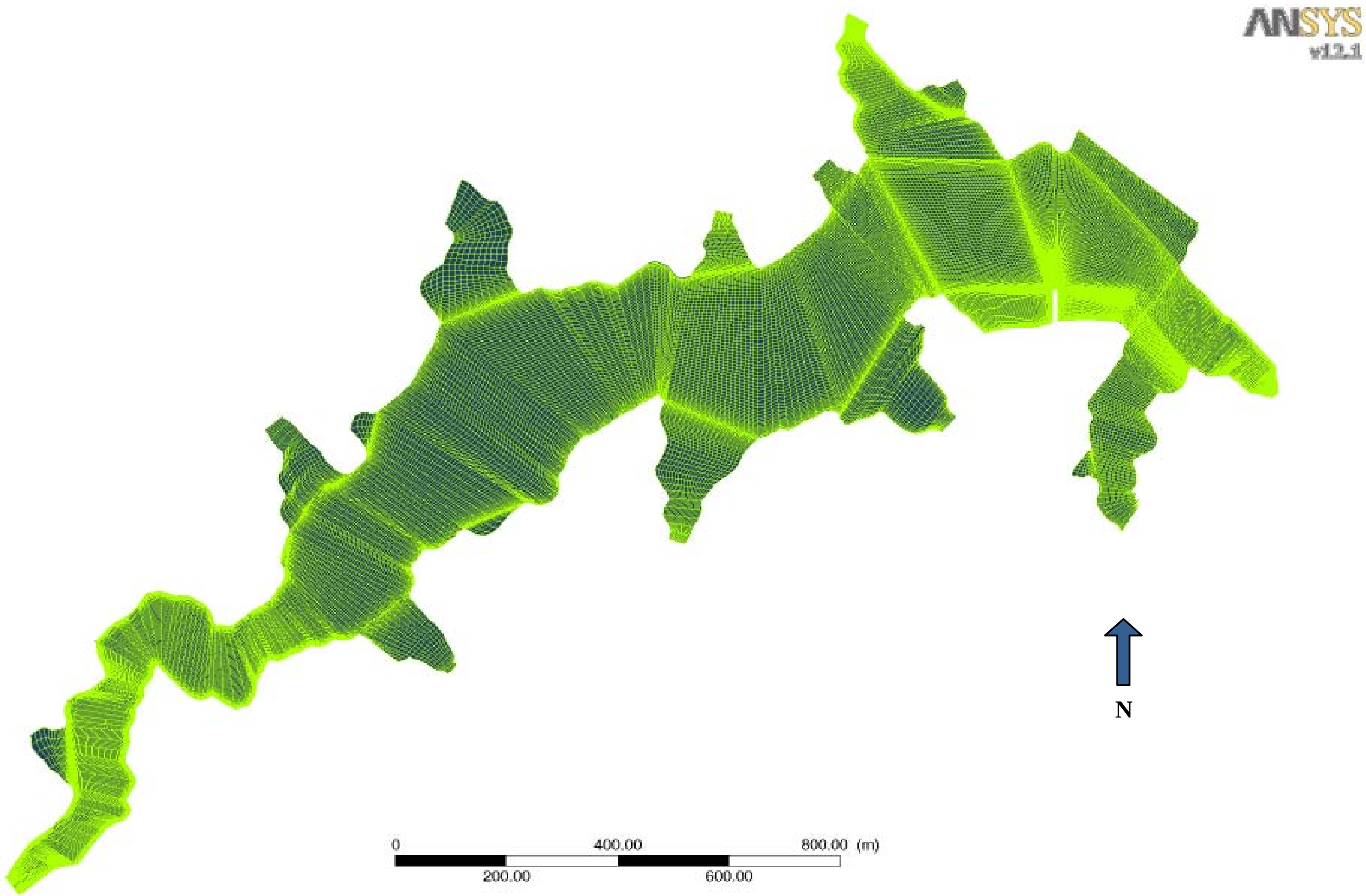

Figure B.1-5 – Computational mesh for Pond C – 45 ft drawdown.

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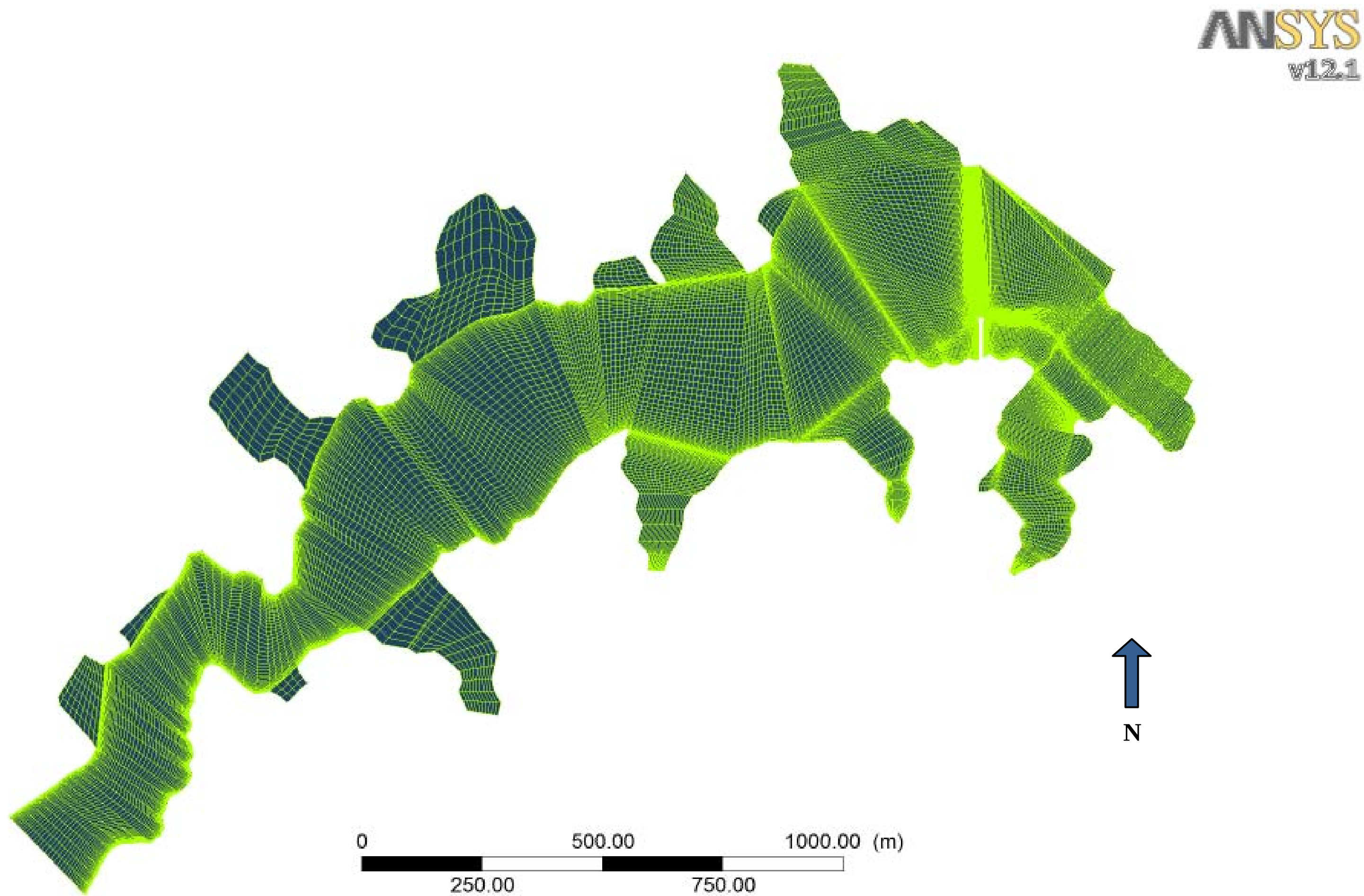

Figure B.1-6 – Computational mesh for Pond C – 30 ft drawdown.

Part VII
Appendix C

Engineering Calculations:
Standard RWS Traveling Screen Calculation
and
Standard RWS Passive Screen Calculation

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AP1000

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CALCULATION COVER SHEET

Title: Standard RWS Traveling Screen Calculation

Plant Applicability: ☐ All AP1000 Plants except:

☒ Only the following AP1000 Plant(s): W.S. Lee III Nuclear Station, Units 1 & 2

Calculation no.	Revision	Page	This Document Contains Unapproved Inputs:
WLG-RWS-M3C-012	**0**	**1** of **16**	☒ Yes ☐ No

Attachments: Appendix A, Appendix B

DCP # / REV. Incorporated in this revision: **NA**

Safety Classification: **E**

Comments: N/A

	Print/Sign	Date	For Pages
Prepared By:	M. Austin/ *(signature)*	7/28/11	All
Reviewed By:	R. Brezina/ *(signature)*	7/28/11	All

SOUTH CAROLINA CERTIFICATE OF AUTHORIZATION STONE & WEBSTER, INC. NO. C00888

SOUTH CAROLINA REGISTERED No. 5871 ENGINEER ROBERT M. DULIN, JR. *(signature)* 7/28/11

PE Stamp and Certification
Stone & Webster, Inc.
Charlotte, NC 28202

Design Verification Method: ☒ N/A ☐ Independent Review ☐ Alternate Calculation ☐ Qualification Testing

Approved By:

S. S. Fong/ *(signature)* — Lead Discipline Engineer — Date: 7/28/2011

Record of Revisions

Rev	Revision Description
0	Issue for permit.

Table of Contents

1.0 Introduction

1.1 Background

The Raw Water System (RWS) River Water Intake consists of two subsystems, the Refill subsystem and the River Water subsystem.

- The Refill subsystem consists of four pumps separated in four pump bays. Each pump has a maximum capacity of 22,500 gpm (REF 3.1.5). These pumps are connected to a common header and will be used to transfer water from the Broad River to either Pond B or Pond C.
- The River Water subsystem consists of four pumps separated in four pump bays. Each pump has a maximum capacity of 20,980 gpm (REF 3.1.1). Two of these pumps are considered in standby. These pumps are connected to a common header and will be used to transfer water from the Broad River to Pond A.

The RWS Raw Water Supply (Pond A) Intake consists of the Raw Water Supply subsystem.

- The Raw Water Supply subsystem consists of six pumps separated in six pump bays. Each pump has a maximum capacity of 15,000 gpm (REF 3.1.6). Two of these pumps are considered in standby. These pumps are connected to a common header and will be used to transfer water from Pond A to meet the nuclear station's water demands.

1.2 Purpose

This calculation will determine the minimum dimensional requirements for a standard size traveling screen in both the river water and raw water supply intake structures which will meet the 0.5 feet/second velocity requirement:

- Minimum screen width
- Minimum water level

This calculation will determine the minimum screen width for both a coarse mesh size and fine mesh size. This information is required as input to the design of the river water and the raw water supply intake structures in support of both units 1 and 2.

1.3 Limits of Applicability

This calculation is only applicable to the William State Lee III Nuclear Station Units 1 and 2 river water and raw water supply intake structures, in all modes of operation.

2.0 Summary of Results and Conclusions

2.1 Results

The general traveling screen dimension results are given in **Table 2-1**.

Table 2-1 General Traveling Screen Dimensions

Dimension	Value	Units
Minimum Traveling Screen Width (W) including Fine Mesh	19.7	ft
Minimum Traveling Screen Width (W) including Coarse Mesh	16.5	ft
Minimum Water Level (Y)	7.9	ft

2.2 Conclusions / Recommendations

- The results listed in the previous section are based on the best available information. Although there will be changes to the system, most of them will likely not affect the traveling screen size.
- This calculation should be used as input to the design of both the river water and raw water supply intake structures. All general dimensions, developed from this calculation, shall be no less than the corresponding value, from **Table 2-1** , for example the width of the traveling screen (W) should be no less than 19.7 ft.
- The intake screen procurement specification shall include the scope of calculating actual head loss by supplier.

2.3 Open Items

ITEM NO.	DESCRIPTION	CLOSED
1.	PUMP BAY DESIGN The pump bay design is a significant assumption within this calculation (See Section 4.2.1). Once the intake structural design is finalized, section 4.2.1 should be reviewed and made consistent with the final intake design.	
2.	UNAPPROVED DESIGN INPUTS This calculation is created using the design inputs based on references 3.1.1, 3.1.2, 3.1.3, and 3.1.4. Each reference should be reviewed and made consistent with section 4.4.	
3.	TRAVELING SCREEN DESIGN This calculation has added margin to account for some screen clogging, however the change in pressure (head loss) with respect to a dirty or clogged screen will be analyzed based on the actual size of the standard traveling screen, by the supplier. Section 4.2.2 should be reviewed and made consistent with the final traveling screen design.	

3.0 References

3.1 AP1000 Documents

3.1.1 WLG-RWS-M3C-006, "RWS, River Water Subsystem Hydraulic Analysis", Revision B

3.1.2 WLG-RWS-M3C-001, "River Water Intake Hydraulic Calculation," Revision B

3.1.3 WLG-RWS-MY18-001, "Intake Screen Selection for the Raw Water System," Revision A

3.1.4 WLG-RWS-M3C-004, "Raw Water (Make-up Pond A) Intake Hydraulic Calculation," Revision A

3.1.5 WLG-RWS-M3C-007, "RWS, Refill Subsystem Hydraulic Analysis" Revision A

3.1.6 WLG-RWS-M3C-008, "RWS, Raw Water Subsystem Hydraulic Analysis" Revision A

3.2 Other

3.2.1 "Cameron Hydraulic Data," C.C. Heald, 19th Edition, 2002

3.2.2 "Particle Size/ Screen Mesh Comparison Table," Screen Technology Group, Inc, February 08 2009 (http://wovenwire.com/reference/particle-size)

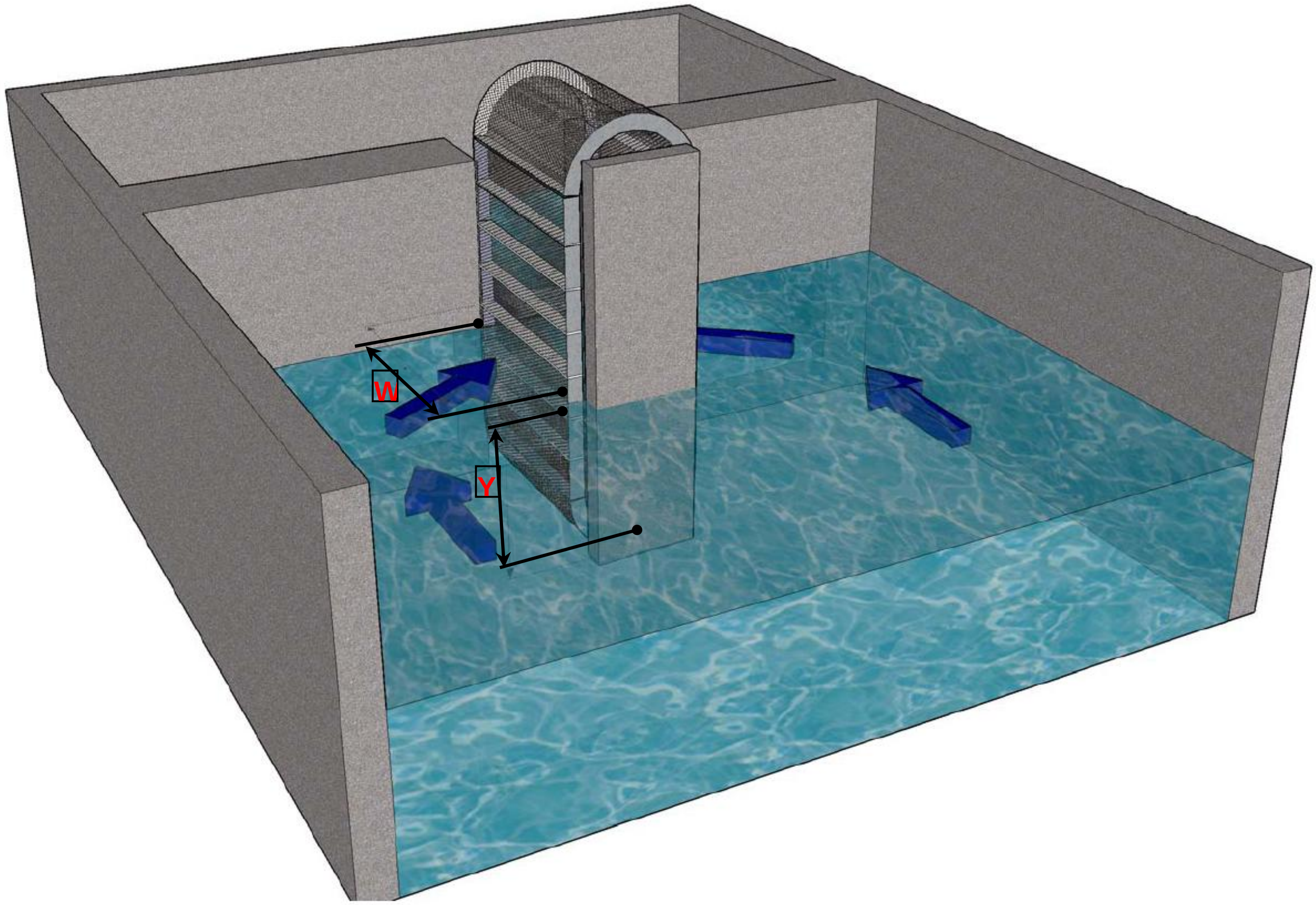
3.2.3 40 CFR Part 125: National Pollutant Discharge Elimination System—Amendment of Final Regulations Addressing Cooling Water Intake Structures for New Facilities (Implements Requirements of Section 316B of the Clean Water Act). "Cameron Hydraulic Data," C.C. Heald, 19th Edition, 2002

4.0 Calculation Methods and Inputs

4.1 Method Discussion

A general pump bay layout is shown below.

Figure 4-1 General Pump Bay Layout



Note: Bar screen is not depicted on this figure

The preliminary standard traveling screen sizing was calculated using equations constructed per REF 3.2.1 and simple geometry of a rectangle. The significant assumptions, inputs, and acceptance criteria are noted in the following sections.

The following steps were used to calculate a standard traveling screen width:

1. Determine the system design flow (Q, ft^3/s).
2. Select maximum velocity (V, ft/s).

3. Calculate the minimum required area (A_{vel}, ft^2) based on the maximum velocity (V) using below equation (REF 3.2.1, page 2-13).

$$A_{vel} = \frac{Q}{V}$$ (Equation 1)

4. Select a mesh size opening (m, %) using Appendix B.

5. Calculate the additional area (A_{slot}, ft^2) based on the selected mesh size opening using the below equation.

$$A_{slot} = \left(\frac{1}{m} - 1\right) A_{vel}$$ (Equation 2)

6. Calculate the additional area (A_{clog}, ft^2) based on a 25% clogged screen using the below equation.

$$A_{clog} = (0.25) A_{vel}$$ (Equation 3)

7. Determine the total adjusted area (A_{total}, ft^2) based on the summation of Equation 1, Equation 2, and Equation 3.

8. Determine the minimum intake level (Y, ft) using references 3.1.2 or 3.1.4 (see section 4.4.2).

9. Calculate the minimum traveling screen width (W, ft) using the below equation. (see section 4.2.1)

$$W = \frac{A_{total}}{1.5\ Y}$$ (Equation 4)

4.2 Discussion of Significant Assumptions

4.2.1 Pump Bay Design

- Each pump will be separated in individual pump bays
- Dual flow traveling screens will be used in each pump bay. Screen width will be calculated based on 1 ½ times the minimum intake level (instead of 2 times the minimum intake level) to provide additional margin since this will conservatively result in a wider screen.

4.2.2 Clogged Screen

This calculation assumes added margin for meeting the 0.5 ft/s requirement up to a 25% clogged screen. This margin is recommended by Duke Energy, based on discussion with a subject matter expert from the Electric Power Research Institute (EPRI). The maximum head loss across the screens will be verified by the supplier when this equipment is purchased.

4.3 Acceptance Criteria

The required thru-screen velocity for the pump bay should be less than 0.5 ft/s per REF 3.2.3.

4.4 Inputs

4.4.1 Maximum Flow Rate

A bounding pump size can be used for the Refill subsystem, Raw Water Supply subsystem, and the River Water subsystem. The pump capacities are not similar; however, this calculation will utilize the larger of the three values plus some additional margin. This standard traveling screen size must meet requirements for all three of the subsystems.

Each river water pump has maximum capacity of 20,980 gpm (REF 3.1.1); each refill pump has maximum capacity of 22,500 gpm (REF 3.1.5), each raw water supply pump has maximum capacity of 15,000 gpm (REF 3.1.6). To standardize the traveling screen design, the maximum flow of the refill pump is selected as the design input to this calculation. The maximum pump flow rate used in this calculation is 24,750 gpm, which includes a 10% design margin. The screen wash pump flow, which is an intermittent flow, is not included in the screen design flow rate; however, it is considered in the Section 5.1.

In comparison, the use of 20,980 gpm or 15,000 gpm as the design input for sizing the standard traveling screen does not result in a significant decrease in the traveling screen dimensions. Thus, it is reasonable to use 24,750 gpm as the maximum flow rate.

4.4.2 Minimum Water Depth

The river water intake has a minimum water level of 9.2 ft (REF 3.1.2) before any pumps shall be run. In comparison the raw water supply intake has a minimum water level of 7.9 ft (REF 3.1.4) before any pump shall be run. The raw water supply intake depth is the shallower of the two intakes and will be used as a minimum depth of the traveling screen.

4.4.3 Percentage Open Area

4.4.3.1 Fine Mesh

The traveling screen shall filter debris and aquatic life 2 mm in size and larger (REF 3.1.3). Based on an approximate 2 mm mesh size, the equivalent percent open area can be determined. The value used is 56.3% referenced from Appendix B (Opening = 0.0787 inches).

4.4.3.2 Coarse Mesh

The traveling screen shall filter debris and aquatic life 6 mm in size and larger (REF 3.1.3). Based on an approximate 6 mm mesh size, the equivalent percent open area can be determined. The value used is 65.9% referenced from Appendix B (Opening = 0.2205 inches).

5.0 Detailed Analysis/Calculations and Results

5.1 Calculations

Table 5-1: Fine Mesh (2.0 mm) Calculation Results

No.	Parameter	Value	Units	Comments
1.	Design Flow (Q_{design})	24750.00	gpm	22500 plus 10%
2.	Converted Flow (Q)	55.14	ft^3/s	Q_{design}/ 448.83
3.	Screen Velocity (V)	0.50	ft/s	
4.	Area based on Velocity (A_{vel})	110.29	ft^2	Equation 1
5.	Percentage Open Area (m)	56.30	%	Appendix B
6.	Area based on Slot (A_{slot})	85.61	ft^2	Equation 2
7.	Percentage of Clogged Screen	25.00	%	Assumption 4.2.2
8.	Area based on Clogged Screen (A_{clog})	27.57	ft^2	Equation 3
9.	Total Adjusted Area (A_{total})	223.48	ft^2	
10.	Minimum Water Level (Y)	7.9	ft	Input
11.	Screen Width (W)	18.86**	ft	Equation 4

Table 5-2: Coarse Mesh (6.0 mm) Calculation Results

No.	Parameter	Value	Units	Comments
1.	Design Flow (Q_{design})	24750.00	gpm	22500 plus 10%
2.	Converted Flow (Q)	55.14	ft^3/s	Q_{design}/ 448.83
3.	Screen Velocity (V)	0.50	ft/s	
4.	Area based on Velocity (A_{vel})	110.29	ft^2	Equation 1
5.	Percentage Open Area (m)	65.90	%	Appendix B
6.	Area based on Slot (A_{slot})	57.07	ft^2	Equation 2
7.	Percentage of Clogged Screen	25.00	%	Assumption 4.2.2
8.	Area based on Clogged Screen (A_{clog})	27.57	ft^2	Equation 3
9.	Total Adjusted Area (A_{total})	194.94	ft^2	
10.	Minimum Water Level (Y)	7.9	ft	Input
11.	Screen Width (W)	16.45	ft	Equation 4

** The minimum screen width was calculated as 18.86 feet; however, to provide added conservatism in meeting the velocity criteria of 0.5 ft/sec (Ref 3.2.3) and considering the screen wash pump flow rate, a value of 19.7 feet will be used as the minimum screen width for the fine mesh.

5.2 Results of Calculation

In conclusion, the minimum traveling screen width (W) dimension is validated with the calculation starting with a velocity less than 0.5 ft/s (REF 3.2.3). Moreover all dimensions developed within this calculation are minimums and the actual dimensions of the traveling screen should be larger than that of the calculated values.

6.0 Listing of Computer Runs Used and Runs Made in Calculation

Table 6-1 Summary of Computer Codes Used in Calculation

Code No.	Code Name	Code Ver.	Configuration Control Reference	Basis (or reference) that supports use of code in current calculation
1	N/A			
2	N/A			

Table 6-2 Electronically Attached File Listing

Run No.	Table 6-1 Code No.	Computer Run Description	Machine Name Run Date/Time	File Type	EDMS File Name or File Location
1		N/A			
2		N/A			

Appendix A: Calculation Preparation Checklist

(Completed By Author(s))Item	Yes	No	N/A	Comments
1. Has the latest Calculation Cover Sheet been used?	☒	☐	☐	
2. Has the calculation been numbered in accordance with DAPP 5-8?	☒	☐	☐	
3. Has the Safety Classifications been marked on the Calculation Cover Sheet in accordance with DAPP 5-2?	☒	☐	☐	
4. Is this a non-safety related calculation? If YES, has the design verification method block been marked ―N/A"?	☒	☐	☐	
5. Has English units been used throughout the calculation?	☒	☐	☐	
6. Are all the pages sequentially numbered, and are the calculation number, revision number, and appropriate proprietary classification listed on each page? Are the page numbers in the Table of Contents correct?	☒	☐	☐	
7. Has the objective/purpose been included in Section 1.0 of the calculation?	☒	☐	☐	
8. Is the Summary of Results and Conclusions provided in Section 2.0 consistent with the purpose stated in Section 1.0 and Results of Calculation contained in Section 5.2?	☒	☐	☐	
9. Is sufficient information provided for all references in Section 3.0 to facilitate their retrieval; or has a copy been provided as appendices?	☒	☐	☐	
10. Are the references accurate? Do the references to other documents point to the latest revision? If not, are the reasons documented?	☒	☐	☐	
11. Is the Method of Calculation/Analysis clearly described in Section 4.2 and reasonable?	☒	☐	☐	
12. Have all the inputs and assumptions listed in Section 4.0 of the calculation? Do all design input values have source identified?	☒	☐	☐	
13. Does the calculation contain Unapproved Inputs? If YES, has the Check Box on the Calculation Cover Sheet been marked? Have the Unapproved Inputs been listed in Section 2.3 (Open Items)?	☒	☐	☐	
14. Do the acceptance criteria define appropriately in Section 4.4?	☒	☐	☐	
15. Do the results and conclusions meet the acceptance criteria? Do the results and conclusions make sense and support the purpose stated in Section 1.0?	☒	☐	☐	
16. Does Table 6-1 identify all software used in the calculation? Are all software used in the calculation listed on the Approved Computer Program List?	☐	☐	☒	
17. Does Table 6-2 identify all electronic files for the calculation?	☐	☐	☒	
18. Are all attachments/appendices included in the calculation and noted on the cover page?	☒	☐	☐	
19. Is the calculation acceptable with respect to spelling, punctuation, and grammar?	☒	☐	☐	
20. Have all comments been resolved?	☒	☐	☐	

Appendix B: Mesh Size Equivalent Comparison

Particle Size / Screen Mesh Comparison

(800) 440-MESH Phone: (360) 835-8936 Fax: (360) 835-8966

Particle Size		Stainless Steel Bolting Cloth					Market Grade					U.S. Std. Sieve	
Inches	Microns	Mesh	Opening Inches	Opening Microns	Wire Dia.	Open Area	Mesh	Opening Inches	Opening Microns	Wire Dia.	Open Area	Closest Sieve	Opening In Inches
.2500	7097						3	.2790	7087	.0540	70.1%		
.2230	5660						4	.2023	5138	.0475	65.9%	3.5	.2205
.1870	4750						4	.1870	4750	.0630	56.0%	4	.1870
.1570	4000						5	.1590	4039	.0410	63.2%	5	.1575
.1320	3350						6	.1318	3348	.0348	62.7%	6	.1319
.1110	2820						7	.1080	2743	.0350	57.2%	7	.1102
.0937	2380						8	.0964	2449	.0286	60.2%	8	.0929
.0787	2000						10	.0742	1885	.0258	56.3%	10	.0787
.0730	1854						11	.0730	1854	.0180	64.5%		
.0661	1680	14	.0620	1575	.0090	76.4%	12	.0603	1532	.0230	51.8%	12	.0669
.0555	1410	16	.0535	1359	.0090	73.3%	14	.0510	1295	.0204	51.0%	14	.0551
.0469	1190	18	.0466	1184	.0090	70.2%	16	.0445	1130	.0181	50.7%	16	.0465
.0410	1041	20	.0410	1041	.0090	67.2%							
.0394	1000	22	.0380	965	.0075	69.7%	18	.0386	980	.0173	48.3%	18	.0394
.0331	841	24	.0342	869	.0075	67.2%	20	.0340	864	.0162	46.2%	20	.0335
.0310	784	26	.0310	787	.0075	64.8%							
.0278	707	28	.0282	716	.0075	62.4%	24	.0277	704	.0140	44.2%	25	.0280
.0268	681	30	.0268	681	.0065	64.8%							
.0248	630	32	.0248	630	.0065	62.7%							
.0234	595	34	.0229	582	.0065	60.7%						30	.0236
.0213	541	36	.0213	541	.0065	58.7%	30	.0203	516	.0128	37.1%		
.0197	500	38	.0198	503	.0065	56.7%						35	.0197
.0185	470	40	.0185	470	.0065	54.8%							
.0183	465	42	.0183	465	.0055	59.1%							
.0172	437	44	.0172	437	.0055	57.4%	35	.0176	447	.0118	37.9%		
.0165	420	46	.0162	411	.0055	55.8%						40	.0167
.0153	388	48	.0153	389	.0055	54.2%	40	.0150	381	.0104	36.0%		
.0145	368	50	.0145	368	.0055	52.6%							
.0139	354	52	.0137	348	.0055	51.0%						45	.0140
.0130	330	54	.0130	330	.0055	49.4%							
.0127	323	58	.0127	323	.0045	54.6%							
.0122	310	60	.0122	310	.0045	53.3%							
.0117	297	62	.0116	295	.0045	51.7%						50	.0118
.0111	282	64	.0111	282	.0045	50.7%	50	.0110	279	.0090	30.3%		
.0106	270	70	.0106	269	.0037	54.9%							
.0102	260	72	.0102	259	.0037	53.8%							
.0098	250	74	.0098	249	.0037	52.7%						60	.0098
.0095	241	76	.0095	241	.0037	51.7%							
.0091	231	78	.0091	231	.0037	50.6%	60	.0092	234	.0075	30.5%		
.0088	224	80	.0088	224	.0037	49.6%							
.0083	210	84	.0084	213	.0035	49.8%						70	.0083
.0079	200	88	.0079	201	.0035	47.9%							
.0076	193	90	.0076	193	.0035	47.8%							
.0070	177	94	.0071	180	.0035	45.0%	80	.0070	178	.0055	31.4%	80	.0071
.0065	165	105	.0065	165	.0030	46.9%							
.0059	149	120	.0058	147	.0025	47.3%	100	.0055	140	.0045	30.3%	100	.0059
.0049	125	145	.0047	119	.0022	46.4%	120	.0046	117	.0037	30.5%	120	.0049
.0041	105	165	.0042	107	.0019	47.1%	150	.0041	104	.0026	37.9%	140	.0042
.0035	88	200	.0034	86	.0016	46.2%	170	.0035	89	.0024	35.4%	170	.0035
.0029	74	230	.0029	74	.0014	46.0%	200	.0029	74	.0021	33.6%	200	.0030
.0025	63						250	.0024	61	.0016	36.0%	230	.0025
.0021	53	300	.0022	56	.0012	42.0%	270	.0021	53	.0016	32.0%	270	.0021
.0017	44						325	.0017	43	.0014	30.5%	325	.0018
.0015	38						400	.0015	38	.0010	36.0%	400	.0015
.0010	25						500	.0010	25	.0010	25.0%	500	.0010
.0008	20						635	.0008	20	.0008	25.0%	635	.0008

AP1000

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CALCULATION COVER SHEET

Title: Standard RWS Passive Screen Calculation

Plant Applicability: ☐ All AP1000 Plants except:

☒ Only the following AP1000 Plant(s): W.S. Lee III Nuclear Station, Units 1 & 2

Calculation no.	Revision	Page	This Document Contains Unapproved Inputs:
WLG-RWS-M3C-013	**1**	**1 of 21**	☒ Yes ☐ No

Attachments: Appendix A, Appendix B, Appendix C,

DCP # / REV. Incorporated in this revision: **NA**

Safety Classification: **E**

Comments: **N/A**

	Print/Sign	Date	For Pages
Prepared By:	M. R. Austin/ [signature]	8/11/11	All
Reviewed By:	R. Brezina/ [signature]	8/11/11	All

SOUTH CAROLINA STONE & WEBSTER, INC. NO. C02386 CERTIFICATE OF AUTHORIZATION

SOUTH CAROLINA REGISTERED No. 5871 PROFESSIONAL ENGINEER ROBERT M. DULIN, JR. [signature]

PE Stamp and Certification
Stone & Webster, Inc.
Charlotte, NC 28202

Design Verification Method: ☒ N/A ☐ Independent Review ☐ Alternate Calculation ☐ Qualification Testing

Approved By: S. S. Fong/ [signature] Lead Discipline Engineer — Date 8/11/2011

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Record of Revisions

Rev	Revision Description
0	Issue for permit
1	Incorporates two screen alternative for Pond C.

Table of Contents

1.0 Introduction

1.1 Background

The Raw Water System (RWS) Pond B Intake consists of the Pond B subsystem and contains two types of pumps. The Pond B subsystem consists of five (5) pumps separated in two (2) forebays.

- There are four (4) Pond B Main pumps and each pump has a maximum capacity of 10,000 gpm (REF 3.1.1). One of the pumps is in standby. These pumps are connected to a common header and will be used to transfer water from Pond B to Pond A.
- There is one (1) Pond B Ancillary pump, and has a maximum capacity of 6000 gpm (REF 3.1.7). This pump will be used to transfer water from Pond B to Pond C.

The RWS Pond C Intake consists of the Pond C subsystem.

- The Pond C subsystem consists of three (3) pumps in one (1) forebay, separated by interior walls which do not span the length of the forebay. Each pump has a maximum capacity of 10,000 gpm (REF 3.1.6). These pumps are connected to a common header and will be used to transfer water from Pond C to Pond B.

1.2 Purpose

This calculation will determine the minimum dimensional requirements for a standard size passive screen in both the Pond B and Pond C intake structures which will meet 0.5 feet/second velocity requirement:

- Minimum screen length
- Minimum screen diameter

This calculation will determine the screen length and screen diameter for both a coarse mesh and a fine mesh. This information is required as input to the design of the Pond B and Pond C intake structures in support of both Units 1 and 2.

1.3 Limits of Applicability

This calculation is only applicable to the William State Lee III Nuclear Station Units 1 and 2, Pond B and Pond C structures.

2.0 Summary of Results and Conclusions

2.1 Results

The general passive screen dimension results are given in **Table 2-1**.

TABLE 2-1 GENERAL PASSIVE SCREEN DIMENSIONS

Screen Mesh	DIMENSION	VALUE	UNITS
FINE	Minimum Passive Screen Length (L)	8.13	ft
	Minimum Passive Screen Diameter (D)	5.83	ft
	Maximum Slot Opening	2.0	mm
	Wedge Wire Size	0.093	in
COARSE	Minimum Passive Screen Length (L)	6.44	ft
	Minimum Passive Screen Diameter (D)	5.00	ft
	Maximum Slot Opening	10.0	mm
	Wedge Wire Size	0.158	in

Pond B will utilize four (4) passive intake screens, while Pond C will require two (2) passive intake screens. The ancillary pump in Pond B is located within one of the main pump bays and therefore utilizes the main pump screen. The ancillary pump does not operate concurrently with the main pump.

2.2 Conclusions / Recommendations

- The results listed in the previous section are based on the best available information. Although there will be changes to the system, most of them will likely not affect the passive screen size.
- This calculation should be used as input to the design of both the Pond B and Pond C intake structures. All general dimensions, developed from this calculation, shall be no less than the corresponding value from Table 2-1, for example the length of the passive screen (L) should be no less than 8.13 ft, fine mesh, or 6.44 ft, coarse mesh.
- The centerline of the passive screens should be installed as stated in the Section 4.3.2 and consistent with the Ref. 3.1.4.
- The intake screen procurement specification shall include the scope of calculating actual head loss by supplier.

- The percent clogging of the screen will need to be monitored with instrumentation to ensure the available flow area maintains a velocity no greater than 0.5 ft/s. Instrumentation showing a differential pressure associated with maximum allowed clogging will require the screen to be cleaned.
- Based on engineering judgment, four (4) screens should be used on Pond B rather than the minimum three (3) screens to provide additional flow area, which is appropriate for Pond B since Pond B will be used more frequent than Pond C and most likely have a greater suspended sediment content.

2.3 Open Items

ITEM NO.	DESCRIPTION	CLOSED
1	PUMP BAY DESIGN The pump bay design is a significant assumption within this calculation (See Section 4.2.1). Once the intake structural design is finalized, section 4.2.1 should be reviewed and made consistent with the final intake design.	Review final design to verify dimensions
2	UNAPPROVED DESIGN INPUTS This calculation is created using the design inputs based on references 3.1.1, 3.1.3, 3.1.6, and 3.1.7. Each reference should be reviewed and made consistent with section 4.4.	Review final input design numbers in References
3	PASSIVE SCREEN DESIGN This calculation has added margin to account for some screen clogging, however the change in pressure (head loss) with respect to a dirty or clogged screen will be analyzed based on the actual size of the passive screen, by the supplier. Section 4.2.2 should be reviewed and made consistent with the final passive screen design.	
4	POND DRAWDOWN LEVELS Assumptions 4.2.3 and 4.2.4 require confirmation later. Information from the HZI analysis, to be provided by Duke Energy, is required to confirm pond drawdown levels and to possibly replace RFI-SSWN-LEE-000047 as a reference.	Confirm final pond drawdown levels

3.0 References

3.1 AP1000 Documents

3.1.1 WLG-RWS-M3C-010, "RWS, Make-up Pond B Subsystem Hydraulic Analysis", Revision B

3.1.2 WLG-RWS-MY18-001, "Intake Screen Selection for the Raw Water System," Revision A

3.1.3 WLG-RWS-M3C-005, "Make-up Pond C & B Intake Hydraulic Calculation," Revision B

3.1.4 WLG-XXER-GF-018, "RFI SHAW Input for Duke Energy's Response to NRC No RAI 210", 09/30/2010

3.1.5 RFI-SSWN-LEE-000047, "Raw Water Design Parameters", 05/07/2009

3.1.6 WLG-RWS-M3C-011, "RWS, Make-up Pond C Subsystem Hydraulic Analysis", Revision B

3.1.7 WLG-RWS-M3C-009, "RWS, Make-up Pond B to Make-up Pond C", Revision A

3.2 Other

3.2.1 "Cameron Hydraulic Data," C.C. Heald, 19th Edition, 2002

3.2.2 "Johnsons Screens: An Overview," Johnson Screens, Inc, 2010 (http://www.johnsonscreens.com/sites/default/files/2/680/Johnson%20Industrial%20Screens.pdf)

3.2.3 "Revolutionary Cleaning Technology Cylinder Screen with External and Internal Brush System," Intake Screens, Inc (http://www.intakescreensinc.com/files/ISIBrushedCylinder.pdf)

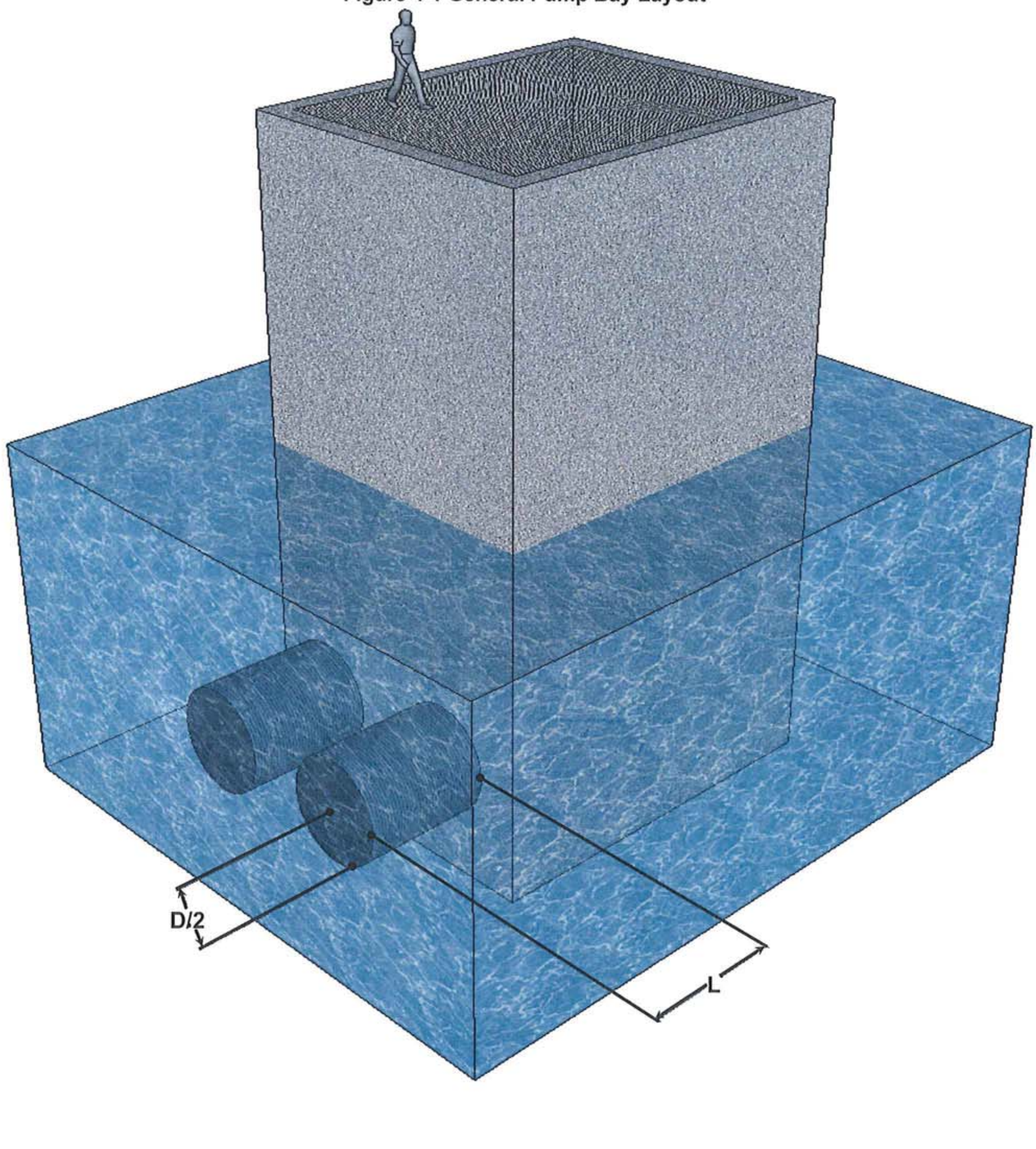
3.2.4 40 CFR Part 125: National Pollutant Discharge Elimination System—Amendment of Final Regulations Addressing Cooling Water Intake Structures for New Facilities (Implements Requirements of Section 316B of the Clean Water Act).

4.0 Calculation Methods and Inputs

4.1 Method Discussion

A general pump bay layout is shown below.

Figure 4-1 General Pump Bay Layout



The preliminary standard passive screen sizing was calculated using equations constructed per REF 3.2.1 and simple geometry of a cylinder. The significant assumptions, inputs, and acceptance criteria are noted in the following sections.

The following steps were used to calculate a standard passive screen length for both fine mesh and coarse mesh:

1. Determine the thru-screen design flow (Q, ft^3/s).
2. Select maximum velocity (V, ft/s).
3. Calculate the minimum required area (A, ft^2) based on the maximum velocity (V) using below equation (REF 3.2.1, page 2-13).

$$A_{vel} = \frac{Q}{V} \qquad \text{(Equation 1)}$$

4. Select a passive screen opening (O, ft). Values of 2 mm and 10 mm are examined.(REF 3.2.1).
5. Select a passive screen wire size (W, ft) using 0
6. Calculate the percentage of open area (m, %) using the following equation.

$$m = \frac{O}{W+O} \qquad \text{(Equation 2)}$$

7. Calculate the minimum area (A_{slot}, ft^2) based on the selected mesh size opening using the below equation.

$$A_{slot} = \left(\frac{1}{m} - 1\right) A_{vel} \qquad \text{(Equation 3)}$$

8. Calculate the additional area (A_{clog}, ft^2) to account for a clogged screen using the below equation.

$$A_{clog} = (\%\ clogged) A_{vel} \qquad \text{(Equation 4)}$$

9. Determine the total adjusted area (A_{total}, ft^2) based on the summation of Equation 1, Equation 3, and Equation 4.

10. Determine the minimum passive screen diameter (D, ft) using Appendix C, Item 1.

11. Calculate the minimum passive screen length (L, ft) using the below equation.

$$L = \frac{A_{total}}{\pi D} \quad \text{(Equation 5)}$$

12. Calculate the length (L) vs. diameter (D) ratio (R). Ensure the ratio is less than 1.5.

13. Calculate the number of screens (N) per intake for Pond B and Pond C.

4.2 Discussion of Significant Assumptions

4.2.1 Pump Bay Design

Two screens will have the capacity to handle three (3) pumps.

4.2.2 Clogged Screen

This calculation assumes a greater than 4% clogged screen percentage based on water quality for both ponds in meeting the 0.5 ft/s requirement (see detailed analysis in Section 5 for clogged percentage). The maximum head loss across the screens will be verified by the supplier when this equipment is purchased.

4.2.3 Pond B Drawdown Level

The occasional pond drawdown is assumed 30 feet.

4.2.4 Pond C Drawdown Levels

Based on the comments received from Duke Energy, dated February 8, 2011, the occasional pond drawdown is 30 feet; and, the maximum pond drawdown is 45 feet.

4.3 Acceptance Criteria

4.3.1 The length of the passive screen shall be less than 150% or 1.5 times the diameter of the passive screen (See Appendix C, Item 2).

4.3.2 The centerline of the passive screens should be installed at a minimum of one screen diameter from the intake structure bottom (supplier recommendation) plus two to five feet to account for sediment loading.

4.3.3 To prevent possible pump cavitation problems, the top of the passive screens shall be lower than the minimum water level of ponds (to keep the screens submerged). This will also ensure that the 0.5 ft/s velocity limit is not exceeded.

4.4 Inputs

4.4.1 Maximum Flow Rate

Each Pond B main pump has maximum capacity of 10,000 gpm (REF 3.1.1); the Pond B ancillary pump has maximum capacity of 6,000 gpm (REF 3.1.7), each Pond C pump has maximum capacity of 10,000 gpm (REF 3.1.6). In addition, a preferred two (2) screen configuration was desired for Pond C.

To standardize the stationary screen design, the maximum thru-screen design flow for Pond B and Pond C utilized a flow rate of 15,000 gpm (based on total system flow for Pond C divided by the number of screens (2 screens).

4.4.2 Percentage Open Area

4.4.2.1 Fine Mesh

The passive screen shall filter debris and aquatic life 2 mm in size and larger (REF 3.1.2). Based on an approximate 2 mm mesh size, the equivalent percent open area can be determined. The value calculated was 45.85%, using an equation referenced from Appendix B.

4.4.2.2 Coarse Mesh

The passive screen shall filter debris and aquatic life 10 mm in size and larger. Based on an approximate 10 mm mesh size the equivalent percent open area can be determined. The value calculated was 71.36%, using an equation referenced from Appendix B.

5.0 Detailed Analysis/Calculations and Results

5.1 Calculations

Table 5-1: Fine Mesh Calculation

No.	Parameter	Value	Units	Comments
1.	Thru-Screen Design Flow (Q_{design})	15,000	gpm	2 screen flow
2.	Converted Flow (Q)	33.42	ft^3/s	$Q_{design}/ 448.8$
3.	Screen Velocity (V)	0.50	ft/s	Input
4.	Area based on Velocity (A_{vel})	66.84	ft^2	Equation 1
5.	Slot Opening Size (O_{mesh})	2.00	mm	Input
6.	Converted Slot Opening Size (O)	0.0787	in	$O_{mesh}/25.4$
7.	Wire Size (W)	0.0930*	in	Input (Appendix B)
8.	Percentage Open Area (m)	45.85	%	Equation 2
9.	Area based on Slot (A_{slot})	78.95	ft^2	Equation 3
10.	Percentage of Clogged Screen	4.7**	%	Assumption 4.2.2
11.	Area based on Clogged Screen (A_{clog})	3.14	ft^2	Equation 4
12.	Total Adjusted Area (A_{total})	148.9	ft^2	$A_{vel}+A_{slot}+A_{clog}$
13.	Typical Screen Diameter (D_{screen})	70	in	Assumption
14.	Converted Screen Diameter (D)	5.83	ft	$D_{screen}/12$
15.	Screen Length (L)	8.13	ft	Equation 5
16.	Length vs. Diameter Ratio (R < 1.5)	1.39	na	L/D
17.	Pond B Ind. Pump Flow (Q_{mkupb})	10,000	gpm	Input
18.	Pond B No. of Pumps (N_{mkupb})	4.00	qty	Input
19.	Required Pond B Screens ($N_{screenb}$)	2.67	qty	Minimum 3 screens required***
20.	Pond C Ind. Pump Flow (Q_{mkupc})	10,000	gpm	Input
21.	Pond C No. of Pumps (N_{mkupc})	3	qty	Input
22.	Required Pond C Screens ($N_{screenc}$)	2.00	qty	Minimum of 2 screens

* A value of 0.0930 inches is selected for the fine mesh based on engineering judgment and conversation with a screen vendor for the determination of screen size limits. Actual wire sizes will be determined based on the design loads required for the screens.

** Meets assumption 4.2.2.

*** Based on engineering judgment, four (4) screens should be used on Pond B rather than the minimum three (3) screens to provide additional flow area, which is appropriate for Pond B since

Pond B will be used more frequent than Pond C and most likely have a greater suspended sediment content.

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Table 5-2: Coarse Mesh Calculation

No.	Parameter	Value	Units	Comments
1.	Thru-Screen Design Flow (Q_{design})	15,000	gpm	2 screen flow
2.	Converted Flow (Q)	33.42	ft^3/s	Q_{design}/ 448.83
3.	Screen Velocity (V)	0.50	ft/s	Input
4.	Area based on Velocity (A_{vel})	66.84	ft^2	Equation 1
5.	Slot Opening Size (O_{mesh})	10.00	mm	Input
6.	Converted Slot Opening Size (O)	0.3937	in	O_{mesh}/25.4
7.	Wire Size (W)	0.1580*	in	Input (Appendix B)
8.	Percentage Open Area (m)	71.36	%	Equation 2
9.	Area based on Slot (A_{slot})	26.83	ft^2	Equation 3
10.	Percentage of Clogged Screen	11.1**	%	Assumption 4.2.2
11.	Area based on Clogged Screen (A_{clog})	7.42	ft^2	Equation 4
12.	Total Adjusted Area (A_{total})	101.09	ft^2	A_{vel}+A_{slot}+A_{clog}
13.	Typical Screen Diameter (D_{screen})	60	in	Assumption
14.	Converted Screen Diameter (D)	5.0	ft	D_{screen}/12
15.	Screen Length (L)	6.44	ft	Equation 5
16.	Length vs. Diameter Ratio (R < 1.5)	1.28	na	L/D
17.	Pond B Pump Flow (Q_{mkupb})	10,000	gpm	Input
18.	Pond B No. of Pumps (N_{mkupb})	4.00	qty	Input
19.	Required Pond B Screens ($N_{screenb}$)	2.67	qty	Minimum 3 screens required***
20.	Pond C Pump Flow (Q_{mkupc})	10,000	gpm	Input
21.	Pond C No. of Pumps (N_{mkupc})	3.00	qty	Input
22.	Required Pond C Screens ($N_{screenc}$)	2.00	qty	Minimum of 2 screens

* A value of 0.1580 in is selected for the coarse mesh based on engineering judgment and conversation with a screen vendor for the determination of screen size limits. Actual wire sizes will be determined based on the design loads required for the screens.

** Meets assumption 4.2.2.

*** Based on engineering judgment, four (4) screens should be used on Pond B rather than the minimum three (3) screens to provide additional flow area, which is appropriate for Pond B since Pond B will be used more frequent than Pond C and most likely have a greater suspended sediment content.

5.1.1 Screen Diameter Compared to Minimum Pond Level

This section is to verify that the screens remain covered under the various pond levels, based on the occasional and maximum drawdown levels.

- Pond B normal level is assumed to be 570 msl and occasional drawdown is 30 feet (Assumption 4.2.3) resulting in a level of 540 msl. The screen is located at 528 msl or 8 feet above the bottom of the intake structure (Ref 3.1.4). This leaves 12 feet to the screen centerline or 9 feet to the top of the screen assuming a 6 foot diameter for the screen.
- Pond C normal level is assumed to be 650 msl and occasional drawdown is 30 feet (Assumption 4.2.4) resulting in a level of 620 msl. The screen is located at 553 msl or 8 feet above the bottom of the intake structure (Ref 3.1.4). This leaves 67 feet to the screen centerline or 64 feet to the top of the screen assuming a 6 foot diameter for the screen.
- Pond C normal level is assumed to be 650 msl and maximum drawdown is 45 feet (Assumption 4.2.4) resulting in a level of 605 msl. The screen is located at 553 msl or 8 feet above the bottom of the intake structure (Ref 3.1.4). This leaves 52 feet to the screen centerline or 49 feet to the top of the screen assuming a 6 foot diameter for the screen.

5.2 Results of Calculation

In conclusion, the minimum passive screen length (L) dimension is validated based on a size ratio less than 1.5 times passive screen diameter (D) (see section 4.3.1).

The screens location satisfies the requirement for the screens to remain submerged based on the pond drawdown. Dimensions developed within this calculation are minimums and the actual dimensions of the passive screen should be larger than that of the calculated values.

6.0 Listing of Computer Runs Used and Runs Made in Calculation

Table 6-1 Summary of Computer Codes Used in Calculation

Code No.	Code Name	Code Ver.	Configuration Control Reference	Basis (or reference) that supports use of code in current calculation
1	N/A			
2	N/A			

Table 6-2 Electronically Attached File Listing

Run No.	Table 6-1 Code No.	Computer Run Description	Machine Name Run Date/Time	File Type	EDMS File Name or File Location
1		N/A			
2		N/A			

Appendix A: Calculation Preparation Checklist

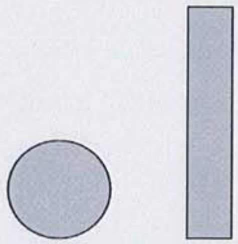
(Completed By Author(s))Item	Yes	No	N/A	Comments
1. Has the latest Calculation Cover Sheet been used?	☒	☐	☐	
2. Has the calculation been numbered in accordance with DAPP 5-8?	☒	☐	☐	
3. Has the Safety Classifications been marked on the Calculation Cover Sheet in accordance with DAPP 5-2?	☒	☐	☐	
4. Is this a non-safety related calculation? If YES, has the design verification method block been marked "N/A"?	☒	☐	☐	
5. Has English units been used throughout the calculation?	☒	☐	☐	
6. Are all the pages sequentially numbered, and are the calculation number, revision number, and appropriate proprietary classification listed on each page? Are the page numbers in the Table of Contents correct?	☒	☐	☐	
7. Has the objective/purpose been included in Section 1.0 of the calculation?	☒	☐	☐	
8. Is the Summary of Results and Conclusions provided in Section 2.0 consistent with the purpose stated in Section 1.0 and Results of Calculation contained in Section 5.2?	☒	☐	☐	
9. Is sufficient information provided for all references in Section 3.0 to facilitate their retrieval; or has a copy been provided as appendices?	☒	☐	☐	
10. Are the references accurate? Do the references to other documents point to the latest revision? If not, are the reasons documented?	☒	☐	☐	
11. Is the Method of Calculation/Analysis clearly described in Section 4.2 and reasonable?	☒	☐	☐	
12. Have all the inputs and assumptions listed in Section 4.0 of the calculation? Do all design input values have source identified?	☒	☐	☐	
13. Does the calculation contain Unapproved Inputs? If YES, has the Check Box on the Calculation Cover Sheet been marked? Have the Unapproved Inputs been listed in Section 2.3 (Open Items)?	☒	☐	☐	
14. Do the acceptance criteria define appropriately in Section 4.4?	☒	☐	☐	
15. Do the results and conclusions meet the acceptance criteria? Do the results and conclusions make sense and support the purpose stated in Section 1.0?	☒	☐	☐	
16. Does Table 6-1 identify all software used in the calculation? Are all software used in the calculation listed on the Approved Computer Program List?	☐	☐	☒	
17. Does Table 6-2 identify all electronic files for the calculation?	☐	☐	☒	
18. Are all attachments/appendices included in the calculation and noted on the cover page?	☒	☐	☐	
19. Is the calculation acceptable with respect to spelling, punctuation, and grammar?	☒	☐	☐	
20. Have all comments been resolved?	☒	☐	☐	

Appendix B: Wire Information

WIRES AND RODS INFORMATION

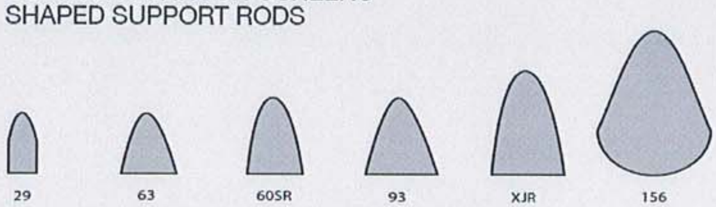
A wide range of wire and rod shapes make it possible to achieve the optimum balance of strength, open area, abrasion resistance and dewatering/separation efficiency.

JOHNSON SCREENS® ROUND AND STRIP SUPPORT RODS



Johnson Screens round rods are available in diameters ranging from 0.125 in. (3.175 mm) to 0.500 in. (12.7 mm). Strip rods are available in widths from 0.070 in. (1.778 mm) to 0.188 in. (4.775 mm) and heights ranging from 0.375 in. (9.525 mm) to 2.0 in. (50.8 mm).

COMMON *JOHNSON SCREENS* SHAPED SUPPORT RODS



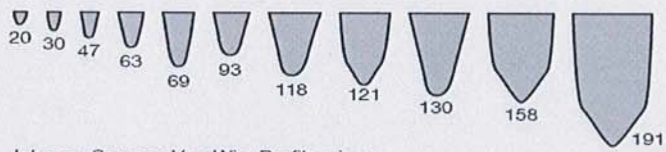
Johnson Screens shaped support rods range in widths from 0.029 in. (0.737 mm) to 0.151 in. (3.835 mm) and heights ranging from 0.102 in. (2.591 mm) to 0.120 in. (3.048 mm).

OPEN AREA CALCULATIONS

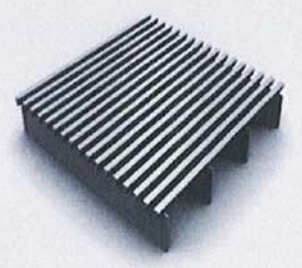
To calculate the open area of a certain screen, use the simple formula provided:

$$\text{Open Area (\%)} = \frac{\text{Slot size} \times 100}{\text{Slot size} + \text{Wire width}}$$

JOHNSON SCREENS VEE-WIRE® PROFILES



Johnson Screens Vee-Wire Profile wires range in widths from 0.020 in. (0.508 mm) to 0.195 in. (4.953 mm) and heights ranging from 0.040 in. (1.016 mm) to 0.363 in. (9.220 mm). Other wire shapes (Tri-Wire, Iso-Wire, Iso-Grizzly Wire, Grizzly-Wire, and more) also available.



Appendix C: Screen Information

Off-Shore Intakes - River Diversions - Facility Retrofits

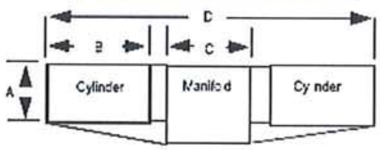
Left: Screens can be retrieved for inspection or during periods of non-use. Tracks can be installed on vertical walls or sloping banks.

Left Below: Cylinder screens can be mounted to existing facilities and can significantly increase intake screen surface area.

Right: Trashrack protects intake while screen is retracted. Rolling manifold and seating system holds unit securely sealed over intake when deployed.

Center: Screens can be manifolded to meet additional flow requirements for large installations. 72-inch diameter screens shown.

Above: Exterior and interior brushing action keeps screen surface very clean, minimizing headloss issues.



Cylinder Screen Specifications

Model *	Unit Dimensions A - B - C - D	Unit Weight	Screen Surface Area	Allowable Flow Rates ** Slot Velocity @ 0.5 ft/sec (0.08 m/s)	Approach Velocity @ 0.2 ft/sec (0.06 m/s)	Approach Velocity @ 0.33 ft/sec (0.10 m/s)	Approach Velocity @ 0.4 ft/sec (0.12 m/s)
ISI T30-42	30" - 42" - 36" - 128"	1,400 lbs.	55.0 ft^2 (5.11 m^2)	13.7 cfs (388 l/s)	9.4 cfs (266 l/s)	18.1 cfs (513 l/s)	22.0 cfs (623 l/s)
ISI T36-54	36" - 54" - 48" - 164"	1,900 lbs.	84.8 ft^2 (7.88 m^2)	21.2 cfs (600 l/s)	17.0 cfs (481 l/s)	28.0 cfs (793 l/s)	33.9 cfs (960 l/s)
ISI T42-66	42" - 66" - 60" - 200"	2,200 lbs.	119.5 ft^2 (11.10 m^2)	29.9 cfs (847 l/s)	23.9 cfs (676 l/s)	39.4 cfs (1116 l/s)	47.8 cfs (1354 l/s)
ISI T48-72	48" - 72" - 60" - 212"	2,900 lbs.	150.8 ft^2 (14.01 m^2)	37.5 cfs (1062 l/s)	30.2 cfs (885 l/s)	48.8 cfs (1382 l/s)	60.3 cfs (1708 l/s)
ISI T60-90	60" - 90" - 60" - 248"	3,800 lbs.	235.6 ft^2 (21.89 m^2)	58.9 cfs (1668 l/s)	47.1 cfs (1334 l/s)	77.8 cfs (2203 l/s)	94.2 cfs (2667 l/s)

ITEM 1

* **Available in Diameters from 24 to 96 inches (with custom lengths) — Call for more information**

ITEM 2

** 1) Allowable flows based on using wedgewire screens with 50% open area. Typical screen with 1.75mm wire is shown below;
2) Maximum recommended slot velocity is 0.5 fps for most applications subjected to heavy debris or poor hydraulic conditions;
3) Cylinder lengths are typically limited to 1.5 times the diameter as shown in the table above. Shorter cylinder lengths are available;
4) Many fisheries agencies use a maximum approach velocity criteria instead of slot velocity. Approach Velocity is the component of velocity perpendicular to the screen surface and measured 3 inches away. A minimum open area is generally specified;
5) Single cylinder units (i.e. "drums" or half of a "T") are also available;
6) Regulatory design criteria varies and typically depends on fish protection needs. Call for information on slot sizes below 1mm.

ISI Intake Screens, Inc.

For more information contact:

E-mail: screens@intakescreensinc.com
Website: www.IntakeScreensInc.com
Office: 8417 River Road, Sacramento, CA 95832
Phone: (916) 665-2727 *Fax:* (916) 665-2729

Part VII
Appendix D

Thermal Stratification

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§ 316(b) DEMONSTRATION FOR WILLIAM STATES LEE III NUCLEAR STATION

APPENDIX D

THERMAL STRATIFICATION

Prepared for:
DUKE ENERGY CAROLINAS, LLC
Charlotte, North Carolina

Prepared by:
HDR ENGINEERING, INC. OF THE CAROLINAS
Charlotte, North Carolina

July 22, 2011

WILLIAM STATES LEE III NUCLEAR STATION
THERMAL STRATIFICATION

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THERMAL STRATIFICATION

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Executive Summary

Duke Energy Carolinas, LLC’s (Duke Energy) proposed William States Lee III Nuclear Station (Lee Nuclear Station) will be located on the Broad River in Cherokee County, South Carolina. Under normal river flow conditions, Lee Nuclear Station will pump water from the Broad River through existing Pond A to support station operations. During significant drought periods, water stored in two drought contingency ponds (the existing Pond B and the proposed Pond C) will be used to support station operations and comply with the proposed Water Management Plan. These drought contingency ponds will be refilled by natural inflow and water withdrawn from the Broad River when river flows return to normal conditions.

The two-dimensional CE-QUAL-W2 model was used to model Pond A as a stand-alone water body. A research version of the CE-QUAL-W2 model, which is capable of simulating water flows pumped between two interconnected ponds, was used to develop a thermal model of the interconnected Ponds B and C. A stand-alone Pond B model was first calibrated to available data, and the resulting calibration coefficients were applied to the Pond A model and to the combined Ponds B and C model.

The CE-QUAL-W2 models were run to determine the projected thermal stratification in the ponds and to determine whether the total design intake flow of the cooling water intake structures for each pond would disrupt ("rupture" or "break apart") the projected thermal stratification. A hypothetical "no withdrawal" case for Ponds A, B, and C was run to determine the thermal stratification for these ponds. Proposed Pond C is designed to be a drought contingency storage pond and its intended use is to store water that will be used as needed during periods of low flow in the Broad River. Since the use of the drought contingency storage ponds is anticipated to be infrequent, Pond C is expected to develop thermal stratification and a turnover pattern similar to Pond B.

To simulate extended drought conditions and to determine whether thermal stratification in Ponds B and C would be disrupted during implementation of Duke Energy's proposed Water Management Plan, Ponds B and C were each modeled to be in continuous use. This hypothetical "continuous withdrawal" was modeled through each drought contingency pond’s cooling water

intake at its design intake capacity until each pond had been drawn down 30 feet. This hypothetical drawdown is more severe than any that would have occurred in the entire period of record (1926-2010) for Broad River flows.

Modeling results for Pond A indicate that the thermocline would be depressed to 509 ft mean sea level (msl) as a result of continuous pumping through the pond to operate the plant and show that the thermal stratification would not be disrupted. Modeling results show that Pond B would remain thermally stratified although the thermocline would be lowered to 523 ft msl as a result of a hypothetical 30 ft drawdown of Pond B; with the water being removed from the bottom of the pond. Pond C would also remain thermally stratified although the thermocline would be lowered to 546 ft msl as a result of a hypothetical 30 ft drawdown of Pond C; with the water being removed from the bottom of the pond.

Section 1
Introduction

Duke Energy Carolinas, LLC's (Duke Energy) William States Lee III Nuclear Station (Lee Nuclear Station) is a proposed two-unit, 2,234 MW power plant to be located on the Broad River in Cherokee County, South Carolina. Lee Nuclear Station will have a cooling water intake on the Broad River composed of two pumping sections: the primary section and the drought contingency section. Under normal river flow conditions, Lee Nuclear Station will pump water from the Broad River through the primary section to Pond A in support station operations. During significant drought periods, water stored in two drought contingency ponds (the existing Pond B and the proposed Pond C) will be used to support station operations and comply with the proposed Water Management Plan. These ponds will be refilled via natural inflow and water withdrawn from the Broad River through the drought contingency section when river flows return to normal conditions. Pond B is an existing on-site drought contingency pond, and the proposed Pond C will be formed by damming London Creek just upstream from its confluence with the Broad River.

Broad River flows from the existing period of record (1926 – 2010) were used to determine how often the drought contingency ponds would be used. To demonstrate the rarity of drought contingency storage use for station operations, the number of days either pond would have been used to provide cooling water for Lee Nuclear Station operations was determined from the station operations water balance model. The number of days Ponds B and C would have been used was converted to the percentage values shown in Table 1 by dividing the number of days Ponds B and C would have been used by the total number of days from 1926 through 2010. These numbers are based on Pond B's usable storage being used first (drawdown of 30 feet) followed by Pond C.

TABLE 1
PERCENTAGE OF DAYS WHEN DROUGHT CONTINGENCY PONDS WOULD HAVE BEEN USED

Pond	Cooling Water Withdrawal
B	2.8%
C	0.4%

During the 1926 through 2010 period of record, three significant drought periods have been identified: 1954-1956, 1998-2002, and 2007-2008. Most of the drought contingency pond-use-days in Table 1 occurred during one of these significant drought periods.

Table 1 shows how infrequently the drought contingency ponds would have been used to support station operations. Under Duke Energy's proposed Water Management Plan, the Broad River would have been able to support station operations 96.8 percent of the time during the 85-year period of record (1926 through 2010).

Pond A and drought contingency Ponds B and C, under 316(b) of the Clean Water Act and corollary State law, are considered to be reservoirs since they have an average hydraulic retention time of greater than 7 days.

The regulations state at 125.84(b)(3)(ii) that:

> "…in a lake or reservoir, the total design intake flow must not disrupt natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);"

Therefore, Duke Energy must establish that the thermal stratification and/or turnover patterns, if any, in each of the three ponds, are not disrupted. Section 125.83 defines natural thermal stratification as:

> “…the naturally-occurring division of a waterbody into horizontal layers of differing densities as a result of variations in temperature at different depths.”

Since the Environmental Protection Agency (EPA) did not define disrupt, the definition of disrupt (to break apart; rupture) as found in the Merriam-Webster dictionary is used.

HDR|DTA was commissioned by Duke Energy to develop two thermal models. The first model simulates Pond A as a stand-alone pond while the second model simulates the interconnected operation of existing drought contingency Pond B and proposed drought contingency Pond C. The thermal modeling and evaluations summarized in this report indicate that the total design intake flow for Lee Nuclear Station during normal and significant drought conditions will not disrupt the thermal stratification in Pond A, nor in drought contingency Ponds B and C.

The seasonal turnover pattern exhibited in existing Ponds A and B is anticipated to continue following start-up of Lee Nuclear Station, with thermal stratification during the summer months and near isothermal conditions during the winter. Proposed Pond C is expected to exhibit similar turnover patterns. The drought contingency ponds are anticipated to be used during low flow periods in the Broad River which typically occur during the hotter months when the ponds are thermally stratified. When these ponds are being used to supply water to the station, the total design intake flow will not disrupt the thermal stratification or turnover pattern.

Section 2
Model Development

All thermal modeling was performed using a research version of the widely accepted two-dimensional CE-QUAL-W2 reservoir modeling software (Environmental Laboratory 2008). Unlike the standard version of the CE-QUAL-W2 modeling software, the research version is capable of modeling flows pumped between Ponds B and C as well as flows withdrawn from the Broad River into the ponds.

The CE-QUAL-W2 model requires numerous input data files to describe the geometry of the ponds mathematically, the influence of meteorology on the ponds, runoff inflows into the ponds, and operational design intake flows pumped out of the ponds, and refill flows pumped into the ponds. The model computes in metric units, with inputs and outputs in meters and degrees Celsius. The outputs have been converted to English units for presentation in this report in feet and degrees Fahrenheit.

Meteorological data used to model pond thermal stratification processes include air temperature, dew point, wind speed, wind direction, solar radiation, and cloud cover. Data for the study periods were obtained from the National Oceanic and Atmospheric Administration (NOAA 2009).

Related parameters used by the CE-QUAL-W2 model to influence meteorological effects on the ponds are wind sheltering coefficients and shading coefficients for each segment. These coefficients were determined by a combination of site familiarity and model calibration to the measured temperature profiles in Pond B from 2006. The wind sheltering and shading coefficients work in conjunction with the azimuth of each segment to influence mixing and evaporation due to wind action as well as heating due to solar radiation.

Meteorological data were also used to determine the temperature of the inflows. The temperature of stream flow and direct runoff into the ponds was assumed to be at equilibrium temperature, which was approximated by the three-day trailing average of air temperatures. This

same equilibrium temperature approximation was used for the water temperature of flows withdrawn from the Broad River into the ponds.

Once a model was built, it was calibrated by running the model for a period of time for which field data was available and adjusting the model's internal parameters so that the model output matches the field data as closely as possible.

The Pond B CE-QUAL-W2 model was calibrated to 2006 data because four temperature profiles were available for that year. Water temperatures were collected by Duke Energy staff on four days in 2006: February 27, May 1, August 22, and October 31. For calibration, Pond B was modeled exactly as it existed in 2006 when the temperature data was collected.

The Pond B model was used to compute temperature profiles for four days in 2006 when the temperature data was collected. The computed temperature profiles were compared to the temperature profiles based on the actual temperature data collected as shown in Figure 1. With the modeled temperature profiles close to the field-measured temperature values, the CE-QUAL-W2 model for Pond B was considered adequately calibrated with respect to temperature.

Since the existing Pond A and the proposed Pond C are located near Pond B and have similar natural inflow characteristics to those of the existing Pond B, the model parameters determined during Pond B calibration were applied to Ponds A and Pond C.

Pond A was modeled as a stand-alone water body with flows pumped through it consistent with the operation of Ponds B and C. For example, the combined Ponds B and C model's temperature time series at the Pond B intake structure location is used for the temperature of flows pumped from Pond B to Pond A in the Pond A model.

The combined Ponds B and C model simulates the connections between Ponds B and C and the Broad River to demonstrate the influence of station operations on the thermal profiles in each pond.

Section 3

Model Results

To demonstrate whether or not the total design intake flow of the cooling water intake structures on each pond would disrupt the thermal stratification or turnover pattern, two cases were run for the three ponds. The first case was to model the ponds with no pumping into or out of the ponds to determine the natural or expected thermal stratification in the ponds. The second case was to model drought pumping operations through Pond A and hypothetical thirty foot maximum drawdown limitation in Ponds B and C to determine whether the natural or expected thermal stratification in the three ponds would be disrupted. The second case represents the worst case conditions under Duke Energy's proposed Water Management Plan.

Figure 2 shows the thermal profiles for the case of no withdrawal from Pond A. Figure 3 shows the results for Pond A with pumping operations through the pond. Pond A would remain thermally stratified although the thermocline would be depressed to an elevation of 509 ft msl as a result of continuous pumping through the pond to operate the plant. The thermal stratification of Pond A would not be disrupted. Figure 4 shows the thermal profiles for the case of no withdrawal from Pond B. Figure 5 shows the results for a 30 ft drawdown on Pond B. Pond B would remain thermally stratified–although the thermocline would drop to an approximate elevation of 523 ft msl as a result of the 30 ft drawdown limitation (note that the water would be removed from the bottom of Pond B). Figure 6 shows the thermal profiles for the case of no withdrawal from Pond C. Figure 7 shows the results for a 30 ft drawdown on Pond C. Pond C would remain thermally stratified although the thermocline would drop to an approximate elevation of 546 ft msl as a result of the 30 ft drawdown limitation. Similar to Pond B, cooling water from Pond C would also be withdrawn from the bottom of the pond.

The drought contingency ponds are anticipated to be used in during low flow periods on the Broad River that typically occur during the hotter months when the ponds are thermally stratified. When these ponds are being used to supply water to the station, the total design intake flow will not disrupt the thermal stratification or turnover pattern.

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Section 4

Conclusions

Section 316(b) of the Clean Water Act and corollary State law governing cooling water intake structures at new facilities states at 125.84(b)(3)(ii) that:

> "…in a lake or reservoir, total design intake flow must not disrupt natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies)."

Pond~~s~~ A and drought contingency Ponds B and C, for the purposes of SCDHEC's regulations, are considered to be reservoirs.

Section 125.83 defines natural thermal stratification as:

> "…the naturally-occurring division of a waterbody into horizontal layers of differing densities as a result of variations in temperature at different depths."

Since EPA did not define disrupt, the definition of disrupt (to break apart; rupture) as found in the Merriam-Webster dictionary is used.

The thermal modeling studies, commissioned by Duke Energy and summarized in this report, indicate that the withdrawal of cooling water for Lee Nuclear Station during normal and significant drought conditions will not disrupt the thermal stratification in Ponds A, B and C. The thermocline in Pond A would drop to an approximate elevation of 509 ft msl as a result of continuous pumping through the pond to operate the plant, but the thermal stratification would not be disrupted. The turnover pattern currently exhibited by existing Ponds A and B is anticipated to continue, with thermal stratification during the summer months and near isothermal conditions during the winter. Proposed Pond C is expected to exhibit similar turnover patterns. Drought contingency Ponds B and C are anticipated to be used during low flow periods on the Broad River which typically occur during the hotter months when the ponds would be thermally stratified. When Ponds B and C are being used to supply water to the station, the total design intake flow will not disrupt the thermal stratification or turnover pattern in the ponds.

This report is focused on the significant drought scenarios when the cooling water intakes on Ponds B and C are used to move water to Pond A. Keep in mind that significant drought periods represent a small percentage of overall station operations. During the 85-year period of record, pumping from drought contingency pond storage would have been used to support station operations approximately 3.2 percent of the time.

Section 5

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FIGURES

FIGURE 1
POND B CALIBRATION TEMPERATURE PROFILES

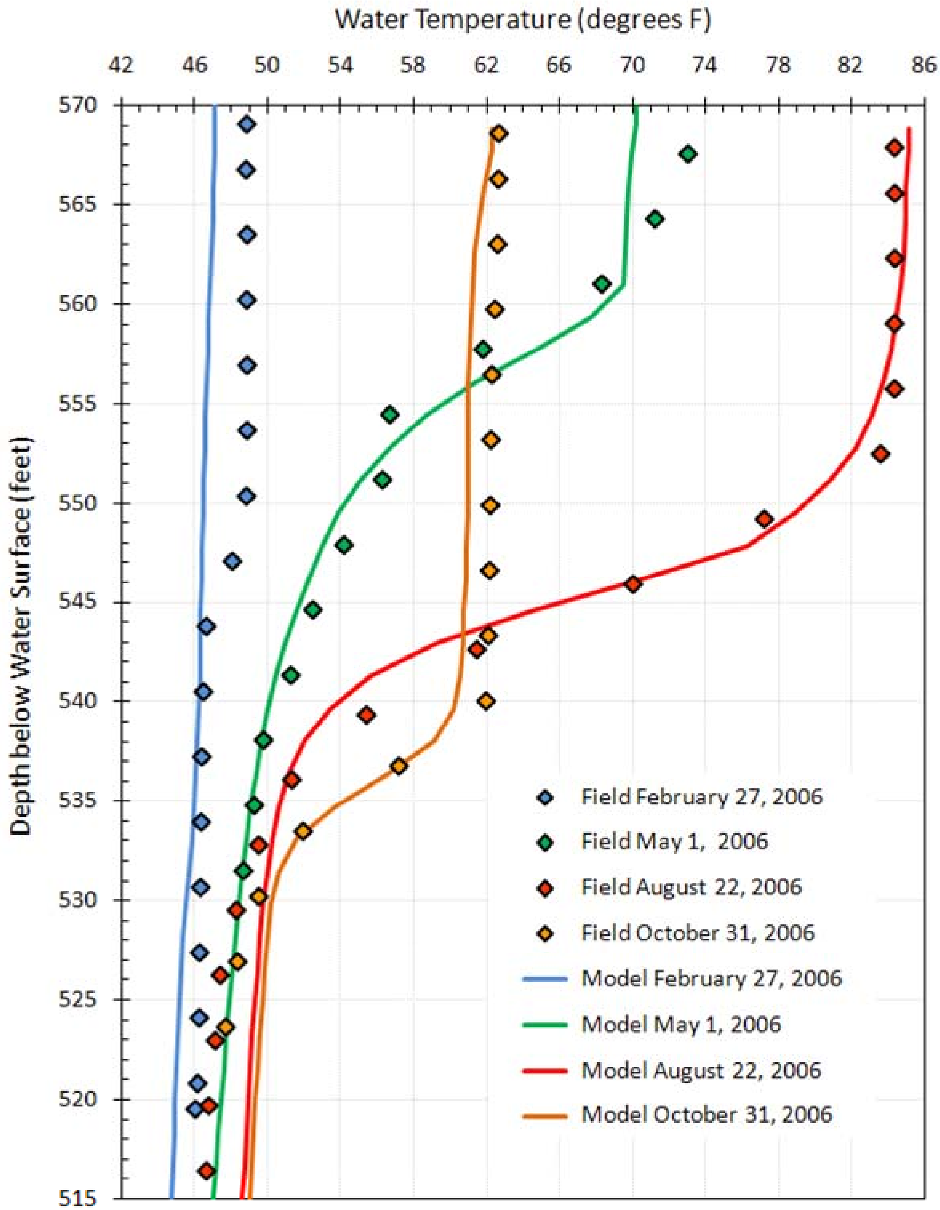

FIGURE 2
POND A THERMAL PROFILES FOR NO WITHDRAWAL FROM POND

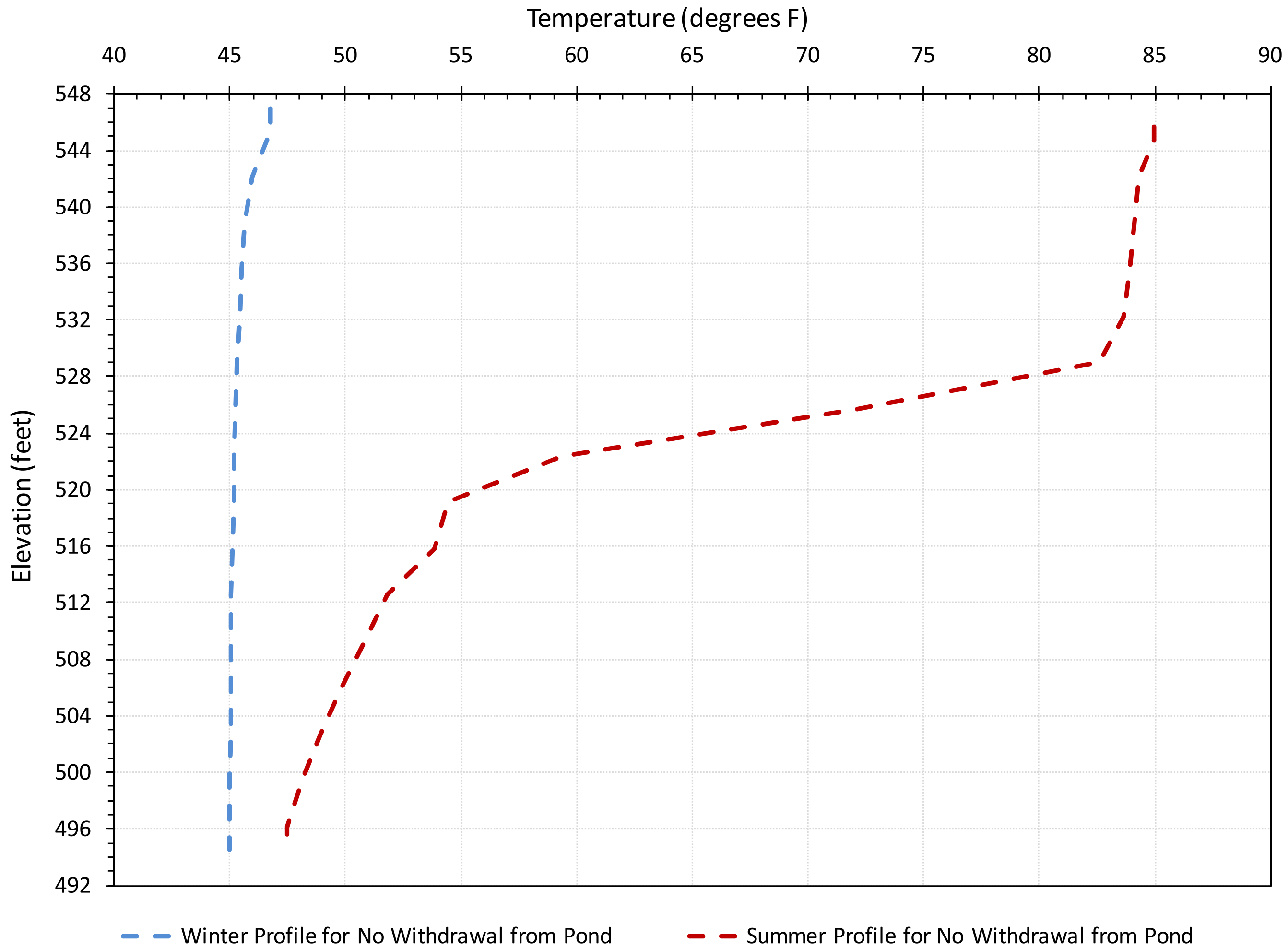

Figure 2

FIGURE 3

POND A THERMAL PROFILES FOR WITHDRAWAL FROM POND

(design intake flow rate of 139 cfs)

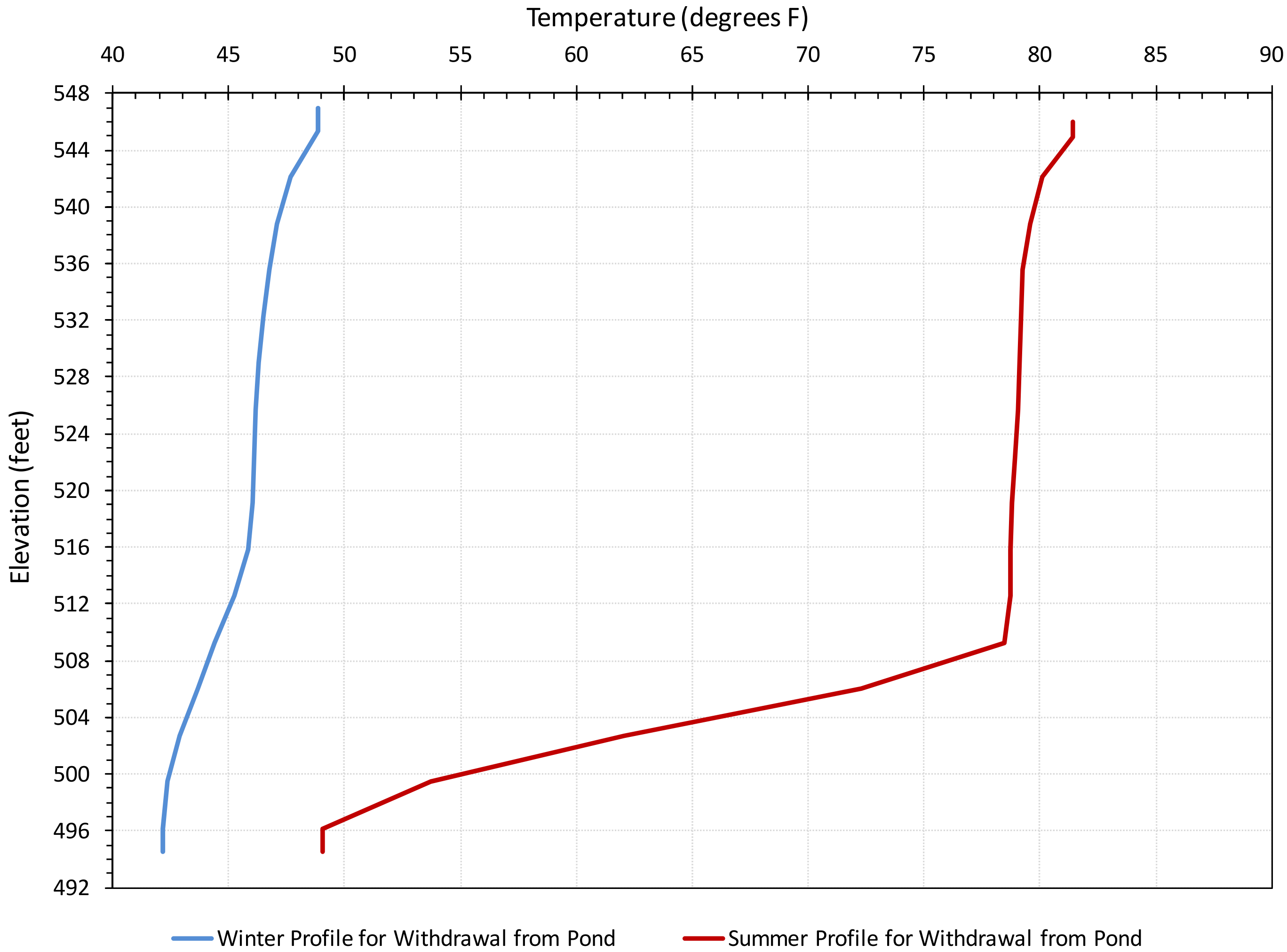

Figure 3

FIGURE 4
POND B THERMAL PROFILES FOR NO WITHDRAWAL FROM POND

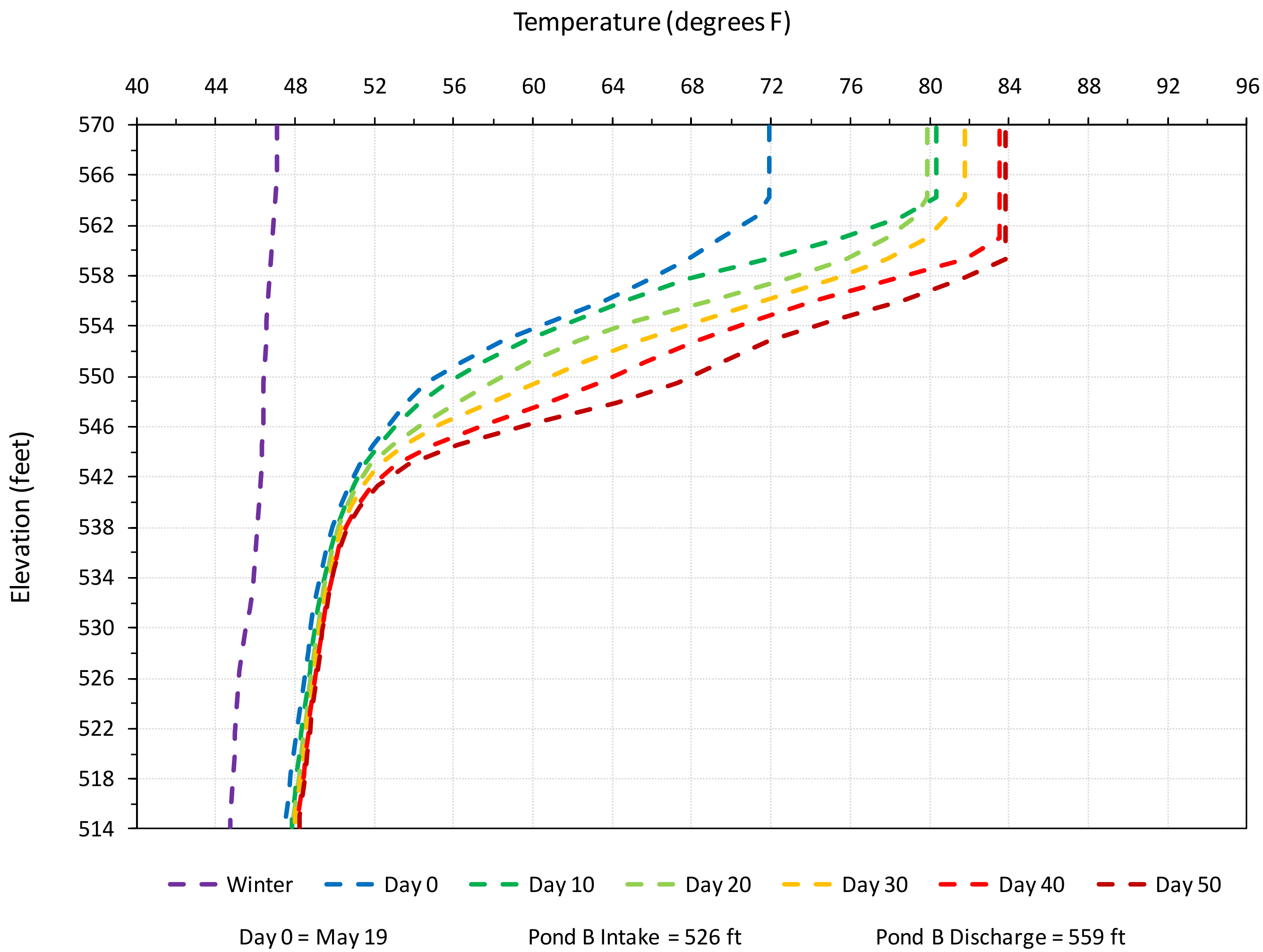

Figure 4

FIGURE 5
POND B THERMAL PROFILES DURING MAXIMUM 30 FT DRAWDOWN

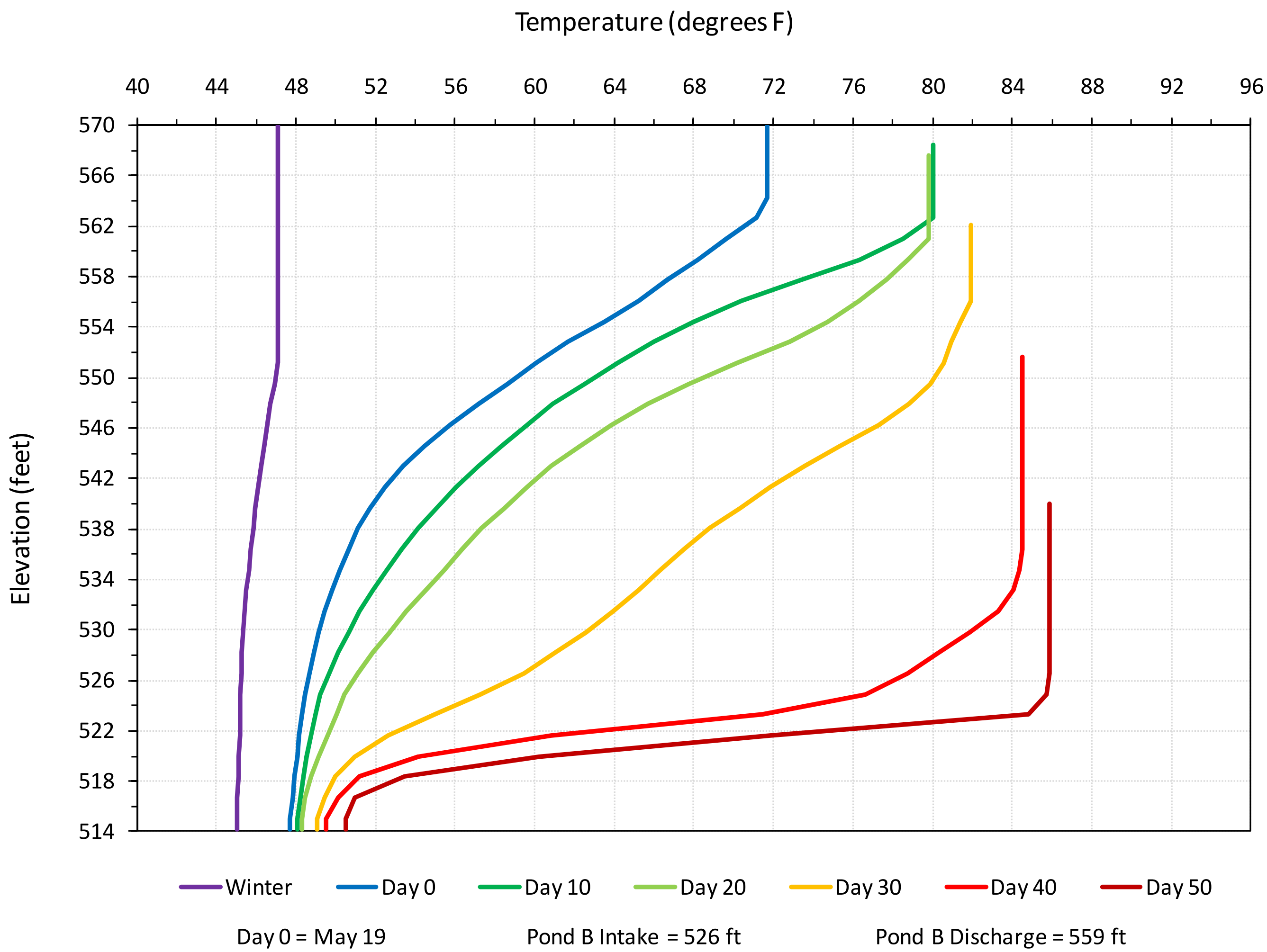

Figure 5

FIGURE 6
POND C THERMAL PROFILES FOR NO WITHDRAWAL FROM POND

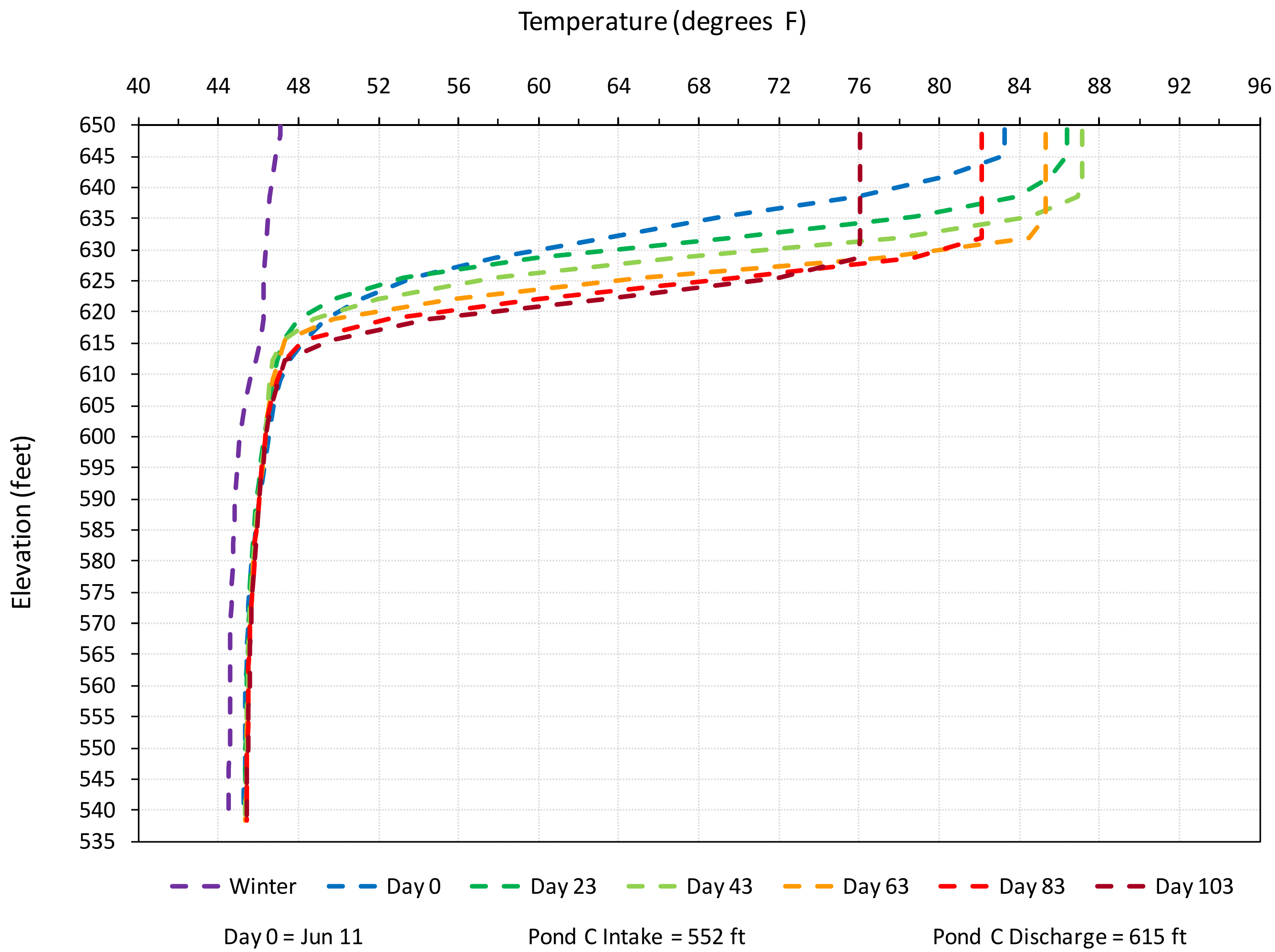

Figure 6

FIGURE 7
POND C THERMAL PROFILES DURING MAXIMUM 30 FT DRAWDOWN

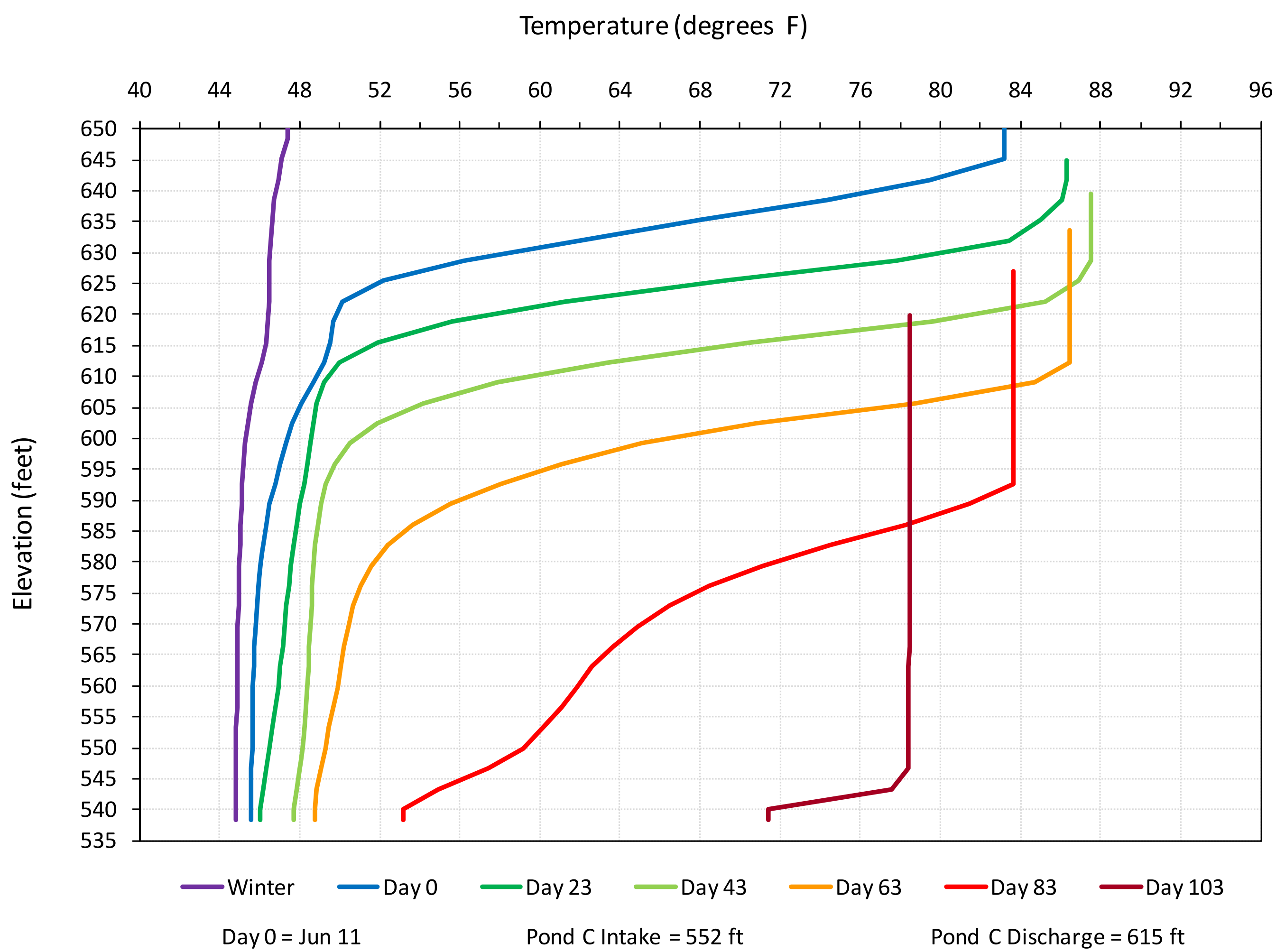

Figure 7

COST INFORMATION REDACTED

Appendix E

EPA's Assumptions and Costing Methodology

COST INFORMATION REDACTED

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Appendix F

Air Quality Impacts

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§ 316(b) COMPLIANCE DEMONSTRATION
FOR WILLIAM S. LEE III NUCLEAR STATION

APPENDIX F

AIR QUALITY

Prepared by:

AKRF, Inc.
and
Duke Energy Carolinas, LLC

August 10, 2011

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Table of Contents

Attachments

List of Tables

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List of Acronyms, Defined Terms and Abbreviations

CAA	Clean Air Act
CO_2	carbon dioxide
Duke Energy	Duke Energy Carolinas, LLC
EPA	United States Environmental Protection Agency
GHG	greenhouse gas
Hg	mercury
IRP	Integrated Resources Plan
Lee Nuclear Station	William S. Lee III Nuclear Station
NAAQS	National Ambient Air Quality Standard
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
PES	Pacific Environmental Services
$PM_{2.5}$	fine particulate matter
ppm	parts per million
SCDHEC	South Carolina Department of Health and Environmental Control
SO_2	sulfur dioxide
VOCs	Volatile Organic Compounds

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1.0 INTRODUCTION

1.1 PURPOSE

Duke Energy Carolinas, LLC (Duke Energy) determined that one potential option to achieve compliance with the South Carolina Department of Health and Environmental Control's (SCDHEC) § 125.84(b)(3)(i) requirements would be to take forced seasonal shutdowns at its proposed William S. Lee III Nuclear Station (Lee Nuclear Station) (see Attachment F.1). Seasonal shutdowns are a component of two of the three compliance options evaluated by Duke Energy as a means of achieving compliance with § 125.84(b)(3)(i): Option 2 – Pond B with Seasonal Shutdowns and Option 3 – Ponds B and C with Seasonal Shutdowns [see Section 3.2.4 of the § 316(b) Compliance Demonstration]. Seasonal shutdowns were modeled for a nine-year period from 2021 through 2029, based on actual 2001-2009 river flows. Duke Energy used the production cost model PROSYM to predict the likely sources of replacement power during these seasonal shutdowns and the potential air quality impacts associated with these sources of replacement power during forced shutdowns. Duke Energy uses PROSYM in preparing its Integrated Resources Plan (IRP), submitted to appropriate regulatory agencies. The air emissions study included potential effects on the Duke Energy Service Area (see Figure F-1) and the need for replacement power during seasonal shutdowns. PROSYM was also used to project impacts to the system from increased fuel consumption at alternative sites that use fossil fuel for power generation that would be required to replace the power lost due to seasonal shutdowns at Lee Nuclear Station. The increased combustion of fossil fuels within the system would result in additional air pollutant emissions to the regional air sheds.

In addition to Options 2 and 3, which included seasonal shutdowns, Duke Energy also evaluated the installation of hybrid wet and dry cooling towers, Option 4 – Hybrid Towers. Option 4 is discussed in Section 3.2.4 of the § 316(b) Compliance Demonstration. The PROSYM model was also used to predict the likely sources of replacement power associated with increased parasitic load from this compliance option.

1.2 BACKGROUND

As discussed above, three of the compliance options considered at Lee Nuclear Station would require Duke Energy to obtain replacement power to meet system-wide demand for electricity. According to the current dispatch model, there are six facilities within the Duke Energy Service Area that would most likely be used for replacement power if seasonal shutdowns or installation of hybrid towers were to occur at Lee Nuclear Station. Replacement power would most likely be generated by the stations listed in Table F-1, which are all located in North Carolina. This assumes

that other existing coal-fired units in the Duke Energy's Service Area will be retired by 2018, in accordance with current IRP projections.

TABLE F-1

Replacement Power Station List

Station Name	Station Type	County
Buck Station	Combined Cycle/Natural Gas	Rowan
Dan River Station	Combined Cycle/Natural Gas	Rockingham
Allen Station	Steam Electric/Coal	Gaston
Cliffside Station	Steam Electric/Coal	Cleveland
Marshall Station	Steam Electric/Coal	Catawba
Belews Creek Station	Steam Electric/Coal	Stokes

As indicated in Table F-1, four of the six stations are coal burning units. Two of the six stations (i.e., Allen and Buck Stations) are located within counties that have been designated by the United States Environmental Protection Agency (EPA) as non-attainment areas for the 8-hour ozone standard (i.e., Gaston and Rowan Counties) (EPA 2008a), based on the 1997 EPA 8-hour ozone National Ambient Air Quality Standard (NAAQS) of 0.080 parts per million (ppm). EPA issued a revised ozone standard of 0.075 ppm in 2008, but has proposed to reconsider and reissue the standard at a value between 0.060 and 0.070 ppm (EPA 2010a). Under this more stringent standard, all or most of the above counties may be designated as non-attainment as early as August 2011.

1.3 POLLUTANTS FOR ANALYSIS

In developing the Phase I § 316(b) regulations, which SCDHEC has adopted, EPA (2001) assessed the potential impacts of four pollutants that are believed to have the greatest potential to cause adverse air quality impacts: nitrogen oxides (NO_x); carbon dioxide (CO_2); sulfur dioxide (SO_2); and mercury (Hg). Each of these pollutants was analyzed.

1.4 NITROGEN OXIDES

Nitrogen oxides are primarily comprised of nitric oxide (NO) and nitrogen dioxide (NO_2), which are collectively referred to as NO_x. NO_x are of principal concern because of their role, together with Volatile Organic Compounds (VOCs), as precursors in the formation of ozone, a respiratory irritant (EPA 2008b). Ozone is formed through a series of reactions that take place in the atmosphere in the presence of sunlight. Because the reactions are slow, and occur as the pollutants drift

downwind, elevated ozone levels are often found many miles from sources of the precursor pollutants. NO_2 is regulated as a criteria pollutant (i.e., a pollutant for which EPA established NAAQS), due to its direct effects on human health (EPA 2009a).

1.5 CARBON DIOXIDE

Carbon dioxide is a greenhouse gas (GHG). GHGs are those gaseous constituents of the atmosphere, both natural and anthropogenic, which absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds. Unlike criteria pollutants, GHGs do not have a direct impact on human health, but are expected to significantly affect the global climate system well into the future and, therefore, could indirectly impact human health and natural systems (EPA 2009b).

1.6 SULFUR DIOXIDE

Sulfur dioxide is a criteria pollutant and its emissions are primarily associated with the combustion of sulfur-containing fuels, such as oil and coal. SO_2 is regulated due to its direct effects on human health (EPA 2009c). SO_2 is also regulated under the Clean Air Act (CAA), because of potential secondary impacts, including fine particulate matter ($PM_{2.5}$), acid rain, and visibility. North Carolina currently has three counties designated as non-attainment for $PM_{2.5}$. Furthermore, EPA is considering tightening the $PM_{2.5}$ standard.

1.7 MERCURY

Mercury is a toxic metal; emissions are primarily associated with the combustion of coal. Mercury deposition in water bodies may enter the biological cycle as methylmercury formed through complex organic chemistry. Methylmercury bioaccumulates in certain fish species and may pose risks to human health based on consumption of these fish. Air emissions of mercury are regulated due to its indirect effects on human health (EPA 2009d).

2.0 AIR QUALITY ASSESSMENT

2.1 APPROACH

The potential for air quality impacts from seasonal shutdowns at Lee Nuclear Station exists because the replacement power that would be required during seasonal shutdown would be generated by non-nuclear facilities that burn fossil fuels. In addition to seasonal shutdowns, potential effects on air quality were also assessed for installation of hybrid wet and dry cooling towers. Replacement power required for this compliance option would also be generated by non-nuclear facilities that burn fossil fuels. To determine the potential effects on air quality, potential emissions were calculated for fossil fuel combustion during projected periods of seasonal shutdowns at Lee Nuclear Station or during periods when supplemental generation would be needed to compensate for the additional parasitic load associated with the operation of hybrid towers. The emissions of four pollutants were calculated (i.e., CO_2, SO_2, Hg, and NO_x) and the potential effects of these emissions were assessed. However, the analysis of impacts has a strong emphasis on NO_x, because parts of the Duke Energy Service Area are in non-attainment for the 8-hour ozone NAAQS (NO_x is a pre-cursor to the formation of ozone).

A summary of the latest available air monitoring data was used to determine the sensitivity of the region to increased NO_x emissions and their effects on future compliance with the 8-hour ozone NAAQS.

2.2 SEASONAL SHUTDOWN ASSESSMENT

Seasonal shutdowns at Lee Nuclear Station would require Duke Energy to generate power at alternative stations within its system. The demand for replacement power was projected for a 9-year period (2021 through 2029) based on an assessment prepared by Duke Energy (see Attachment F.1) of the number of days when Lee Nuclear Station would be required to take a seasonal shutdown due to inadequate supplies of water (based on modeling of 2001-2009 river flows) for Lee Nuclear Station to operate in compliance with the § 125.84(b)(3)(i) requirements. Seasonal shutdown schedules were determined for two scenarios based on the availability of drought contingency Ponds B and/or C at Lee Nuclear Station. Option 2 – Pond B with Seasonal Shutdowns - had five shutdowns over a 9-year period. Option 3 – Ponds B and C with Seasonal Shutdowns – had one shutdown over a 9-year period. Based on the demand for power during these seasonal shutdowns, potential emissions of NO_x, CO_2, SO_2, and Hg were calculated on a calendar year basis. Both Options 2 and 3 were compared to a scenario assuming no additional seasonal shutdowns above normal operation at Lee Nuclear Station. The total increase of emissions was then determined by subtracting the Option 2 or Option 3 emissions from the emissions with normal operations. These emissions were expressed as annual totals (i.e., tons of pollutant by year for the years 2021 - 2029). A summary of this emissions study is presented in Attachment F.1. The

simulation of shutdowns that would have occurred in 2027 and 2028 (based on modeling of river flow data during the 2007 and 2008 droughts) resulted in significant emission increases.

Table F-2 presents the projected emissions increase of NO_x, CO_2, SO_2, and Hg for the peak emissions year (2028) for Options 2 and 3. As indicated in Table F-2, Option 2 – Pond B with Seasonal Shutdowns – has the highest projected emission increases and, therefore, would have the greater potential to adversely affect regional air quality.

Although the emphasis of this assessment is on NO_x and ozone formation, other pollutants are also of concern due to their adverse health effects. NO_2 and SO_2 are highly reactive gases that are linked to adverse health effects on the human respiratory system (EPA 2009a; EPA 2009c). Mercury is a neurotoxin that adversely affects human health and the environment (EPA 2009d). Increasing emissions of these pollutants could further deteriorate regional air quality.

CO_2 is a GHG, and efforts to reduce these emissions on a regional scale are important (EPA 2009b). In the previous sessions of Congress, several bills had been introduced in both the United States Senate and House of Representatives to address CO_2, including Lieberman/Warner (2007), Dingell/Boucher (2008), Waxman/Markey (2009 – passed the House of Representatives) and most recently Kerry/Graham/Lieberman (2010). While none of these bills are presently under consideration, similar legislation may be introduced in the current Congress. The details of each piece of legislation differ, but in concept they all propose to reduce nationwide CO_2 emissions by approximately 40% by 2030 and 80% by 2050. Using a 2005 baseline year for the Duke Energy system, the 2030 goal for total emissions would be approximately 26 million tons of CO_2. An increase in CO_2 emissions in the range of 2 to 4 million tons, outlined in Table F-2, would represent 8% to 15% of the target CO_2 emission limit.

Additional concerns for NO_2 have come into focus with the promulgation of a new 1-hour averaging standard for this pollutant (EPA 2010c). Until recently, NO_2 was regulated only on an annual average basis (EPA 2010d). It was mostly of concern as a region-wide pollutant or in connection with local impacts from large stationary sources. However, with the promulgation of a new 1-hour standard for NO_2, local sources (including emission increases from large stationary sources) could be deemed to have a greater adverse effect on air quality in the future when air quality impacts will be compared to the new standard.

TABLE F-2

Peak Emissions Increase Estimates for Replacement Power: Seasonal Shutdown Scenarios

Pollutant	Peak Projected Annual Emissions Increase (tons per year)	
	Option 2 Pond B with Seasonal Shutdowns	Option 3 Ponds B and C with Seasonal Shutdowns
Nitrogen Oxides	1,900	900
Carbon Dioxide	3,800,000	1,500,000
Sulfur Dioxide	900	400
Mercury	35 (pounds)	16 (pounds)

In the case of NO_x emissions (a precursor to ozone), the region would be especially sensitive to large increases, because eight counties in close proximity to the stations likely to provide replacement energy are deemed to be in non-attainment with the ozone standard. Seven of these counties are located in North Carolina and one is located in South Carolina. These eight non-attainment counties are listed below:

Union County, North Carolina;
Mecklenburg County, North Carolina;
Gaston County, North Carolina;
Lincoln County, North Carolina;
Carbarrus County, North Carolina;
Rowan County, North Carolina;
Iredell County, North Carolina (partial); and
York County, South Carolina (partial).

These counties are shown on state maps in Attachment F.2.

2.3 MONITORING DATA

Table F-3 provides monitored 8-hour ozone concentrations for several regional metropolitan areas close to or within the Duke Energy Service Area. As indicated in Table F-3, the monitored concentrations are above the current 8-hour ozone standard of 0.075 ppm (EPA 2010b). These concentrations were based on 2008 sampling data (EPA 2009e). Documentation is provided in Attachment F.3.

TABLE F-3

2008 8-Hour Ozone Monitoring Data

Core Based Statistical Area	8-Hour Ozone Concentration[a] (ppm)	8-Hour Ozone NAAQS (ppm)
Charlotte-Gastonia-Concord, NC-SC	0.093	0.075[b]
Asheville, NC	0.080	
Greenville, SC	0.080	
Columbia, SC	0.078	

Notes:
a. Represents the highest fourth daily maximum 8-hour concentration.
b. EPA has proposed lowering the current standard of 0.075 ppm to within the range of 0.060 to 0.070 ppm.

2.4 NITROGEN OXIDES AND OZONE NON-ATTAINMENT

As presented in Table F-1, there are six fossil fuel electric generating stations that would most likely be called into service to provide replacement power to compensate for reductions in generation at Lee Nuclear Station. Two of the six stations (Allen Station in Gaston County and Buck Station in Rowan County) are located in North Carolina counties that have been designated by EPA as being in non-attainment for the 1997 8-hour ozone standard of 0.080 ppm. Two other stations (Cliffside Station in Cleveland County and Marshall Station in Catawba County) are in close proximity to the non-attainment counties, and also are located upwind of the non-attainment area (based on a predominant southwest wind direction during the summer ozone season) (PES 2010). As noted, EPA promulgated a revised ozone standard of 0.075 ppm and, subsequently, issued a proposal to lower the standard to 0.060 or 0.070 ppm. These lower standards will result in additional non-attainment counties in the region.

2.5 HYBRID COOLING TOWER ASSESSMENT

If hybrid wet and dry cooling towers were to be constructed at Lee Nuclear Station, the decreased efficiency and increased parasitic load would require Duke Energy to generate power at alternative stations within its system. The demand for replacement power was projected for a nine-year period (2021 through 2029) based on an assessment prepared by Duke Energy (see Attachment F.1), which includes potential emissions of NO_x, CO_2, SO_2, and Hg calculated on a calendar year basis. These emissions were compared to a base case emissions scenario assuming no changes to normal operation at Lee Nuclear Station. The total increase of emissions was then determined by

subtracting the emissions of the cooling tower scenario from the base case emissions. These emissions were expressed as annual totals (i.e., tons of pollutant by year for the years 2021 through 2029). A summary of this emissions study is presented in Attachment F.1.

Table F-4 presents the projected emissions increase of NO_x, CO_2, SO_2, and Hg for the peak emissions year. As indicated in Table F-4, there would be an increase of air emissions associated with the hybrid cooling tower option that could have the potential to adversely affect regional air quality.

TABLE F-4

Peak Emissions Increase Estimates for Replacement Power: Hybrid Cooling Tower Scenario

Pollutant	Peak Projected Annual Emissions Increase (tons per year)
Nitrogen Oxides	200
Carbon Dioxide	300,000
Sulfur Dioxide	180
Mercury	7 (pounds per year)

3.0 CONCLUSION

A requirement to take seasonal shutdowns or to operate hybrid towers at Lee Nuclear Station to comply with § 125.84(b)(3)(i) would have negative impacts on air quality within the Duke Energy Service Area. These would result from the increased need to generate electricity from fossil fuel-fired power plants as well as significant national environmental policy implications with regard to GHG emissions.

The most significant impact on regional air quality would be related to the additional release of NO_x emissions. The Duke Energy Service Area in North and South Carolina is in a geographic region that is favorable for production of ground-level ozone during warm seasons. At least some of the seasonal shutdowns at Lee Nuclear Station would likely occur during warm weather, particularly under Option 2. Currently, there are areas within and in close proximity to the Duke Energy Service Area that are classified as non-attainment for the 1997 8-hour ozone standard. EPA is in the process of implementing a more stringent ozone standard that will likely result in classification of many more counties in the region as non-attainment. States will be required to develop SIPs demonstrating necessary reductions in NO_x emissions to attain the revised standard by 2014 to 2031. Failure to attain the standards, established to protect public health and welfare, by these dates may result in various sanctions.

In addition, increased operation of fossil fuel-fired power plants would result in a significant increase in the release of CO_2 emissions. While there are no current regulations that restrict the amount of CO_2 emissions, EPA has recently finalized a rulemaking finding that CO_2 and other GHG emissions associated with motor vehicles pose an endangerment to human health and welfare in relation to the global issue of climate change. EPA has also stated its intent to regulate CO_2 emissions from power plants and other large stationary sources by 2011 under provisions of the CAA. To place the significance of seasonal shutdowns at Lee Nuclear Station in context, the additional CO_2 emissions resulting from that requirement would amount to 2 - 4 million tons in a given year, approximately 8 - 15% of the likely year 2030 CO_2 target emissions for Duke Energy operations in North Carolina and South Carolina under the proposed legislation.

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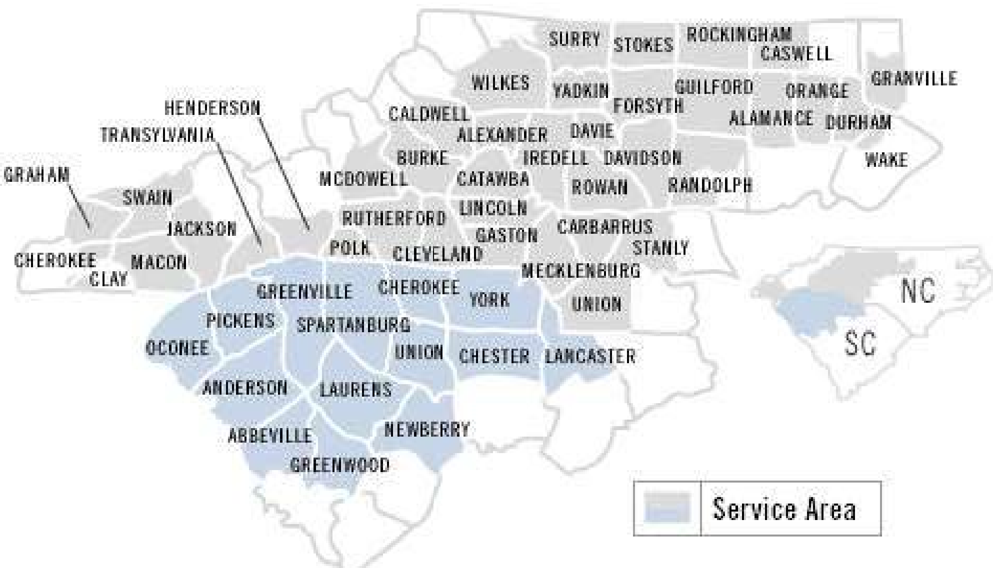
Figures

Duke Energy Carolinas, LLC Service Territory

Service Area Map

Stretching north to the Virginia border and south to Georgia, our service territory covers 22,000 square miles in North Carolina and South Carolina. Duke Energy Carolinas serves more than 2 million customers in one of the fastest growing regions in the United States.



Source: Duke Energy 2010

Figure F-1

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§ 316(b) COMPLIANCE DEMONSTRATION
FOR WILLIAM S. LEE III NUCLEAR STATION

Attachment F.1

Lee Nuclear Station Air Emissions Study

Prepared by:

Duke Energy Carolinas, LLC

August 10, 2011

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Attachment F.1
Lee Nuclear Station Air Emissions Study

The air emissions study for Lee Nuclear Station calculated the increased air emissions associated with replacement power to offset several long shutdowns at the station due to low flow during drought conditions. Two compliance options studied were: Option 2 — Pond B with Seasonal Shutdowns and Option 3 — Ponds B and C with Seasonal Shutdowns. Option 2 assumed that there would be five shutdowns over nine years. Option 3 assumed that over nine years there would be one shutdown due to the low flow. Tables F.1-1 and F.1-2 below show the seasonal shutdown dates used in Options 2 and 3. The production cost model PROSYM was used to simulate the Duke Energy Carolinas, LLC system impacts between Duke Energy's normal operational schedule for Lee Nuclear Station and Options 2 and 3.

Table F.1-1 Option 2 – Pond B and Seasonal Shutdowns

Model Year	Historical Year	Start Day	Stop Day	Total Offline Days
2021	2001	10/9	11/10	32
2022	2002	7/8	10/14	98
2023	2003			0
2024	2004			0
2025	2005			0
2026	2006			0
2027	2007	8/22	11/30	100
2028	2008	7/1	9/15	76
2028	2008	11/5	12/15	40
2029	2009			0

Table F.1-2 Option 3 – Ponds B and C with Seasonal Shutdowns

Model Year	Historical Year	Start Day	Stop Day	Total Offline Days
2021	2001			0
2022	2002			0
2023	2003			0
2024	2004			0
2025	2005			0
2026	2006			0
2027	2007			0
2028	2008	10/21	12/4	44
2029	2009			0

The table below shows the increased emissions for Compliance Options 2 and 3 over the emissions without any forced shutdowns at Lee Nuclear Station due to water availability. The years with an emission delta

include a forced shutdown. Also included in the table are the emissions resulting from replacement power to offset the higher parasitic load associated with the operation of hybrid cooling towers.

CO_2 Emissions (Tons)								
	Lee Nuclear Station Normal Operations	Option 2 - Pond B with Seasonal Shutdowns	Option 3 - Ponds B and C with Seasonal Shutdowns	Option 4 - Hybrid Towers		Option 2 Delta	Option 3 Delta	Option 4 - Delta
2021	30,242,842	31,605,737	30,242,842	30,523,347		1,362,895	0	280,505
2022	33,150,112	36,396,191	33,150,112	33,445,636		3,246,079	0	295,524
2023	34,644,340	34,644,340	34,644,340	34,822,821		0	0	178,481
2024	36,373,858	36,373,858	36,373,858	36,657,523		0	0	283,665
2025	37,658,476	37,658,476	37,658,476	37,906,486		0	0	248,010
2026	40,637,822	40,637,822	40,637,822	40,856,083		0	0	218,261
2027	41,565,269	45,017,124	41,565,269	41,837,067		3,451,855	0	271,798
2028	43,696,711	47,526,453	45,249,302	44,018,146		3,829,742	1,552,591	321,435
2029	44,948,462	44,948,462	44,948,462	45,172,524		0	0	224,062
SO_2 Emissions (Tons)								
	Lee Nuclear Station Normal Operations	Option 2 - Pond B with Seasonal Shutdowns	Option 3 - Ponds B and C with Seasonal Shutdowns	Option 4 - Hybrid Towers		Option 2 Delta	Option 3 Delta	Option 4 Delta
2021	13,813	14,427	13,813	13,910		614	0	97
2022	15,472	16,421	15,472	15,593		949	0	121
2023	15,667	15,667	15,667	15,736		0	0	68
2024	16,449	16,449	16,449	16,567		0	0	118
2025	17,019	17,019	17,019	17,119		0	0	100
2026	18,128	18,128	18,128	18,169		0	0	41
2027	18,191	19,117	18,191	18,269		926	0	77
2028	19,137	20,001	19,554	19,319		865	418	183
2029	19,257	19,257	19,257	19,295		0	0	38

NO_x Emissions (Tons)								
	Lee Nuclear Station Normal Operations	Option 2 - Pond B with Seasonal Shutdowns	Option 3 - Ponds B and C with Seasonal Shutdowns	Option 4 - Hybrid Towers		Option 2 Delta	Option 3 Delta	Option 4 Delta
2021	12,852	13,638	12,852	12,943		786	0	91
2022	14,829	16,615	14,829	15,029		1,786	0	200
2023	15,516	15,516	15,516	15,536		0	0	20
2024	16,426	16,426	16,426	16,594		0	0	168
2025	17,175	17,175	17,175	17,291		0	0	116
2026	18,901	18,901	18,901	19,026		0	0	125
2027	19,910	21,872	19,910	19,963		1,962	0	53
2028	20,736	22,684	21,729	20,994		1,948	992	207
2029	21,487	21,487	21,487	21,518		0	0	31
Hg Emissions (Pounds)								
	Lee Nuclear Station Normal Operations	Option 2 – Pond B with Seasonal shutdowns	Option 3 – Ponds B and C with Seasonal Shutdowns	Option 4 - Hybrid Towers		Option 2 Delta	Option 3 Delta	Option 4 Delta
2021	489	511	489	493		22	0	4
2022	548	583	548	553		35	0	5
2023	559	559	559	561		0	0	2
2024	586	586	586	590		0	0	5
2025	606	606	606	610		0	0	4
2026	649	649	649	651		0	0	1
2027	655	689	655	658		34	0	3
2028	687	719	702	693		32	16	7
2029	692	692	692	695		0	0	3

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WILLIAM S. LEE III NUCLEAR STATION
FOR § 316(b) COMPLIANCE DEMONSTRATION

Attachment F.2

Non-Attainment Counties

Prepared by:

AKRF, Inc.
7250 Parkway Drive
Hanover, MD 21076

February 11, 2011

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AirData

You are here: EPA Home Air & Radiation AirData Reports and Maps Select Geography Select Report/Map Nonattainment Areas Map Criteria Nonattainment Areas Map

EPA is assessing its data systems, including AirData reports and maps. Data updates are suspended while the assessment is underway. The last update included data through January 10, 2009; see database status for details. For more recent air quality data, visit the AirExplorer and Air Emission Sources sites.

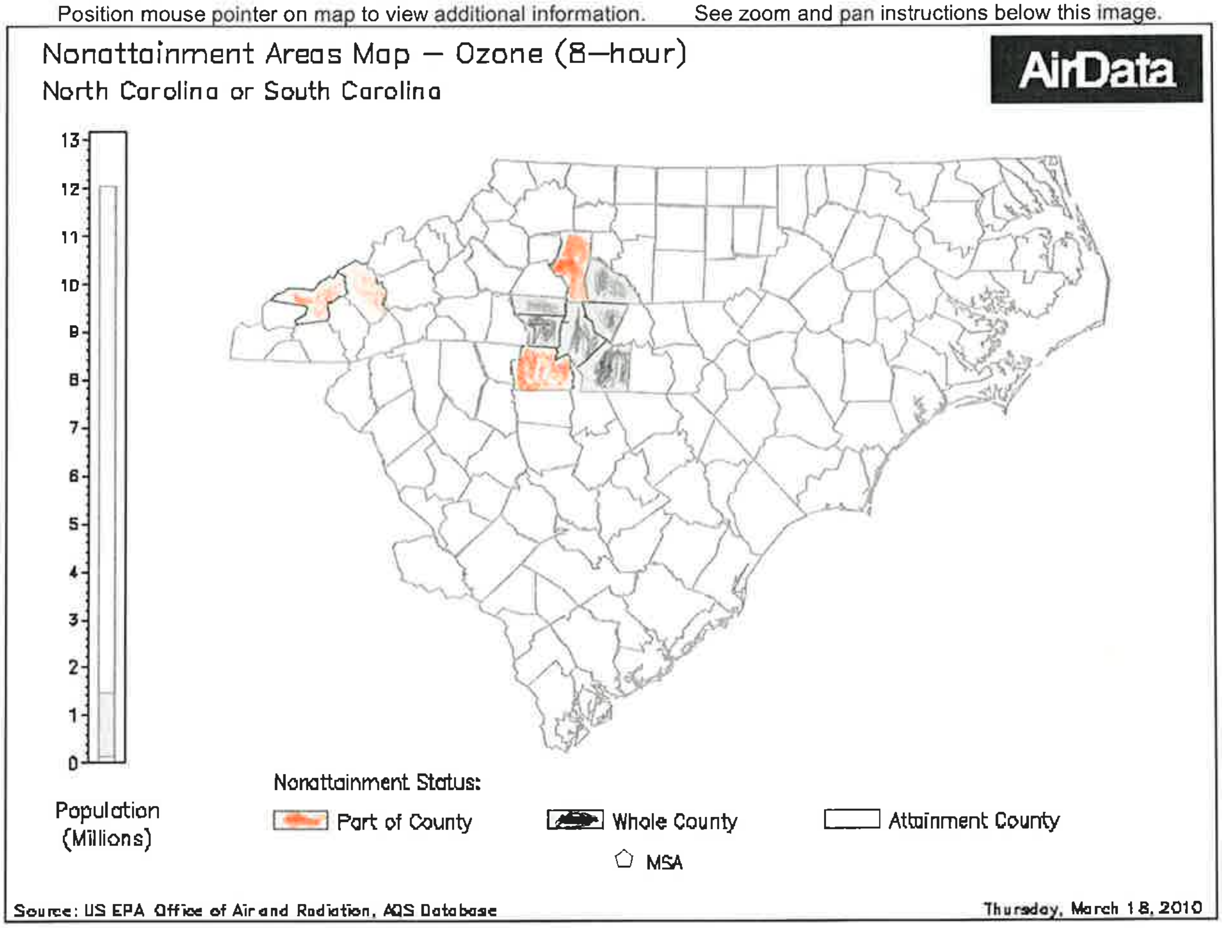
Nonattainment Areas Map - Criteria Air Pollutants

Geographic Area: North Carolina or South Carolina
Pollutant: Ozone (8-hour)
Effective Date of Nonattainment Designations: December 2008
Geographic Features Selected: MSA outlines

10 Nonattainment Counties

See Disclaimer

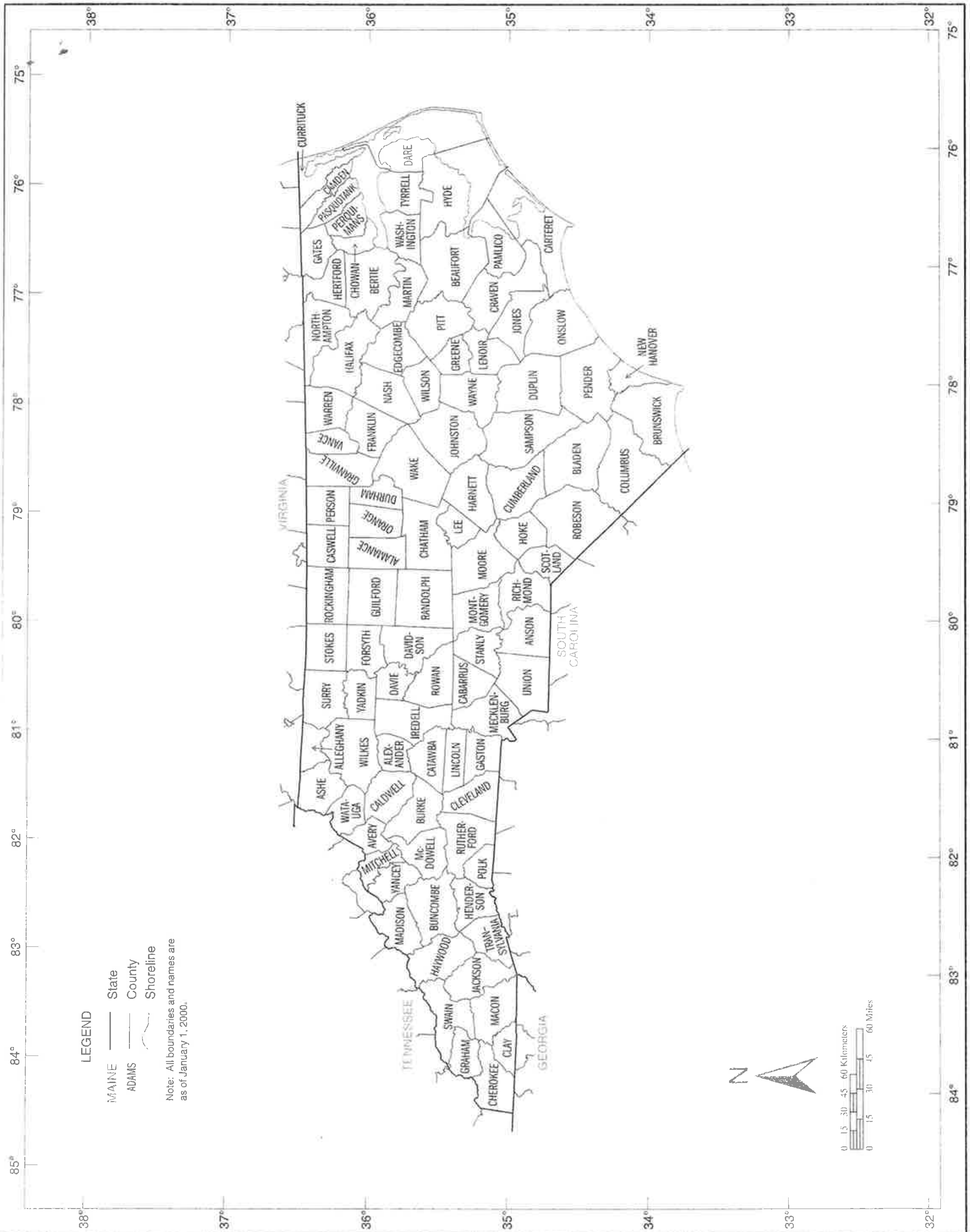
Position mouse pointer on map to view additional information. See zoom and pan instructions below this image.



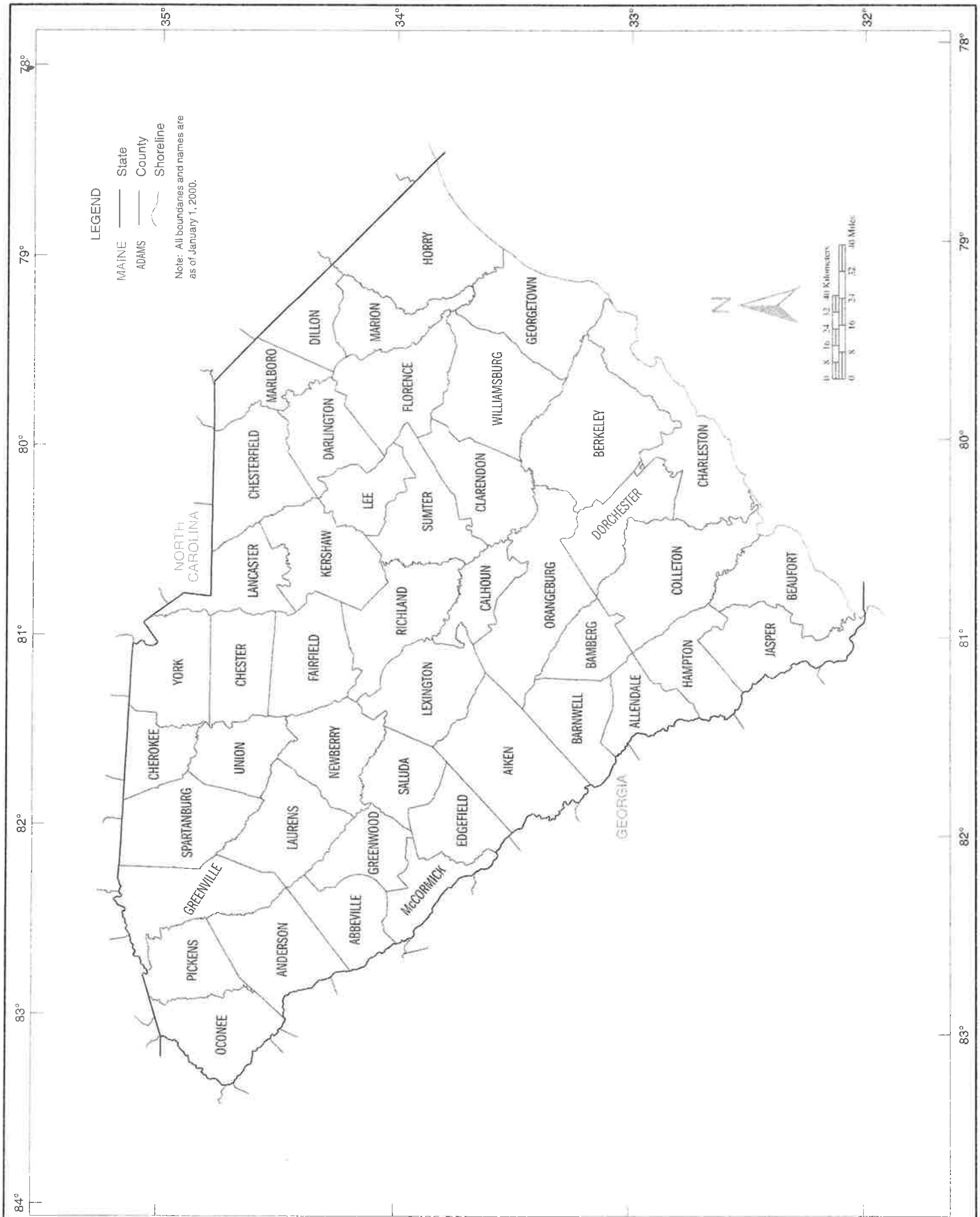
100 %

To ZOOM: Click slider with mouse, type in zoom percentage number, or use keyboard Shift + arrow keys.
To PAN: Click and drag image with mouse, or use keyboard arrow keys.

NORTH CAROLINA - Counties



SOUTH CAROLINA - Counties



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WILLIAM S. LEE III NUCLEAR STATION

FOR § 316(b) COMPLIANCE DEMONSTRATION

Attachment F.3

Ambient Monitoring Data

Prepared by:

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Hanover, MD 21076

February 11, 2011

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Air Quality Statistics by City, 2008; www.epa.gov/airtrends/factbook.html

Core Based Statistical Areas	2008 Population*	NO_2 AM (ppm)	O_3 8-hr (ppm)	SO_2 AM (ppm)	SO_2 24-hr (ppm)
Charlotte-Gastonia-Concord, NC-SC	3403598	0.011	0.093	0.002	0.013
Asheville, NC	816872	ND	0.08	ND	ND
Augusta-Richmond County, GA-SC	1068436	IN	0.076	ND	ND
Boone, NC	90392	ND	ND	ND	ND
Charleston-North Charleston, SC	1289012	0.009	0.071	0.002	0.011
Columbia, SC	1456126	0.005	0.078	0.003	0.016
Durham, NC	979524	ND	0.078	0.002	0.006
Elizabeth City, NC	127298	ND	ND	ND	ND
Fayetteville, NC	712210	ND	0.075	ND	ND
Florence, SC	399662	ND	0.076	ND	ND
Gaffney, SC	108788	ND	0.08	ND	ND
Georgetown, SC	121462	ND	ND	IN	IN
Goldsboro, NC	227342	ND	ND	ND	ND
Greensboro-High Point, NC	1411368	ND	0.084	ND	ND
Greenville, NC	353516	ND	0.077	ND	ND
Greenville-Mauldin-Easley, SC	1249430	0.01	0.08	0.001	0.006
Hickory-Lenoir-Morganton, NC	726072	ND	0.076	ND	ND
Hilton Head Island-Beaufort, SC	345490	ND	ND	ND	ND
Jacksonville, NC	331876	ND	ND	ND	ND
Kinston, NC	113652	ND	0.074	ND	ND
Lincolnton, NC	149492	ND	0.079	ND	ND
Lumberton, NC	258246	ND	ND	ND	ND
Myrtle Beach-Conway-North Myrtle Beach,	514760	ND	ND	ND	ND
Orangeburg, SC	180672	ND	ND	ND	ND
Raleigh-Cary, NC	2177530	ND	0.078	0.002	0.008
Rocky Mount, NC	292712	ND	0.075	ND	ND
Salisbury, NC	278450	ND	0.084	ND	ND
Seneca, SC	142548	ND	0.072	0.001	0.005
Spartanburg, SC	561476	ND	0.085	ND	ND
Thomasville-Lexington, NC	316332	ND	ND	ND	ND
Virginia Beach-Norfolk-Newport News, VA-I	3316584	0.01	0.079	0.004	0.014
Walterboro, SC	78038	ND	0.07	ND	ND
Washington, NC	92070	ND	ND	0.002	0.009
Wilmington, NC	694024	ND	0.063	0.005	0.028
Winston-Salem, NC	936248	0.011	0.081	0.006	0.012

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Part VII
Appendix G

Relevant Requests for Additional Information

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Appendix G: Relevant Requests for Additional Information
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VP, Nuclear Plant Development

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704-382-0605

Bryan.Dolan@duke-energy.com

October 29, 2010

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Duke Energy Carolinas, LLC
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Response to Request for Additional Information
Ltr# WLG2010.10-09

References: (1) Letter from Sarah Lopas (NRC) to Bryan Dolan (Duke Energy), Request for Additional Information Regarding the Supplement to the Environmental Report for the William States Lee III Nuclear Station, Units 1 and 2 Combined License Application, dated June 22, 2010 (ML101370398)

(2) Letter from Sarah Lopas (NRC) to Bryan Dolan (Duke Energy), Follow-Up Requests for Additional Information Regarding the Supplement to the Environmental Report for the William States Lee III Nuclear Station, Units 1 and 2 Combined License Application, dated September 14, 2010 (ML102371173)

This letter provides the Duke Energy response to the Nuclear Regulatory Commission's request for additional information (RAI) included in References 1 and 2.

RAI 128, Alternatives
RAI 216, Alternatives

The responses to the NRC information requests described in Reference 1 and Reference 2 are addressed in separate enclosures, which identify associated changes to the Combined License Application for the Lee Nuclear Station, when appropriate.

If you have any questions or need any additional information, please contact Peter S. Hastings, Nuclear Plant Development Licensing Manager, at 980-373-7820.

Bryan J. Dolan
Vice President
Nuclear Plant Development

Enclosures:

1) RAI 128, Alternatives
2) RAI 216, Alternatives

AFFIDAVIT OF BRYAN J. DOLAN

Bryan J. Dolan, being duly sworn, states that he is Vice President, Nuclear Plant Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

Bryan J. Dolan

Bryan J. Dolan

Subscribed and sworn to me on October 29, 2010

Vickie M Prenatt

Notary Public

My commission expires: May 11, 2011

SEAL

VICKIE M PRENATT
NOTARY PUBLIC
Mecklenburg County
North Carolina
My Commission Expires May 11, 2011

xc (w/o enclosures):

Loren Plisco, Deputy Regional Administrator, Region II
Robert Schaaf, Branch Chief, DSER

xc (w/ enclosures):

Sarah Lopas, Project Manager, DSER
Brian Hughes, Senior Project Manager, DNRL
Mickie Chamness, PNNL

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter Dated: June 22, 2010

Reference NRC RAI Number: ER RAI 128, Alternatives

NRC RAI:

Provide details of the quantitative analyses used to evaluate hybrid wet-dry tower options for cooling of the proposed Lee Nuclear Plant during periods of low river flow. Include alternatives considered for cooling water sources and cooling system technologies. Include in the metrics of the analyses foregone net power due to parasitic energy losses, reduced generation efficiency, and frequency of outages due to loss of water supply.

Duke Energy Response:

Before addressing the specific questions in this RAI, a broad overview is presented of the overall water management strategy for Lee Nuclear Station, including discussion of how this strategy is supported and integrated with the selected heat dissipation system (wet cooling towers) and selected alternative for supplemental cooling water (Make-Up Pond C). This overview provides context for the topic of cooling water required to support station operations and enables meaningful comparisons of alternatives evaluated for cooling system technologies and cooling water sources. Quantitative analyses of cooling system technologies and respective cooling water requirements are presented for both wet cooling towers and hybrid cooling towers so as to substantiate and validate the selections previously made of the heat dissipation system and alternative for supplemental cooling water for Lee Nuclear Station. Finally, a review and comparison of environmental impacts and other considerations are presented to support and substantiate a conclusion regarding the environmentally preferable and the most practicable alternative for a heat dissipation system and for supplemental cooling water.

Lee Nuclear Station and its selected heat dissipation system consume a minimal amount of the mean annual flow of the Broad River. As stated in Subsection 5.2.2.1.1 of the Supplement to Revision 1 of the Environmental Report (ER Supplement), based on the mean annual flow of approximately 2,500 cubic feet per second (cfs) at the Lee Nuclear Site approximately 2 percent of the mean annual flow of the Broad River will be consumed by the plant. (Approximately 3 percent of the mean annual river flow at the Lee Nuclear Site is expected to be withdrawn for plant use and the plant will return 1 percent of the mean annual river flow as discharge of cooling tower blowdown and screen wash.) Consumptive losses of this magnitude are expected to be barely discernible under normal circumstances (typical flows).

The overall water management strategy being deployed by Duke Energy for Lee Nuclear Station also mitigates water availability impacts of station operations during both normal operations and during low flow conditions on the Broad River. Lee Nuclear Station would withdraw make-up cooling water from Make-Up Ponds B and C during low flow conditions on the Broad River as outlined in Subsection 5.2.1 of the ER Supplement. The Federal Energy Regulatory Commission (FERC) has jurisdiction over the Ninety-Nine Islands Reservoir, and the FERC license minimum release from the Ninety-Nine Islands Reservoir is 483 cfs, for low flow conditions. Normally (98 percent of the time), Broad River flows are well above this level. However, during

significant droughts, flows fall below 483 cfs. If the river flow drops below 538 cfs (FERC minimum release of 483 cfs + Lee Nuclear Station average consumptive use for two-unit operation of 55 cfs) Lee Nuclear Station would begin to draw proportionally from the river and Make-Up Ponds B and C to in order to preserve the 483 cfs minimum release from the Ninety-Nine Islands Reservoir. If the river flow is at or below 483 cfs, Lee Nuclear Station would suspend withdrawals from the Broad River for consumptive use and rely on Make-Up Ponds B and C to provide cooling water needs. The volume of Make-Up Pond A would be maintained for station shutdown cooling water needs. Cooling water would be withdrawn from Make-Up Pond B until Make-Up Pond B is drawn down 30 feet (ft) below full pond (from 570 ft mean sea level (msl) to 540 ft msl). Cooling water then would be withdrawn from Make-Up Pond C until Make-Up Pond C is drawn down approximately 45 ft below full pond (from 650 ft msl to 605 ft msl), as allowed by permit conditions. Once flow in the river exceeds 538 cfs, Lee Nuclear Station would resume operating from the river and use any excess flow (> 538 cfs) to refill the ponds, within permit conditions. Make-Up Pond B would be refilled first, followed by Make-Up Pond C, if necessary, when river flows are higher and outside the peak entrainment period (i.e., when fish larvae are less likely to be present). Operating in this manner not only uses Make-Up Ponds B and C to support station needs but also maintains maximum flow in the Broad River downstream of the Ninety-Nine Islands Reservoir during drought conditions to maintain the biological, chemical, and physical integrity of the river, taking into account the needs of downstream users. As stated in ER Supplement Subsection 5.2.2.2.1, the impact of Lee Nuclear Station operations during low flow conditions on downstream future water availability is considered SMALL.

Selected Heat Dissipation System – Wet Mechanical-Draft Cooling Towers

Wet mechanical-draft cooling towers are the selected heat dissipation system for Lee Nuclear Station as described in Subsection 9.4.1.1 of the ER. The Circulating Water System uses three wet mechanical-draft cooling towers per unit to dissipate heat. The wet mechanical-draft cooling towers use fans to force heat transfer within the wet cooling towers. Water from the wet cooling towers is discharged to the plant outfall structure on the upstream side of the Ninety-Nine Islands Dam through a blowdown pipe/diffuser. The Broad River is used to supply make-up water to support operations of the wet cooling towers and for refilling Make-Up Ponds A, B, and C within permit limitations when flows are above threshold limits as described above. If Broad River flow is below the threshold limits, make-up water for station operations would be supplemented by water stored in Make-Up Ponds B and C. If flow in the Broad River is below 483 cfs Lee Nuclear Station would suspend withdrawals from the Broad River for consumptive use and rely on water stored in Make-Up Ponds B and C.

Quantitative Analysis of Wet Mechanical-Draft Cooling Towers

To determine how often low flow conditions in the Broad River would result in the need for Lee Nuclear Station to withdraw from Make-Up Ponds B or C for supplemental cooling water, a water model was developed to analyze water balance needs to support station operations with wet mechanical-draft cooling towers. A summary of water model inputs along with stage-volume data, stage-area data, and daily evaporation rates for Make-Up Ponds A, B, and C are provided in Duke Energy's response to RAI 216 (Enclosure 2 of this letter). United States Geological Survey (USGS) stream flow gauge data for the Broad River was available for an 83-year period of record, 1926 through 2008. This data was used to establish daily average flows for the Broad River at the Lee Nuclear site. The water model was then used to analyze the

daily average flow data for the Broad River as if Lee Nuclear Station was operating during this timeframe.

Results of the water model analyses identified 2002 as the most severe drought year and determined that the Broad River flow dropped below 483 cfs for an 112-day period (from 6/11/2002 through 9/30/2002) during this year. During this extended drought, all of the usable volume in Make-Up Pond B (3,156 acre-feet (ac-ft)) would have been depleted to support operations of the wet cooling towers and Make-Up Pond B would have been at its maximum drawdown level for 69 days. Calculations described in Duke Energy's response to RAI 206 (Reference 1) reflect that approximately 11,000 ac-ft of usable storage is needed in Make-Up Pond C to support continued station operations. Additional supplemental water storage to support approximately 20 days of station operations (approximately 2,500 ac-ft) was applied as design margin in the sizing of Make-Up Pond C due to the uncertainty of the length/severity of a future drought. This design margin provides a reasonable buffer to prevent forced outages in the future as a result of loss of cooling water supply.

Daily water consumption data, Broad River daily flows, and water balance model results using wet cooling towers for 2002 are provided in Duke Energy's response to RAI 216 (Enclosure 2 of this letter). Figure 5.2-1 of the ER Supplement illustrates the number of times Make-Up Pond B or Make-Up Pond C would have been used during the 83-year period of record as well as the magnitude of the drawdowns assuming Lee Nuclear Station was operating during this timeframe. The water available in Make-Up Pond B would have been insufficient five times during the 83-year period of record and the station would have drawn additional water from Make-Up Pond C. Supplemental water from Make-Up Pond C would have been used in 1954, 1956, 2002, 2007, and 2008 with drawdown magnitudes of 5 to 19 ft.

Associated changes to ER Supplement Subsection 5.2.1 and ER Supplement Tables 5.2-3 and 5.2-4 to reflect minor changes resulting from an enhancement that was made to the water balance model are provided as Attachments 128-01, 128-02, and 128-03, respectively. Changes to this text and these tables do not affect any conclusions. ER Supplement Figures 5.2-2 through 5.2-6 will not be changed because the changes are so small that they are not discernible in these figures.

Evaluation of Hybrid (Wet-Dry) Cooling Towers – Alternative to Selected Heat Dissipation System

Screening of Alternatives for Heat Dissipation System

Screening of alternatives to the selected heat dissipation system is outlined in ER Subsection 9.4.1.2. Hybrid (wet-dry) cooling towers were evaluated in this screening of alternatives for a preferred heat dissipation system as noted in Subsection 9.4.1.2.4 of the ER. Additional cooling technologies were also included in the alternatives evaluation, as discussed later in this response.

Evaluation of Alternatives for Supplemental Water

Duke Energy also considered hybrid cooling as an option in the evaluation of cooling water alternatives for providing supplemental water required to support station operations during periods of low flow in the Broad River. This evaluation concluded that hybrid cooling would not support sufficient reduction in the volume of supplemental cooling water required so as to obviate the need for Make-Up Pond C; therefore, this alternative was eliminated from further consideration at that time.

Feasibility Evaluation of Hybrid (Wet-Dry) Cooling Towers

Additional review of a hybrid (wet-dry) cooling system was conducted by way of a detailed feasibility evaluation of hybrid cooling; this evaluation was performed to determine if sufficient consumptive water savings could be realized such that the usable storage in Make-Up Pond B would support station operations during low flow periods in the Broad River, thereby eliminating the need for Make-Up Pond C.

The feasibility evaluation (described in further detail below) has reaffirmed the conclusion that hybrid cooling would not support sufficient reduction in the volume of supplemental cooling water required so as to obviate the need for Make-Up Pond C. This evaluation also concludes that hybrid cooling in addition to Make-Up Pond C is neither environmentally preferable to the selected heat dissipation system nor practicable. Associated changes to ER Subsection 9.4.1.2.4 to clarify why wet-dry or hybrid cooling is not considered superior to the selected heat dissipation system for Lee Nuclear Station are provided as Attachment 128-05.

Hybrid Cooling System Sizing

The feasibility evaluation considered a hybrid cooling system comprised of 50% indirect dry cooling towers in series with 100% wet mechanical-draft cooling towers as shown in Figure 1 (Attachment 128-07). The dry cooling towers are assumed to be sized to reject 50% of the heat load at the design dry bulb temperature for the Lee Nuclear site of 92°F (1% exceedance). The wet cooling towers would be sized to reject 100% of the heat load. The dry cooling towers (3 per unit) would be very large (100 ft wide by 935 ft long by 100 ft high) owing to the significant surface area required for heat transfer to support the selected range of heat dissipation. A summary of the equipment footprint for the dry cooling towers is provided in Table 1 (Attachment 128-08). Land in the vicinity of the dry cooling towers would have to be cleared and maintained devoid of vegetation to avoid impacts to air flow and performance of the equipment.

Conceptual Layout

A conceptual layout of the hybrid cooling system including placement of the dry cooling towers on the Lee Nuclear Station site is provided as Figure 2 (Attachment 128-09). Owing to the large footprint and manufacturer's spacing requirements of this equipment, many other facilities on the site shown in ER Supplement Figure 3.1-1 would have to be relocated (e.g., wet cooling towers, 230 kV and 525 kV switchyards, waste water retention basins, construction office building and parking, receiving warehouse, etc.). The meteorological tower for the site would also have to be relocated to avoid being in close proximity of any tall structures, systems, or components.

Design Margin

The hybrid cooling system feasibility evaluation considered temperature data for 2002, the most severe drought year on record for the Lee Nuclear Station site. The conceptual design of the hybrid cooling system, and in particular the dry cooling towers, includes a 25% design margin to the theoretical maximum heat transfer to account for degradation in performance (e.g., interior fouling of tubing, exterior fouling of heat transfer fins, and wind and recirculation effects from adjacent cooling towers). The potential for higher temperatures in future years (i.e., potential for temperatures in excess of the data used from the most severe drought year) and issues associated with "first-of-a-kind" engineering also contribute to uncertainty in this system, but are conservatively not included in the design margin.

Generation Efficiency

Because the hybrid cooling system uses the wet cooling towers to keep the Circulating Water System temperature from exceeding 91°F during the hot summer conditions, there would be no negative impact to the generation efficiency of the nuclear units.

Control Strategies

Hybrid cooling towers can be operated under various control philosophies. For completeness, Duke Energy performed evaluations under a maximum "water savings" control strategy as well as under a "power savings" control strategy. These evaluations are presented below.

Quantitative Analysis of Hybrid Cooling Towers – Maximum "Water Savings" Evaluation

For the maximum "water savings" evaluation, the dry cooling towers were assumed to operate year-round with the wet cooling towers being placed in and out of service as required based on ambient dry bulb temperatures. For ambient dry bulb temperatures below 69°F, the dry cooling towers would reject 100% of the heat dissipation duty and the wet cooling towers could be shut down. As the ambient dry bulb temperature increases, the wet cooling towers would be placed into service one tower at a time as required to support heat dissipation. The control philosophy (on a per-unit basis) for the maximum "water savings" hybrid cooling system is shown on Figure 3 (Attachment 128-10).

The hybrid cooling system evaluation calculated the consumptive water demand on an hourly basis for the 50% indirect dry cooling towers in series with the 100% wet cooling towers for the year 2002. These hourly results were converted to daily water consumption for the "water savings" evaluation and are summarized in a table provided with Duke Energy's response to RAI 216 (Enclosure 2 of this letter). Duke Energy then applied the daily water consumption data for the "water savings" evaluation of the hybrid cooling system in the water model for Lee Nuclear Station to determine the volume of supplemental water required to support station operations during 2002, the most severe drought year on record. The water model results show that Make-Up Pond B usable storage was depleted on 08/12/2002 and 2,778 ac-ft of additional supplemental water would be required to support station operations. Broad River daily flows and water balance model results with hybrid cooling towers for 2002 (under the "water savings" evaluation, where dry cooling towers are assumed to run year-round) are provided in Duke Energy's response to RAI 216 (Enclosure 2 of this letter).

The hybrid cooling system would result in an overall reduction in the water consumption to support heat dissipation; however, these savings come at a loss of generation output from the plant due to higher parasitic loads. The additional parasitic load to power the large fans on the dry cooling towers is approximately 23 to 24 megawatts per unit as shown in Figure 4 (Attachment 128-11). The variation in parasitic load is a consequence of the variation in air density which is a function of the dry bulb temperature.

Quantitative Analysis of Hybrid Cooling Towers – "Power Savings" Evaluation

A "power savings" evaluation for the hybrid cooling system was also considered. Noting that flows in the Broad River are normally (98 percent of the time) well above the minimum flow release for the Ninety-Nine Islands Reservoir of 483 cfs and dry cooling towers have a generation penalty on plant output (parasitic loads of fans), a separate evaluation considered limiting the operation of the dry towers to periods of significant drought. Figure 5.2-1 of the ER

Supplement illustrates the number of times Make-Up Pond B or Make-Up Pond C would have been used during the 83-year period of record as well as the magnitude of the drawdowns, assuming Lee Nuclear Station was operating during this timeframe. Over 90% of the drawdowns on Make-Up Pond B are less than 6 ft; therefore, a 6-ft drawdown on Make-Up Pond B was selected for this evaluation as the threshold to place the dry cooling towers into operation (i.e., selected as the indicator of a significant drought). Once placed into operation, the dry cooling towers would remain in service until both Make-Up Ponds B and any additional required supplemental water storage had been restored to full pond elevation.

The daily water consumption for the "power savings" evaluation is based on the consumptive water required for operation of the wet cooling towers until Make-Up Pond B is drawn down 6 ft and the dry cooling towers are placed into service. The daily water consumption is then based on the hybrid cooling system evaluation (i.e., same as "water savings" evaluation). When Make-Up Ponds B and any additional required supplemental water storage are refilled, the dry cooling towers are then removed from service and the daily water consumption reverts back to being based on the consumptive water required for operation of the wet cooling towers. The daily water consumption data for 2002 corresponding to the "power savings" evaluation are summarized in a table provided with Duke Energy's response to RAI 216 (Enclosure 2 of this letter). Duke Energy then applied the daily water consumption data for the "power savings" evaluation of the hybrid cooling system to the water model to determine the volume of supplemental water required to support station operations during 2002, the most severe drought year on record. The water model results indicate that Make-Up Pond B usable storage would have been depleted on 08/04/2002 and 3,263 ac-ft of additional supplemental water would be required to support station operations. Broad River daily flows and water balance model results with hybrid cooling towers for 2002 (under the "power savings" evaluation, where dry cooling towers are placed in service only after Make-Up Pond B is drawn down 6 ft) are provided in Duke Energy's response to RAI 216 (Enclosure 2 of this letter).

As would be expected, the "power savings" scenario results in a less significant loss in generation from parasitic load as the "water savings" scenario. Based on the water balance model results for the "power savings" evaluation, the dry cooling towers would have been placed into service on 06/18/2002 when drawdown in Make-Up Pond B reached a 6 ft drawdown, and removed from service on 10/29/2002 when Make-Up Ponds B and C would have returned to full pond levels (for the purposes of the water model analysis to support this evaluation, Make-Up Pond C was assumed to be the additional required supplemental water storage). With a more limited period of dry cooling tower operation, the generation losses from the "power savings" scenario are approximately 37% of the losses experienced in the "water savings" scenario. In years with no significant drought, there would be no appreciable generation losses under the "power savings" scenario beyond those associated with the selected heat dissipation system (i.e., for running the wet cooling towers).

<u>Make-Up Pond C Requirements Using Hybrid (Wet-Dry) Cooling Towers</u>

The maximum "water savings" evaluation of hybrid cooling towers identified that 2,778 ac-ft of additional supplemental water would be required to support station operations under this control strategy. To provide a reasonable buffer to prevent forced outages in the future as a result of loss of cooling water supply, additional supplemental water storage to support approximately 20 days of station operations (approximately 2,500 ac-ft) should be applied as a design margin.

Therefore, the overall volume of additional supplemental water that would be required for the maximum "water savings" evaluation of hybrid cooling towers is 5,278 ac-ft.

The "power savings" evaluation of hybrid cooling towers identified that 3,263 ac-ft of additional supplemental water would be required to support station operations under this control strategy. Adding the 20-day buffer as discussed above (approximately 2,500 ac-ft) yields an overall volume of additional supplemental water that would be required for the "power savings" evaluation of hybrid cooling towers of 5,763 ac-ft.

Make-Up Pond C is a viable alternative for providing storage for the additional supplemental water required to support station operations with hybrid cooling towers. The sizing of Make-Up Pond C to support hybrid cooling towers should average the storage needs of both the maximum "water savings" evaluation and the "power savings" evaluation since the required storage volumes are very similar in magnitude (i.e., 5,278 ac-ft and 5,763 ac-ft, respectively).

In calculating the size of Make-Up Pond C, an average storage volume of approximately 5,500 ac-ft is assumed. With the floor of the intake in Make-Up Pond C at elevation 545 ft and 10 ft of submergence for the pump intake, dead storage is 147 ac-ft. Adding this dead storage volume to the 5,500 ac-ft of required usable storage yields 5,647 ac-ft which corresponds to a Make-Up Pond C elevation of approximately 610 ft. Adding 20 ft to this elevation based on compliance with CWA §316(b) requirements [40 CFR §125.84(b)(3)(ii)] as described in Duke Energy's response to RAI 206 (Reference 1) results in a full pond elevation of 630 ft msl.

The full pond elevation of Make-Up Pond C required to support 100% wet cooling towers as indicated in the ER Supplement is 650 ft msl. Refer to Figure 5 (Attachment 128-12) for a footprint and water depths of Make-Up Pond C at this full pond elevation. Both the maximum "water savings" evaluation and the "power savings" evaluation of a hybrid cooling system with 100% wet cooling towers and 50% indirect dry cooling towers determined that additional supplemental water would be required to support station operations. A smaller Make-Up Pond C with a full pond elevation of 630 ft msl would support station operations with hybrid cooling towers as noted above. Refer to Figure 6 (Attachment 128-13) for a footprint and water depths of Make-Up Pond C at a full pond elevation 630 ft msl.

Additional Alternatives to Selected Heat Dissipation System

Additional cooling technology alternatives to the selected heat dissipation system that were evaluated are Dry Cooling Towers and Wet-Dry Cooling Towers (i.e., hybrid towers) as summarized in ER Supplement Subsection 9.4.1.2.3 and ER Subsections 9.4.1.2.3 and 9.4.1.2.4, respectively.

Air-Cooled Condenser

The most common type of dry cooling tower technology deployed at power generation facilities is the air-cooled condenser (ACC). However, as noted in ER and ER Supplement Subsection 9.4.1.2.3, the ACC technology would require large-scale changes to the standardized AP1000 design. The ACC is not compatible with the condenser and turbine design described in the AP1000 certified design and would require extensive revision to fundamental design elements of the main steam, feedwater, and heater drains systems. Essential elements of the turbine building foundation, structure, and turbine missile evaluation would also require revision. Therefore, this system does not meet the need for heat dissipation supporting operation of the Lee Nuclear Station.

Indirect Dry Cooling

The other type of dry cooling tower technology is the indirect dry tower. Duke Energy performed a feasibility evaluation of a 100% indirect dry cooling system. This evaluation, based on 2002 temperature data for the site, concluded that this type of cooling technology is not feasible for use at Lee Nuclear Station since the system cannot maintain Circulating Water System temperature within standard plant design limits for the AP1000 for most days in the months of June, July, and August. Accordingly, this type of system does not meet the need for heat dissipation supporting operation of the Lee Nuclear Station.

Associated changes to ER and ER Supplement Subsection 9.4.1.2.3 to clarify why dry cooling towers are not feasible for Lee Nuclear Station are provided in Attachment 128-04.

As noted in ER Subsection 9.4.1.2.4, wet-dry or hybrid cooling towers use a combination of wet and indirect dry cooling technologies. Hybrid cooling towers can be one of two configurations: a design that uses the combination of separate wet cooling towers and dry cooling towers (air-cooled heat exchangers), or a single cooling tower equipped with integrated wet and dry cooling sections.

The configuration consisting of a combination of separate wet and dry cooling towers is thoroughly evaluated and addressed in this RAI response.

Single Cooling Tower with Wet and Dry Cooling Sections

The single cooling tower with wet and dry cooling capability operates in a manner similar to a wet cooling tower. Plume abatement is the most common reason for selecting this technology. The decrease in tower consumptive water use is limited by the size of the dry cooling section; accordingly, this configuration does not save as much water as the hybrid cooling system with separate wet and dry cooling towers. As discussed in ER Subsection 5.3.3, the design and environmental impacts from cooling tower plumes are considered SMALL or non-existent. Therefore, the selection of a plume abatement technology is not warranted for the Lee Nuclear site.

Supplemental Water Alternatives Considering Hybrid Cooling System

ER Supplement Subsection 9.4.2.2.5 evaluated several alternatives for providing the additional supplemental water required to support station operations during extended periods of low flow in the Broad River. The quantitative analyses of hybrid cooling towers in this response concluded that, even if hybrid towers were deployed, approximately 5,500 ac-ft of additional supplemental water would be required.

The supplemental water alternatives of groundwater, treated wastewater, increasing the size of Make-Up Pond B, and release of water from upstream reservoirs were previously evaluated as summarized in ER Supplement Subsections 9.4.2.2.5.1, 9.4.2.2.5.2, 9.4.2.2.5.3, and 9.4.2.2.5.4, respectively, to determine if any were viable alternatives for providing the required 11,000 ac-ft of supplemental water to support wet cooling towers. None were viable alternatives. For completeness, each of these supplemental water alternatives is reevaluated below to determine if any is a viable alternative for providing approximately 5,500 ac-ft of supplemental water required to support a hybrid cooling system alternative to the selected heat dissipation system.

Groundwater

Groundwater is not a viable alternative for providing 5,500 ac-ft of supplemental water as groundwater yields in the vicinity of the Lee Nuclear site will not supply sufficient water and the site is not large enough to support the required number of wells.

Treated Wastewater

Two wastewater treatment facilities are currently located in Cherokee County, South Carolina. The Clary Wastewater Treatment Plant discharges treated wastewater into Thicketty Creek which flows into the Broad River downstream of the Ninety-Nine Islands Reservoir. The Broad River Wastewater Treatment Plant discharges treated wastewater into the Broad River upstream of the river water intake structure for Lee Nuclear Station. However, the combined utilization rates from both the Clary and Broad River Wastewater Treatment Plants as shown in ER Table 2.5-19 are insufficient to provide the required supplemental water; therefore, treated wastewater is not a viable alternative.

Increasing the Size of Make-Up Pond B

The full pond elevation of Make-Up Pond B is 570 ft msl. Draining, dredging, blasting and excavating to lower the entire bottom of Make-Up Pond B by 15 ft would increase the usable storage by 2,569 ac-ft. Significant additional environmental impacts to open water, streams, and wetlands would result from implementing these changes and the changes would not result in adequate storage for additional supplemental water. In addition to lowering the bottom of Make-Up Pond B by 15 ft, the dam could be raised 15 ft to support raising the full pond elevation to 585 ft msl. Raising the dam 15 ft would result in significant additional environmental impacts to land use, open water, streams, and wetlands. This change would also result in significant site flooding concerns for Lee Nuclear Station, whose plant grade elevation is 589.5 ft (i.e., flooding concerns from Probable Maximum Flood (PMF) and Probable Maximum Precipitation (PMP)). These concerns would have to be addressed by adding safety-related flood protection walls and other features to protect safety-related structures, systems, and components (SSCs) of the plant from flooding. However, the addition of dry cooling towers present a significant challenge to overall land use on the Lee Nuclear site as shown on Figure 2 (Attachment 128-09), and the site layout and overall land use cannot support the addition of both dry cooling towers and safety-related flood protection walls and other features to protect safety-related SSCs from flooding.

The combination of both of these changes to Make-Up Pond B could increase usable storage by 5,645 ac-ft, which would satisfy the required 5,500 ac-ft of supplemental water in support of the use of hybrid cooling. But as discussed above, layout and land use do not support this combination of options, and increasing the size of Make-Up Pond B also results in significant additional environmental impacts to open water, streams, and wetlands. Considering these site layout/land use issues and environmental impacts, increasing the size of Make-Up Pond B is not a viable alternative for providing 5,500 ac-ft of supplemental water.

Release of Water from Upstream Reservoirs

ER Supplement Subsection 9.4.2.2.5.4 states that the maximum dependable storage from upstream reservoirs is 4,900 ac-ft. Noting that the upstream reservoirs are a long distance from the Lee Nuclear site and there is no guarantee that released water would actually reach the site in extended droughts (i.e., owing to the potential for released water to be consumed by upstream

users), reliance on release of water from upstream reservoirs is considered to be high risk. Therefore, release of water from upstream reservoirs is not a viable alternative for providing the required 5,500 ac-ft of supplemental water.

None of these alternatives is viable for providing the supplemental water that is required to support a hybrid cooling system. Make-Up Pond C is still the preferred alternative for supplemental water, even considering the possible use of a hybrid cooling system.

Associated changes to ER Supplement Subsection 9.4.2.2.5.3 to clarify the evaluation of increase in storage volume from increasing the size of Make-Up Pond B are provided in Attachment 128-06.

Environmental Impacts Considering a Hybrid Cooling System

Guidance provided in NUREG-1555 (Sections 9.4.1 and 9.4.2) was used to identify key screening factors for evaluating environmental impacts associated with alternatives for heat dissipation systems and for supplemental water supply (i.e., land use impacts, aquatic ecology impacts, and water use impacts). Environmental impacts from other discriminators between hybrid cooling towers and wet cooling towers were also evaluated (i.e., noise, atmospheric emissions).

Duke Energy has evaluated the environmental impacts associated with construction and operation of Lee Nuclear Station with hybrid cooling towers (addition of dry cooling towers) and Make-Up Pond C with a full pond elevation of 630 ft msl. These impacts are compared below to the environmental impacts documented in the ER Supplement and Revision 1 of the ER associated with construction and operation of Lee Nuclear Station with round mechanical-draft wet cooling towers and Make-Up Pond C with a full pond elevation of 650 ft msl. Comparisons were made of environmental impacts resulting from: increased plant equipment footprint on the Lee Nuclear site from hybrid cooling towers compared to wet cooling towers; decreased footprint from Make-Up Pond C at full pond elevation 630 ft msl to support hybrid cooling towers, versus Make-Up Pond C at full pond elevation 650 ft msl to support wet cooling towers; decreased water use to support station operations with a hybrid cooling system compared to wet cooling towers; increased noise from hybrid cooling system compared to wet cooling towers; and increased atmospheric emissions (CO_2, SO_2, and NO_X) resulting from purchase of replacement power due to higher parasitic loads associated hybrid cooling towers compared to wet cooling towers.

Impacts on the Lee Nuclear Site

A review of the Lee Nuclear site equipment footprint from hybrid cooling towers (layout of dry cooling towers and relocation of other SSCs on the site) results in a land use impact of approximately 370 ac. Land use impacts of approximately 270 ac result from construction at the Lee Nuclear site with wet cooling towers, as summarized in ER Table 4.3-1. Ecological cover types impacted of each alternative are summarized on Table 2 (Attachment 128-14). Impacts to land use within the Lee Nuclear site are discussed in ER Subsection 4.1.1.1 and are considered SMALL with the use of wet cooling towers. Land use impacts associated with the deployment of a hybrid cooling system are larger, considering the additional area disturbed from the larger footprint of plant equipment (addition of dry cooling towers), but are also considered SMALL.

For the purpose of analyzing impacts to wetlands, streams, and open water, delineation data for the Lee Nuclear site that became available after issuance of Revision 1 of the ER was used. The

impacts to wetlands, streams, and open water on the Lee Nuclear site from a hybrid cooling system increase to approximately 3 ac, 1400 ft, and 6 ac, respectively, as compared to the impacts from use of wet cooling towers of approximately 0 ac, 0 ft, and 1 ac, respectively. Environmental impacts are summarized on Table 2 (Attachment 128-14). Considering the use of wet cooling towers, the impacts from construction to aquatic communities on the Lee Nuclear site, which are discussed in Subsection 4.3.2 of the ER, were found to be SMALL. The impacts to aquatic communities are also SMALL on the Lee Nuclear site when considering the additional impacts from deployment of a hybrid cooling system.

Impacts at Make-Up Pond C

Land use associated with construction of Make-Up Pond C at full pond elevation 630 ft msl (i.e., to support a hybrid cooling system) impacts approximately 900 ac. Land use impacts of approximately 1,100 ac result from construction of Make-Up Pond C to full pond elevation 650 ft msl as summarized in Duke Energy's response to RAI 157 (Reference 2) for wet cooling towers. Ecological cover types impacted of each heat dissipation system alternative are summarized on Table 2 (Attachment 128-14). Impacts to land use at Make-Up Pond C are described in ER Supplement Subsection 4.1.2.2 and are considered MODERATE within the area of Make-Up Pond C and on a site and vicinity scale. While a 630-ft msl elevation constitutes a reduction in land use impacts, the associated land use impacts are still considered MODERATE within the area of Make-Up Pond C and on a site and vicinity scale.

Impacts to wetlands, streams, and open water for Make-Up Pond C at elevation 630 ft msl decrease to approximately 4 ac, 57,000 ft, and 14 ac respectively, as compared the impacts for Make-Up Pond C at elevation 650 ft msl of 4 ac, 68,000 ft and, 14 ac. Stream impacts reflect updated information provided in Duke Energy's response to RAI 164 (Reference 3). The results of this comparison are outlined in Table 2 (Attachment 128-14). Impacts from construction of Make-Up Pond C to full pond elevation 650 ft msl to aquatic communities are discussed in ER Supplement Subsection 4.3.2. As noted in ER Supplement Subsection 4.3.2.2.3, these impacts are LARGE at the London Creek watershed scale and MODERATE at the site and vicinity scale. Considering the decrease in impacted streams associated with a smaller Make-Up Pond C required to support a hybrid cooling system, the impacts to aquatic communities remain LARGE at the London Creek watershed scale and MODERATE at the site and vicinity scale.

Impacts to Water Use

Duke Energy has previously evaluated existing and future water supply needs in the Broad River to ensure that Lee Nuclear Station has sufficient water supply during operation and will not affect the water supply of downstream users. Impacts to water supply resulting from the operation of Lee Nuclear Station are discussed in Subsections 5.2.1.7 and 5.2.2 of the ER and ER Supplement. As stated in ER Supplement Subsection 5.2.2.2.1, Lee Nuclear Station uses Make-Up Ponds B and C to supply make-up water if river flow drops below 538 cfs; therefore, the impact of Lee Nuclear Station operations during low flow conditions on downstream future water availability is considered SMALL. Because a hybrid cooling system would require less consumptive water than wet cooling towers, this impact would also be considered SMALL for a hybrid cooling system. Environmental impacts are summarized on Table 2 (Attachment 128-14).

Impacts from Noise

ER Subsection 5.8.1.5 describes the potential impacts from noise. The main sources of continuous noise on the site are the cooling towers. The hybrid cooling system would consist of three dry cooling towers per unit with 48 large fans each, and three wet cooling towers with 12 large fans each, for a total of 180 large fans per unit. Therefore, the number of large fans required for a hybrid cooling system is five times the number of large fans required to support heat dissipation from a wet cooling tower system. Environmental impacts are summarized on Table 2 (Attachment 128-14). Projected noise from Lee Nuclear Station operations is considered to be of SMALL significance to workers and the public for a heat dissipation system with wet cooling towers. Owing to a significant increase in the projected noise from Lee Nuclear Station operations with a hybrid cooling system, noise impact would be considered to be SMALL to MODERATE to workers and would remain SMALL to the public.

Impacts to Air Quality from Atmospheric Emissions

Due to the higher parasitic loads from operating the high number of large fans on the dry cooling towers, deployment of the hybrid cooling system will result in higher atmospheric emissions (CO_2, SO_2, and NO_X) resulting from purchase of replacement power than experienced from the use of wet cooling towers. Environmental impacts are summarized on Table 2 (Attachment 128-14). Impacts to air quality from atmospheric emissions impact would be considered to be SMALL for hybrid cooling towers and for wet cooling towers.

In consideration of the relative impacts of a hybrid (wet-dry) cooling system at the Lee Nuclear Station site, such a technology would not be an environmentally preferable alternative.

Other Considerations Associated With a Hybrid Cooling System

40 CFR 230.10(a)(2) states that "an alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of the overall project purposes." Other considerations beyond the environmental impacts discussed above make the alternative of deploying a hybrid cooling system impracticable for Lee Nuclear Station. These considerations include: higher capital costs of a hybrid cooling system; higher replacement power costs due to higher parasitic loads; higher O&M costs due to additional equipment and more moving parts; and uncertainty associated with the evaluated technology not operating anywhere in the world at a comparable scale.

Capital Costs

Incremental costs (i.e., those costs above and beyond those associated with providing wet cooling towers) were estimated for deploying a hybrid cooling system at Lee Nuclear Station in accordance with the conceptual layout shown on Figure 2 (Attachment 128-09). The overall incremental costs are approximately $1 billion for both units. Additional details on the incremental costs are provided on Table 3 (Attachment 128-15). These incremental costs are disproportionate when compared to the estimated costs of deploying wet cooling towers and constructing Make-Up Pond C to support the operations of Lee Nuclear Station, particularly given that hybrid towers would not obviate the need to construct Make-Up Pond C.

Replacement Power Costs

Deployment of a hybrid cooling system would result in higher replacement power costs due to the higher parasitic loads associated with operating the high number of large fans on the dry

cooling towers. Approximate replacement power costs for the first year of station operation (both units) are shown on Table 3 (Attachment 128-15) for the hybrid "water savings" option and the hybrid "power savings" option. Note that the replacement power cost for the hybrid "power savings" option varies from $0 (in years with no significant drought periods, the dry cooling towers would not operate, thus there would be no replacement power costs associated with the dry towers) to $11 million.

Higher O&M Costs

Higher O&M costs would be anticipated for a hybrid cooling system due to significantly more equipment and moving parts (i.e., five times as many fans on the hybrid cooling system that was evaluated as compared to wet cooling towers).

"First of a Kind" Technology Rather Than Existing Technology

The hybrid cooling system evaluated as an alternative heat dissipation system is comprised of 50% indirect dry cooling towers in series with 100% wet mechanical-draft cooling towers as shown in Figure 1 (Attachment 128-07). The dry cooling towers evaluated would be twice as large as any similar towers currently installed worldwide. Deployment of this hybrid cooling system would be "first of a kind" technology with uncertainties and questions about the system's operational capability that would put a substantial generating and capital asset at risk of not performing adequately. Wet mechanical-draft cooling towers are in use at many operating power generation facilities in the United States and the world. Wet cooling towers are considered "existing technology" rather than "first of a kind" technology.

The EPA rejected dry cooling as the best technology available for a national requirement because the technology carries costs that are sufficient to pose a barrier to its entry to the marketplace for some projected new facilities (Reference 4).

Accordingly, in addition to not being environmentally preferable, other considerations dictate that a hybrid (wet-dry) cooling system also would not be a practicable alternative for Lee Nuclear Station.

Conclusion

The development of Make-Up Pond C supports the overall water management strategy established by Duke Energy for Lee Nuclear Station. This strategy provides for management of water resources and minimizes water availability impacts that station operations might otherwise have on downstream ecology and water users during low flow conditions on the Broad River. Make-Up Pond C is sized to ensure adequate storage in anticipation of the most severe drought conditions. Permitting for Make-Up Pond C is expected to respect existing minimum release requirements in the FERC licensing for the Ninety-Nine Islands Reservoir, satisfy conditions in the South Carolina Water Withdrawal Permitting, Use, and Reporting Act, and minimize impacts to downstream resources and communities along the Broad River. Implementation of the preferred water management strategy allows the purpose and need for the project to be met, while minimizing the potential for downstream impacts.

Based on the alternatives evaluation performed in support of the ER Supplement, Duke Energy concludes that, pursuant to the guidance in NUREG-1555 (Subsections 9.4.1 and 9.4.2), no environmentally preferable option exists to wet mechanical-draft cooling towers (the selected heat dissipation system) and to the development of Make-up Pond C (the selected supplemental

water alternative in support of the Circulating Water System) to support Lee Nuclear Station operation during potential extended periods of low flow in the Broad River.

Duke Energy also concludes that the selected water management strategy and cooling systems, consisting of wet mechanical-draft cooling towers and Make-Up Ponds A, B, and C constitute the Least Environmentally Damaging Practicable Alternative (pursuant to 40 CFR 230.10(a)) for achieving the overall project purpose.

References:

1. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information, Ltr# WLG2010.10-04 dated October 14, 2010.
2. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information, Ltr# WLG2010.07-03 dated July 9, 2010 (ML101950207).
3. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information, Ltr# WLG2010.07-06 dated July 16, 2010 (ML102100214).
4. United States Environmental Protection Agency (EPA). 2001. National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities; Final Rule. [40 CFR Parts 9, 122, 123, 124, and 125] December 18, 2001. 66 Federal Register 65256, 65281.

Associated Revisions to the Lee Nuclear Station Combined License Application:

ER Supplement Subsection 5.2.1

ER Supplement Table 5.2-3

ER Supplement Table 5.2-4

ER and ER Supplement Subsection 9.4.1.2.3

ER Subsection 9.4.1.2.4

ER Supplement Subsection 9.4.2.2.5.3

Attachments:

Attachment 128-01	Mark-up of ER Supplement Subsection 5.2.1
Attachment 128-02	Mark-up of ER Supplement Table 5.2-3
Attachment 128-03	Mark-up of ER Supplement Table 5.2-4
Attachment 128-04	Mark-up of ER and ER Supplement Subsection 9.4.1.2.3
Attachment 128-05	Mark-up of ER Subsection 9.4.1.2.4

Attachment 128-06	Mark-up of ER Supplement Subsection 9.4.2.2.5.3
Attachment 128-07	Figure 1 – Indirect Dry Cooling Towers in Series with Wet Cooling Towers
Attachment 128-08	Table 1 – Equipment Footprint for Dry Cooling Towers
Attachment 128-09	Figure 2 – Conceptual Layout of Hybrid Cooling System on the Lee Nuclear Station Site
Attachment 128-10	Figure 3 – Control Philosophy for Hybrid Cooling System to Maximize Water Savings
Attachment 128-11	Figure 4 – Parasitic Load for Dry Cooling Towers (Per Unit)
Attachment 128-12	Figure 5 – Make-Up Pond C Full Pond Elevation 650 Ft. MSL – Footprint and Water Depths
Attachment 128-13	Figure 6 – Make-Up Pond C Full Pond Elevation 630 Ft. MSL – Footprint and Water Depths
Attachment 128-14	Table 2 – Environmental Impacts Considering a Hybrid Cooling System
Attachment 128-15	Table 3 – Other Considerations Associated with a Hybrid Cooling System

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-01

Mark-up of ER Supplement Subsection 5.2.1

COLA Part 3, ER Supplement, Subsection 5.2.1, Hydrologic Alterations and Plant Water Supply, next to last paragraph, is revised as follows:

Figure 5.2-3 shows the two Make-Up Pond C drawdown events that would have hypothetically occurred in 1954 and 1956, where Make-Up Pond C would have supplied supplemental water for 25 and 21 days, respectively. In both of these drawdown events, Make-Up Pond C would have drawn down approximately 5 feet and would have taken between ~~7~~8 and ~~8~~9 days to fully recover. During the 2002 event (Figure 5.2-4), Make-Up Pond C would have been used for supplemental water for 75 days, resulting in a drawdown of approximately 19 ft. Refill operations would have taken ~~34~~36 days. During the 2007 event (Figure 5.2-5), Make-Up Pond C would have been used for supplemental water for ~~57~~56 days, resulting in a drawdown of approximately ~~13~~12 ft. Refill operations would have taken approximately 28 days. The remaining hypothetical event for Make-Up Pond C is shown graphically in Figure 5.2-6. Beginning in June 2008, Make-Up Pond C would have provided supplemental water for 52 days, which would have resulted in a drawdown of approximately 13 ft. Due to fluctuations in Broad River flows the refill operations would have taken ~~112~~113 days (Table 5.2-4). Table 5.2-6 provides the relationship between water surface elevation, area, and volume in Make-Up Pond B, and Make-Up Pond C.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-02

Mark-up of ER Supplement Table 5.2-3

Table 5.2-3
Make-up Pond B Drawdown Occurrences (January 1926 - April 2009) [a]

Histogram Breakouts	Magnitude of Drawdown Event (ft)	# Days to Lowest Elevation Reached[c]	# Days at Lowest Elevation	# Days to Refill Pond B from Lowest Elevation Reached[d]	Total # Days in Drawdown Event	Start Date	End Date
0 - 0.5 ft[b]	0.5	1	1	1	2	12/31/2001	1/1/2002
0.5 - 1 ft[b]	1.0	2	1	1	3	9/4/1954	9/6/1954
1 - 2 ft[b]	2.0	3	1	1	4	10/11/1930	10/14/1930
2 - 3 ft[b]	3.0	5	1	1	6	7/8/2000	7/13/2000
3 - 4 ft[b]	3.5	8	1	2	10	8/31/1999	9/9/1999
4 - 5 ft[b]	4.8	7	1	2	9	9/4/2008	9/12/2008
5 - 6 ft[b]	5.3	19	1	8	27	10/29/2001	11/24/2001
6 - 20 ft	6.1	7	1	5	12	9/20/2008	10/1/2008
6 - 20 ft	6.4	7	1	2	9	7/17/2000	7/25/2000
6 - 20 ft	6.7	9	1	2	11	9/14/2000	9/24/2000
6 - 20 ft	8.1	11	1	11	22	10/3/2000	10/24/2000
6 - 20 ft	10.0	15	1	3	18	9/13/1999	9/30/1999
6 - 20 ft	11.4	12	1	5	17	8/10/1999	8/26/1999
6 - 20 ft	14.0	17	1	19	36	8/18/2001	9/22/2001
6 - 20 ft	17.3	49	1	13	62	10/13/2008	12/13/2008
20- 30 ft	20.3	21	1	6	27	8/12/2000	9/7/2000
20- 30 ft	21.4	22	1	17	39	7/6/1986	8/13/1986
20- 30 ft	30.0	33	3	26 27	61 62	7/31/1956	9/29 30/1956
20- 30 ft[5]	30.1	33	13	28	73	9/8/1954	11/19/1954
20- 30 ft[5]	30.1	30	10	53	92	6/2/2008	9/1/2008
20- 30 ft[5]	30.2	69 68	27 28	44	139	7/21/2007	12/6/2007
20- 30 ft[5]	30.8	29	69	15	112	6/11/2002	9/30/2002

Notes:

a Provisional USGS data (12/23/2008-4/30/2009) was not used in this analysis.

b Only the largest drawdown event in Figure 5.2-2 is shown.

c Number of days to lowest pond elevation includes the first day at the lowest elevation which results in this day being counted twice. As a result, the # days to the lowest elevation reached + # days at the lowest elevation + # days to refill Pond B do not equal the total # of days in the drawdown event (i.e., off by one day).

d Number of days to refill Pond B from lowest elevation begins on the first day that water can be pumped from the Broad River (1 to 251.1 225 cfs) into Pond B until the full pond elevation (570 ft msl) is reached.

e Magnitude of drawdown event exceeds 30 ft due to evaporation losses during periods when Pond B had no usable storage.

ft = feet

ft msl = feet above mean sea level

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-03

Mark-up of ER Supplement Table 5.2-4

Table 5.2-4

Make-up Pond C Drawdown Occurrences (January 1926 - April 2009) [a]

Drawdown Event	Magnitude of Drawdown Event (ft)	# Days of Evaporation Loss Prior to Lee Nuclear Station Alignment to Pond C[c]	# Days ~~Lee-Nuclear-Station-Aligned-to-~~ Make-up Withdrawn from Pond C[d]	# Days at Lowest Elevation	# Days to Refill Pond C from Lowest Elevation Reached[e]	Total # Days in Drawdown Event	Start Date	End Date
2001 [b,f]	0.4	35 ~~36~~	0	1	2 ~~1~~	37	8/18/2001	9/23/2001
1986 [g,f]	0.5	38	0	1	2	40	7/6/1986	8/14/1986
1954	4.7	32 ~~31~~	25	1	8 ~~7~~	80 ~~78~~	9/8-~~9~~/1954	11/26-~~25~~/1954
1956	4.9-~~5.0~~	32	21	2 ~~1~~	9 ~~8~~	69	7/31/1956	10/7/1956
2007	12.3 ~~12.5~~	68 ~~67~~	56 ~~57~~	2 ~~1~~	28	166 ~~165~~	7/21/2007	1/2 ~~1~~/2008
2008	12.9	29	52	1	113 ~~112~~	204-~~203~~	6/2/2008	12/22 ~~21~~/2008
2002	19.3 ~~19.2~~	28	75	1	36 ~~34~~	147 ~~145~~	6/11/2002	11/4 ~~2~~/2002

Notes:

a Provisional USGS data ~~(12/23/2008 – 4/30/2009)~~ was not used in analysis.

b Only the largest drawdown event less than 0.5 ft in Figure 5.2-2 is shown.

c Period when Lee Nuclear Station would have withdrawn supplemental cooling water from Pond B and flows in the Broad River are below pumping threshold.

d Number of days that ~~Lee-Nuclear-Station-aligned-to~~ make-up withdrawn from Pond C are not necessarily consecutive days because Lee Nuclear Station pumped from Broad River as flow was available. As a result, the # days of evaporation loss prior to Lee Nuclear Station alignment to Pond C + # days ~~Lee-Nuclear-Station-aligned-to-~~make-up withdrawn from Pond C + # days at the lowest elevation + # days to refill Pond C do not equal the total # of days in the drawdown event.

e Number of days to refill Pond C from lowest elevation begins on the first day that water can be pumped (1 to ~~225~~ 200 cfs) from the Broad River into Pond C until the full pond elevation (650 ft msl) is reached.

f These events are not drawdowns to supply make-up water; Make-Up Pond C was drawn down from evaporative losses.

g Only the largest drawdown event between 0.5 ft and 1 ft from Figure 5.2-2 is shown.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-04

Mark-up of ER and ER Supplement Subsection 9.4.1.2.3

COLA Part 3, ER and ER Supplement Subsection 9.4.1.2.3, is revised as follows:

9.4.1.2.3 Dry Cooling Towers

Dry cooling is an alternative cooling method in which heat is dissipated directly to the atmosphere using a tower. This tower transfers the heat to the air by conduction and convection rather than by evaporation. Heat transfer is then based on the dry-bulb temperature of the air and the thermal transport properties of the piping material. A natural- or mechanical-draft configuration can be used to move the air.

Because there are no evaporative or drift losses in this type of system, many of the problems of conventional cooling systems are eliminated. For example, there are no problems with blowdown disposal, chemical treatment, fogging, or icing when dry cooling towers are utilized. Although elimination of such problems is beneficial, most currently available dry tower technologies require condenser and turbine designs outside the scope of the AP1000 standardized design.

While a wet tower uses the processes of evaporation, convection and conduction to reject heat, a dry tower is dependent on conduction and convection only. As a result, heat rejection is limited by the dry bulb temperature at the site. The higher the ambient temperature at the site, the higher the steam saturation pressure, and consequently, the higher the turbine backpressure will be.

Since dry towers do not rely on the process of evaporative cooling as does the wet tower, larger volumes of air must be passed through the tower compared to the volume of air used in wet cooling towers. As a result, dry cooling towers need larger heat transfer surfaces and must be larger in size than comparable wet towers.

The U.S. Environmental Protection Agency (EPA) rejects dry cooling as the best available technology for a national requirement because the technology carries costs that are sufficient to pose a barrier to its entry to the marketplace for some projected new facilities. Dry cooling technology also poses some detrimental effects on electricity production by reducing the energy efficiency of steam turbines.

The increased exhaust gas emissions of dry cooling tower systems as compared with wet cooling tower systems provide additional support for EPA's rejection of dry cooling as the best available technology. Dry cooling technology results in a performance penalty for electricity generation that is likely to be significant under certain climatic conditions. A performance penalty is applied by the EPA to any technology (i.e., dry cooling) that requires the power producer to use more energy than would be required by another available technology (i.e., recirculating wet cooling) to produce the same amount of energy. Therefore, EPA does not consider dry cooling technology as the best available technology for minimizing adverse environmental impacts.

Two technologies are used in dry coolers: the air-cooled condenser and the indirect dry cooling tower.

The most common form of dry cooling tower technology is the air-cooled condenser (ACC). In this design, steam from the turbine exhaust is piped through large ducts to a separate air-cooled condenser located next to the turbine building. Fans draw air through cooling coils to reject heat from the exhaust steam. As the steam loses its heat, it condenses to water and is returned as steam generator feedwater.

Incorporation of the ACC technology (Reference 5) would require large-scale changes to the standardized design. The ACC is not compatible with the condenser and turbine design described in the certified design and would require extensive revision to fundamental design elements of the main steam, feedwater and heater drains systems. Essential elements of the turbine building foundation, structure and turbine missile evaluation would require revision.

The cooling units for an ACC must be located in immediate proximity to the turbine building and the size of the units requires extensive land use. As stated previously, dry towers require much larger heat transfer surfaces and are much larger in size than comparable wet towers. Extensive changes to the AP1000 turbine building footprint would be required to accommodate this design.

Because of the larger volume of air required for heat rejection, fan horsepower requirements for the ACC are typically 3 to 4 times higher than wet towers. This will significantly decrease the net electrical output of the unit. In addition, the AP1000 standardized electrical distribution design is not sized to accommodate these additional loads.

In addition to the impact on the AP1000 design, an ACC is not as thermally efficient as a wet cooling tower system, which would have a negative impact on plant performance. Dry cooling designs are unable to maintain design plant thermal performance during the hottest months of the year. Depending on weather conditions and the design heat rate, a plant can experience capacity reductions of up to 10 to 25 percent on the steam side alone, because of increased turbine backpressure.

As previously stated, the AP1000 turbine low pressure stage design requires operation at an average condenser backpressure of 3 inches (in.) Hg absolute to maintain design electrical output and has operational limits at 5 inches Hg absolute. State-of-the-art ACC designs can not operate within these parameters during the summer temperature conditions expected at the Lee Nuclear Station. ~~This would increase the probability of forced down powers and turbine trips.~~ Under typical summer temperature conditions at the site, plant operators would be required to decrease electrical output numerous times during the day to reduce the heat load on the ACC and maintain the turbine within specified operating limits. It is important to note that ACC designs in current use in the United States are combined with turbines specially designed to operate at these higher backpressures.

Incorporation of the ACC technology at the Lee Nuclear Station would extensively revise the AP1000 design reviewed during the 10CFR 52 Design Certification process. The revisions would impact safety-related design attributes, such as the offsite dose analysis. An ACC can not be integrated with the standardized turbine generator design without greatly increasing the probability of plant transients during summer operation. Therefore, this system is inferior to the selected heat dissipation system.

The second type of dry cooling tower technology is the indirect dry tower. In this design, the wet tower in the AP1000 standardized design is replaced with a large air-water heat exchanger. Circulating water from the condenser is piped through metal-finned tubes and fans force air over the tubes to reject heat to the air and atmosphere.

The advantages of indirect dry cooling towers are the same as the ACC design. The requirement for cooling water is eliminated and there are no problems with blowdown disposal, chemical treatment, icing or fogging.

~~The most significant disadvantage of indirect dry cooling towers is the size of the units. Indirect dry cooling is much less efficient than air cooled condensers because heat rejection is dependent on two thermal interfaces (steam/CWS/air), rather than the single interface used in the ACC (steam/air). Since indirect cooling has never been utilized at a 1000 MWe fossil or nuclear unit in the United States, establishing the actual size of the unit is difficult. However, based on relative efficiencies, an indirect dry cooling tower would require much more space than an ACC and would dwarf the footprint of a wet cooling tower.~~ An indirect dry cooling design, sized to reject 100% of the heat load would exceed the available space on the Lee Nuclear Station site. A system sized to fit in the available space, would not be capable of maintaining the circulating water temperatures required by the AP1000 standard plant design during typical summer temperature conditions.

~~Because of the loss of efficiency, the indirect dry cooling tower requires an even larger volume of air for heat rejection than the ACC. Therefore, fan horsepower requirements would increase beyond the ACC design, which is already 3 to 4 times greater than wet towers. An indirect cooling tower would decrease the plant net electrical output even more than an ACC. And as stated previously, the standardized electrical distribution design for the AP1000 is not sized to accommodate either the ACC or indirect dry cooling tower fan horsepower requirements.~~ Because an indirect dry cooling system uses the surrounding air to cool heat rejected from the condenser, it requires a large number of fans to circulate air through the cooling coils. The parasitic electrical requirement for these fans is very high; approximately 5 times the fan power requirements for a similarly sized wet tower system. The standardized electrical distribution design for the AP1000 is not sized to accommodate these fan horsepower requirements.

~~The ACC and indirect dry cooling towers both rely upon sensible heat rejection for cooling, so the turbine backpressure limitations in the ACC technology discussion are applicable to the indirect dry cooling design. Like the ACC, indirect dry cooling towers in current use are combined with turbines specially designed to operate at higher backpressures than the AP1000 standard design.~~

Incorporation of the indirect dry cooling tower technology at the Lee Nuclear Station is not possible because the site cannot provide the land usage ~~required~~ for ~~the~~ towers sized to maintain the circulating water temperatures required by the AP1000 standard design. The tower fan horsepower requirements greatly exceed the AP1000 standardized electrical distribution design and would substantially decrease the net electrical output of the plant. The indirect dry cooling towers would also require changes to the AP1000 design that would impact the 10CFR 52

certification of the plant design and negatively impact utility efforts towards plant standardization. Therefore, this system is inferior to the selected heat dissipation system.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-05

Mark-up of ER Subsection 9.4.1.2.4

COLA Part 3, ER Subsection 9.4.1.2.4, is revised as follows:

9.4.1.2.4 Wet Dry Cooling Towers

Wet-dry or hybrid cooling towers use a combination of wet and dry cooling technologies. If a hybrid design is used in conjunction with the AP1000 design, it will need to be a wet and indirect dry cooling combination to satisfy the design requirements for the turbine/condenser package specified in the Design Control Document certified by the NRC, because the AP1000 design has a surface condenser.

Hybrid cooling technologies that combine wet and indirect dry cooling technologies are composed of two configurations: a single tower equipped with integrated wet and dry cooling sections and a design that uses the combination of a separate wet tower and air-cooled heat exchangers.

The single tower with wet and dry cooling capability operates in a manner similar to that of a wet cooling tower. The additional dry section, typically located in the upper part of the cooling tower, transfers heat from the circulating water into an air stream that is then mixed with the moist air exiting the wet tower section. This increases the temperature and lowers the humidity of the air leaving the tower, suppressing formation of a visible plume. The plume abatement feature is the primary reason for selecting this technology as the decrease in tower consumptive water use is limited by the size of the dry cooling section. Consumptive water savings from this design are achieved through the decreased heat load on the wet section of the tower due to sensible heat rejection in the dry section. In addition, sensible heat rejection is dependent on the temperature of the ambient air, and during summer conditions, the heat rejection (and therefore consumptive water savings) decreases substantially. Therefore, these towers are not a good choice for sites with high ambient conditions during the summer, like those experienced at the Lee Nuclear Station.

Further reductions in consumptive water use would require increasing the size of the dry section. However, because the tower structure must support both wet and dry sections, there is a physical limitation to the size of the dry cooling sections that can be housed in a single tower arrangement. ~~For decreased consumptive water use, a second wet-dry cooling tower design that utilizes a separate wet tower and air-cooled heat exchangers is available. In this design, circulating water is routed to the wet and dry systems in a series or parallel flow arrangement to provide operating flexibility. Because the indirect dry cooling section can be located at a significant distance away from the wet tower, it can be sized large enough to accommodate a significant portion of the heat rejection requirements for the station.~~

<u>As discussed in ER Subsection 5.3.3, the design and environmental impacts from cooling tower plumes are considered SMALL or non-existent. Therefore, the selection of a plume-abatement technology is not indicated for the Lee site. The desired reductions in consumptive water use for the Lee Nuclear Station exceed the capabilities of a single tower with wet and dry cooling capability. Therefore, this hybrid cooling design was not selected.</u>

For decreased consumptive water use, a second wet-dry cooling tower design is available. This design utilizes wet towers and separate indirect dry cooling towers. Because the indirect dry cooling tower is a separate component, its size (and the attendant consumptive water savings) is not limited by the wet tower structure and can be sized large enough to accommodate a significant portion of the heat rejection requirements for the station. The indirect dry and wet towers are typically arranged in a series configuration. Hot circulating water from the condenser passes through the indirect dry cooling towers, where forced draft air circulation rejects heat to the atmosphere. Under low ambient temperature conditions, the indirect dry cooling towers can cool circulating water to the temperature requirements of the standard plant design and the wet towers are not used. As ambient temperatures increase, the wet cooling towers can be sequentially placed into operation to maintain the required circulating water temperature.

Like the integrated wet-dry tower, consumptive water use savings from the separate tower design are still dependent on the temperature of the ambient air. During hot weather conditions, heat rejection from the air-cooled heat exchangers decreases substantially, with the wet tower rejecting most of the heat load and a limited decrease in consumptive water usage.

Wet-dry cooling technologies have higher capital costs, land use, and consumptive power requirements than other technologies, such as wet mechanical draft cooling towers.

As discussed in ER Subsection 5.3.3, the design and environmental impacts from cooling tower plumes are considered SMALL or non-existent. Therefore, the selection of a plume-abatement technology is not indicated for the Lee site.

Although the average flow on the Broad River will support station operation with minimal effects on the downstream environment or users, the flow is subject to seasonal variations. As described in ER Subsection 5.2.1.3, the station plans to limit withdrawal from the Broad River during low flow conditions, utilizing water stored in on-site impoundments to supplement or replace withdrawals on the river.

The Lee Nuclear Station has evaluated the use ofwet-dry towers a hybrid system that utilizes separate indirect dry and wet towers, based on their its ability to reduce consumptive water use at the site and extend the availability of the water stored in on-site impoundments during extended periods of low-flow conditions on the river. The evaluated hybrid system utilized the largest indirect dry cooling towers that could be feasibly accommodated by the site layout. However, the watersavingwater saving features of the wet-dry technologies decrease markedly during hot weather operation, which is the time when low-flow conditions occur on the Broad River. During the months that favor operation of the wet-dry technologies for consumptive water savings, ample flow is available in the Broad River to support station operation with minimal effects on the downstream environment or users. While wet-dry tower technologies have the ability to reduce consumptive water use, the timing of the water conservation feature does not align with the need for this feature at the Lee Nuclear Site. Specifically, a hybrid tower configuration sized to conserve enough water to preclude shutdown during all historical low-flow) river conditions would require a footprint that would be prohibitive for the site as it currently exists. Based on this discussion, and giving due consideration to the higher capital costs and consumptive power

~~requirements of the wet-tower technologies, the systems are considered inferior to the selected heat dissipation system.~~

The hybrid cooling system results in an overall reduction in the water consumption to support heat dissipation; however, these savings come at a loss of generation output from the plant due to higher parasitic loads. The larger footprint of the hybrid system will require additional clearing and grading, which will negatively impact land use. Based on this discussion, and giving due consideration to the higher capital costs of the wet-dry tower technologies, the systems are considered inferior to the selected heat dissipation system.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-06

Mark-up of ER Supplement Subsection 9.4.2.2.5.3

COLA Part 3, ER Supplement Subsection 9.4.2.2.5.3, is revised as follows:

9.4.2.2.5.3 Increase the Size of Make-Up Pond B

This alternative includes dredging out several arms of Make-Up Pond B that were filled in during the original construction activities; dredging out remnants of a cofferdam that was used during construction of the main Make-Up Pond B dam; dredging out the entire bottom of Make-Up Pond B by 5 ft, 10 ft, and 15 ft; and increasing the height of the dam 10 ft and 15 ft.

During construction of the earthen dam, virtually all available material from the impounded area was used as fill material in the dam. Therefore, in order to increase the usable volume in the Make-Up Pond B, the pond would need to be dewatered and then a combination of excavation/ripping and blasting would be required. Increasing the Make-Up Pond B dam height would provide additional capacity but also invalidate the probable maximum flood (PMF) calculation for the Lee Nuclear Station and jeopardize the safety of the Lee Nuclear Station during the PMF. Even if these obstacles could be overcome, this alternative only increases the available supplemental water by 5,645 ~~to 8,800~~ ac-ft which is 5,355 ~~2,200~~ ac-ft less than the supplemental water requirement.

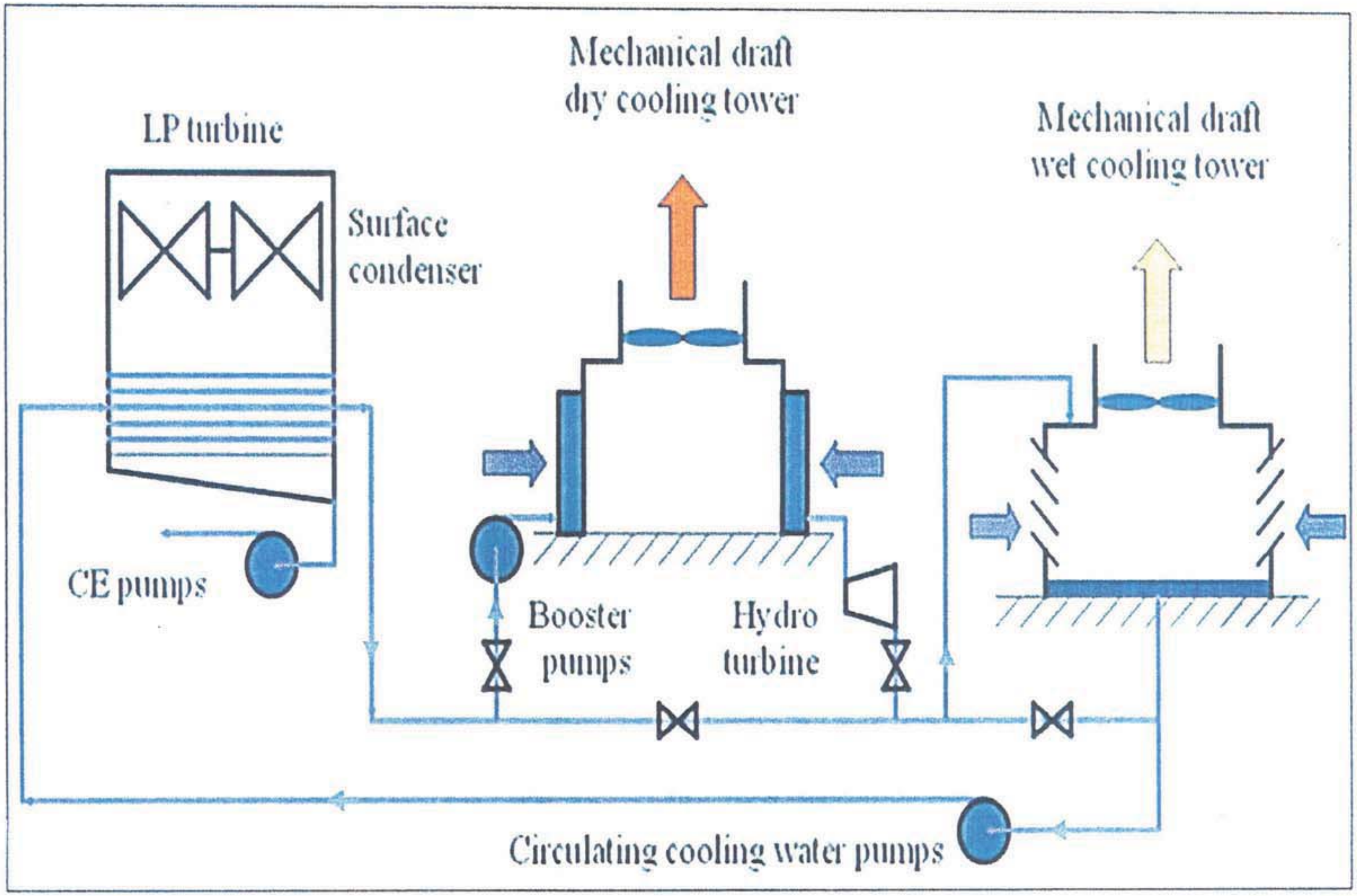
Consequently, this alternative was rejected as not meeting the need for supplemental water.

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-07

Figure 1 – Indirect Dry Cooling Towers in Series with Wet Cooling Towers

Figure 1 – Indirect Dry Cooling Towers in Series with Wet Cooling Towers



Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-08

Table 1 – Equipment Footprint for Dry Cooling Towers

Table 1 – Equipment Footprint for Dry Cooling Towers

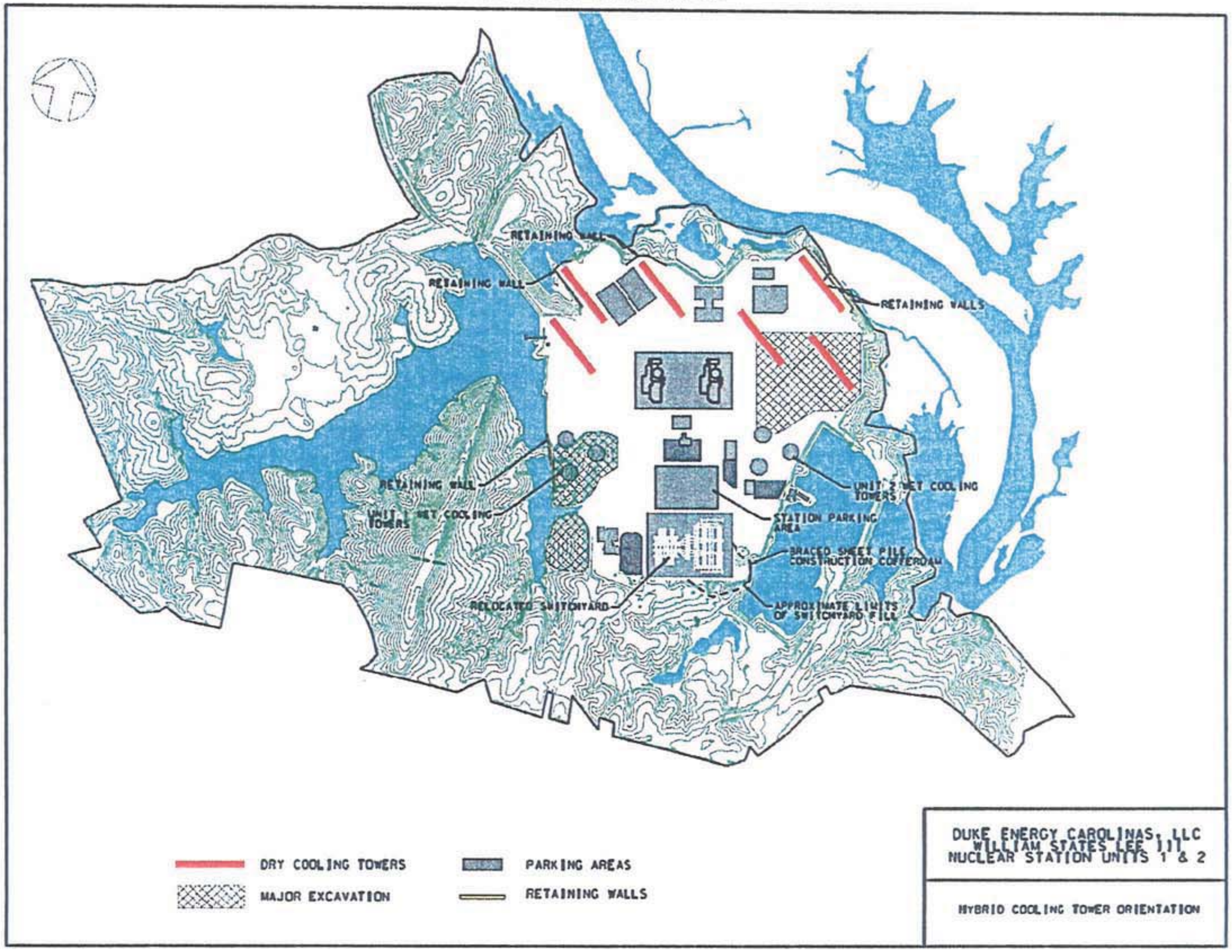
Parameter	Value
Total Number of Cells per unit	72
Total Number of Fans per unit	144
Number of fans per cell	2
Motor Rating per fan	200 HP
Number of towers per unit	3
Number of cells per tower	24
Tower length	935 ft
Cell dimensions (W x L)	100 ft x 39 ft
Tower width	100 ft
Tower height	100 ft

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-09

Figure 2 – Conceptual Layout of Hybrid Cooling System on the Lee Nuclear Station Site

Figure 2 – Conceptual Layout of Hybrid Cooling System on the Lee Nuclear Station Site

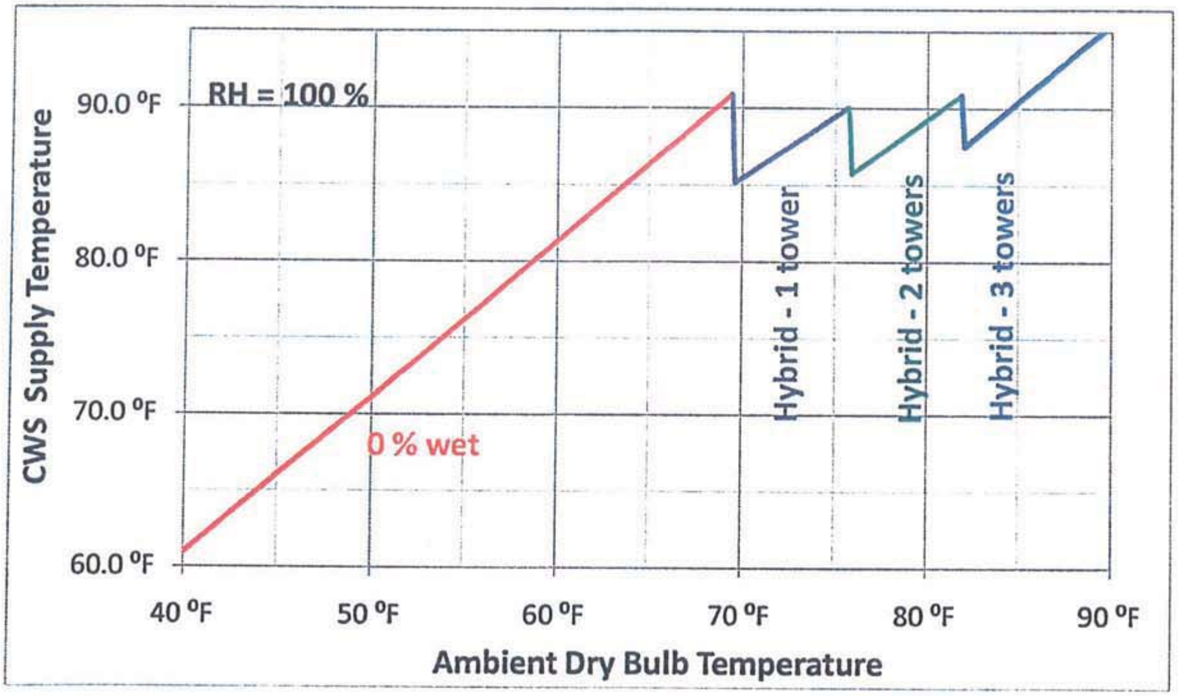


Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-10

Figure 3 – Control Philosophy for Hybrid Cooling System to Maximize Water Savings

Figure 3 – Control Philosophy for Hybrid Cooling System to Maximize Water Savings

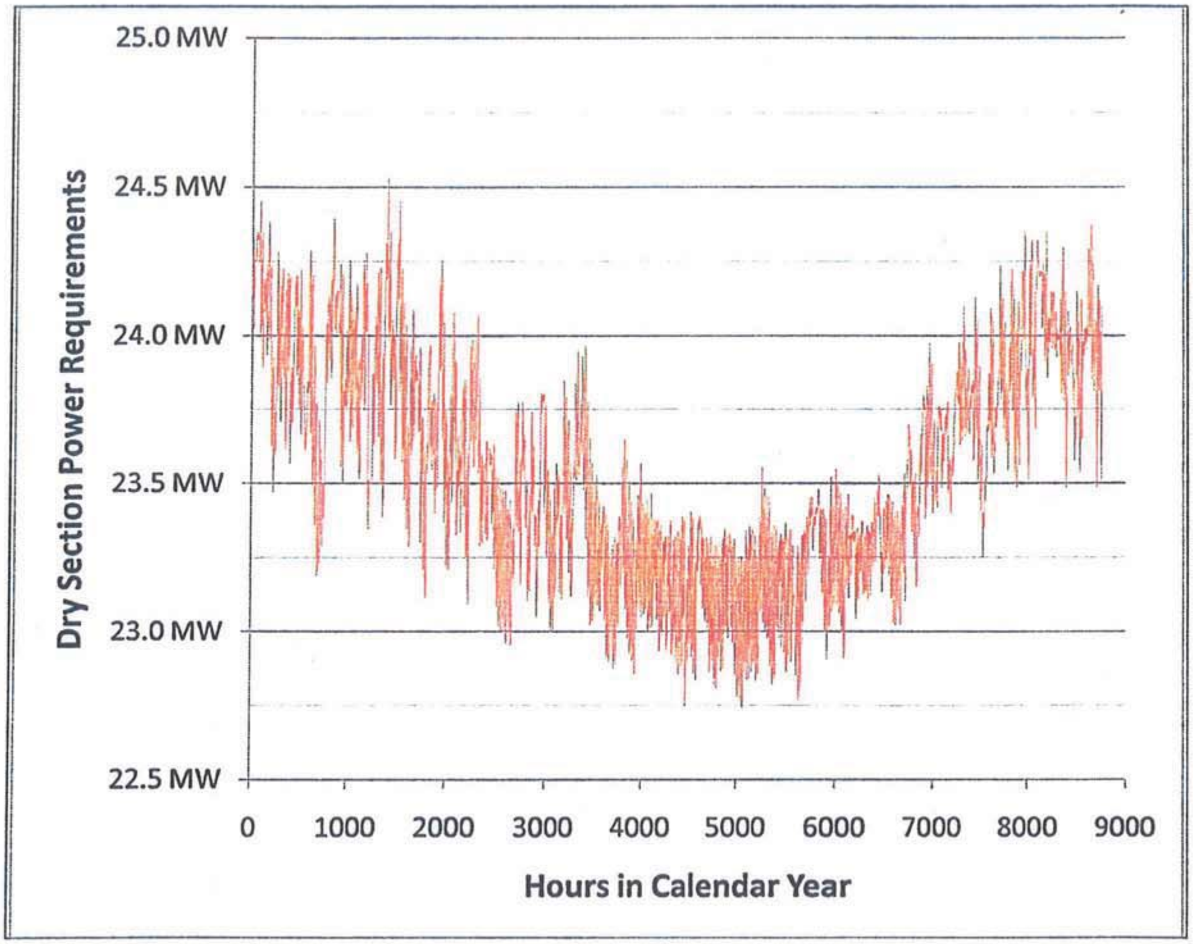


Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-11

Figure 4 – Parasitic Load for Dry Cooling Towers (Per Unit)

Figure 4 – Parasitic Load for Dry Cooling Towers (Per Unit)

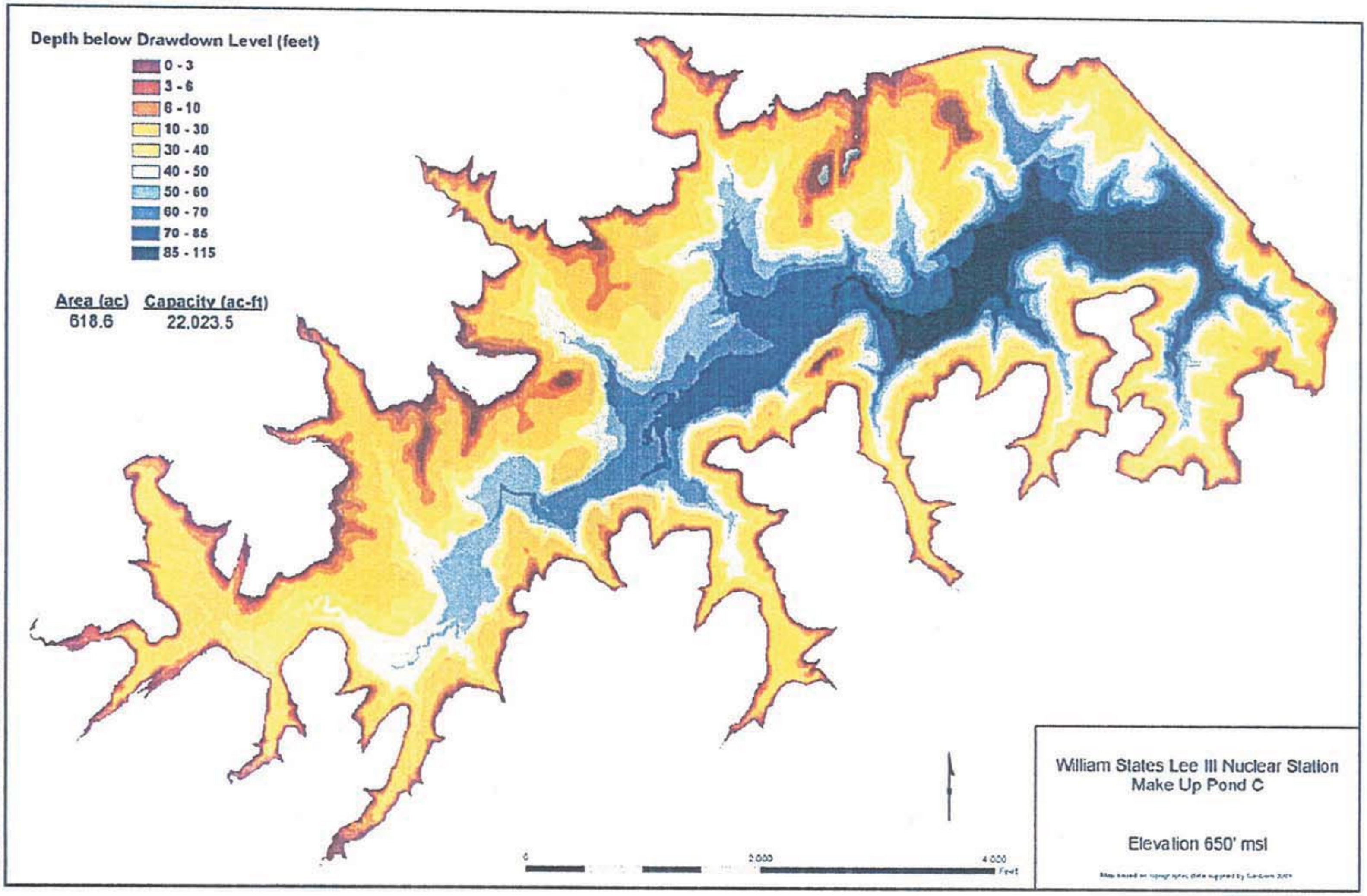


Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-12

Figure 5 – Make-Up Pond C Full Pond Elevation 650 Ft. MSL – Footprint and Water Depths

Figure 5 – Make-Up Pond C Full Pond Elevation 650 Ft. MSL – Footprint and Water Depths

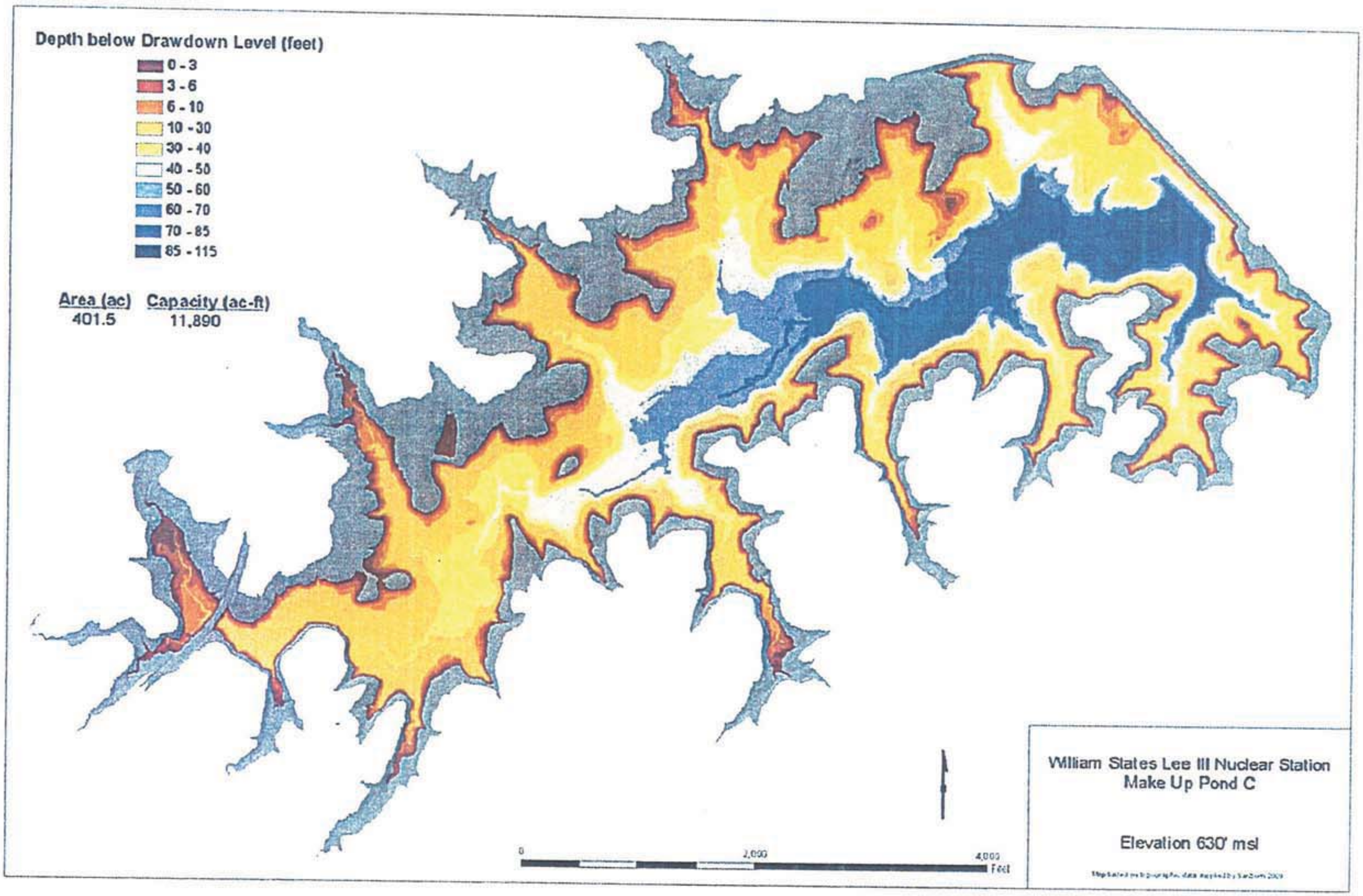


Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-13

Figure 6 – Make-Up Pond C Full Pond Elevation 630 Ft. MSL – Footprint and Water Depths

Figure 6 – Make-Up Pond C Full Pond Elevation 630 Ft. MSL – Footprint and Water Depths



Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-14

Table 2 – Environmental Impacts Considering a Hybrid Cooling System

Table 2 – Environmental Impacts Considering a Hybrid Cooling System

SHEET 1 OF 2

	Land Use	Cover Type										
		MH	MHP	PMH	NJW	OFM	USC	AW	OW	OPMH	P	NAW
	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)	(Ac.)
Hybrid Cooling Towers												
Lee Nuclear Site	368.82	51.36	22.17	25.46	26.12	211.12	26.97	0.97	4.64	0	0	0
Make-Up Pond C (@ EL. 630) Impact	856.27	308.5	98.13	21.11	0	200.08	14.5	0.05	16	0.26	197.64	0
Total	1225.09	359.86	120.3	46.57	26.12	411.2	41.47	1.02	20.64	0.26	197.64	0
Wet Cooling Towers												
Lee Nuclear Site	270.13	4.49	17.75	10.75	32.54	192.12	16.67	0	0	0	0	
Make-Up Pond C (@ EL. 650) Impact	1114.69	412.02	147.96	34.3	0.03	253.84	15.13	0	15.99	6.12	229.22	0.08
Total	1384.82	416.51	165.71	45.05	32.57	445.96	31.8	0	15.99	6.12	229.22	0.08

	Wetlands	Streams	Open Water
	(Ac.)	(Ft.)	(Ac.)
Hybrid Cooling Towers			
Lee Nuclear Site	2.92	1408.26	5.24
Make-Up Pond C (@ EL. 630) Impact	4.03	56,719.00	13.68
Total	6.95	58127.26	18.92
Wet Cooling Towers			
Lee Nuclear Site	0	0	0.18
Make-Up Pond C (@ EL. 650) Impact	4.3	68,038	13.67
Total	4.3	68038	13.85

Table 2 – Environmental Impacts Considering a Hybrid Cooling System

SHEET 2 OF 2

		Hybrid Cooling Towers	Wet Cooling Towers
Land Use	Lee Nuclear Site	SMALL	SMALL
	Make-Up Pond C	MODERATE	MODERATE
Vegetative Cover Types	Lee Nuclear Site	SMALL	SMALL
	Make-Up Pond C	MODERATE	MODERATE
Wetlands, Streams, and Open Water	Lee Nuclear Site	SMALL	SMALL
	Make-Up Pond C	MODERATE	MODERATE
Water Use	Lee Nuclear Site	SMALL	SMALL
Noise	Lee Nuclear Site	SMALL - MODERATE	SMALL
Air Quality	Lee Nuclear Site	SMALL	SMALL
Cost	Lee Nuclear Site	LARGE	SMALL

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128-15

Table 3 – Other Considerations Associated with a Hybrid Cooling System

Table 3 - Other Considerations Associated With A Hybrid Cooling System

Incremental Capital Costs - Dry Cooling Towers for Hybrid Cooling System - 2 Units		
Total Costs		**$1,040,799,161**
Major Cost Components:		
Dry Cooling Tower Design and Supply		
Dry Cooling Tower Erection		
Excavation		
Foundations		
Piping		
Electrical		
Construction Services		
Project Office Services		
Allowances, Contingency, Overhead		
Replacement Power Costs for Higher Parasitic Loads Associated with Dry Cooling Towers (Annual Costs for First Year of 2 Unit Operation)		
Maximum "Water Savings" Option		**$30,000,000**
"Power Savings" Option	**Varies**	**$0 to $11,000,000**
Higher O&M Costs		
Hybrid Cooling System Has Much More Equipment Than Wet Cooling Towers		
Hybrid Cooling System - 180 Large Fans Per Unit Wet Cooling Towers - 36 Large Fans Per Unit		
"First of a Kind" Technology Rather Than Existing Technology		
Dry Cooling Towers Evaluated Would Be Twice As Large As Any Similar Operating Towers		

January 25, 2011

MEMORANDUM TO: Robert G. Schaaf, Chief
Environmental Projects Branch 3
Division of Site and Environmental Reviews
Office of New Reactors

FROM: Sarah L. Lopas, Project Manager ***/RA/***
Environmental Projects Branch 3
Division of Site and Environmental Reviews
Office of New Reactors

SUBJECT: SUMMARY OF PUBLIC TELECONFERENCE HELD ON NOVEMBER 17, 2010, BETWEEN THE U.S. NUCLEAR REGULATORY COMMISSION AND DUKE ENERGY CAROLINAS, LLC, REGARDING THE WILLIAM STATES LEE III NUCLEAR STATION, UNITS 1 AND 2 COMBINED LICENSE APPLICATION ENVIRONMENTAL REVIEW

The U.S. Nuclear Regulatory Commission (NRC or the staff), NRC contractor representatives, representatives of Duke Energy Carolinas, LLC (Duke), Duke contractors, and members of the public and State regulatory agencies participated in a telephone conference on November 17, 2010, regarding the William States Lee III Nuclear Station, Units 1 and 2 combined license application environmental review. The purpose of the public teleconference was to discuss Duke's response to a request for additional information (RAI) regarding an analysis of hybrid wet-dry cooling as a potential alternative to the proposed Make-Up Pond C. The RAI response, dated October 29, 2010, can be found in NRC's Agencywide Documents Access and Management System (ADAMS) under Accession Number ML103070311. ADAMS is accessible at http://www.nrc.gov/reading-rm/adams.html. Persons who do not have access to ADAMS or who encounter problems in accessing documents located in ADAMS should contact the NRC's Public Document Room staff by telephone at 1-800-397-4209/301-415-4737, or via e-mail to PDR.Resource@nrc.gov.

The public teleconference was noticed on the NRC's public meeting website on November 5, 2010 (ML103070537). In preparation for the teleconference, the staff transmitted discussion questions via e-mail to Duke on November 16, 2010, (ML103260471). Duke provided answers to the discussion questions and clarified portions of the RAI response.

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NRC requested follow-up information to the response to RAI 128:

- A revised description of Figure 3 – Control Philosophy for Hybrid Cooling System to Maximize Water Savings (Attachment 128-10, page 39, RAI 128 response)
- A more detailed breakdown of Table 3 – Other Considerations Associated with a Hybrid Cooling System – Incremental Capital Costs – Dry Cooling Towers for Hybrid Cooling System – 2 Units (Attachment 128-15, page 51, RAI 128 response)

The NRC staff requested that this follow-up information be submitted by Duke within 30 days of the publication of this meeting summary. On December 17, 2010, the NRC received the detailed breakdown of Table 3 (ML103550032).

A list of participants on the call is included as Enclosure 1, and a summary of the discussion is included as Enclosure 2.

Docket Nos.: 52-018 and 52-019

Enclosures:
As stated

cc: See next page

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ADAMS Accession No.: ML103630488 **NRO-002**

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November 17, 2010, Public Teleconference
RAI Response 128 Regarding Hybrid Wet-Dry Cooling Alternative Analysis
William States Lee III Nuclear Station, Units 1 and 2
Docket Nos. 52-018 and 52-019

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November 17, 2010, Public Teleconference
RAI Response 128 Regarding Hybrid Wet-Dry Cooling Alternative Analysis
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SUMMARY OF DISCUSSION QUESTIONS

In preparation for the teleconference, the staff transmitted discussion questions via e-mail to Duke on November 16, 2010 (ML103260471). These questions and Duke's responses, provided during the teleconference, are summarized below.

1. In the Environmental Report (ER) Revision 0 submitted by Duke Energy Carolinas, LLC (Duke), Duke proposed two units with the acknowledgement that the plants would experience forced shutdown with some non-zero frequency. During the May 2008 site audit, the staff requested that Duke include recent low water years in their water budget analysis. After the associated reanalysis, Duke declared that the ER needed to be supplemented to include Make-Up Pond C in the plant design. Subsequent analyses all appear to be predicated on a zero-frequency of forced outage due low water conditions. Why does Duke now think a zero forced outage frequency is appropriate, whereas in the original ER, they did not?

   Duke Response: In ER Revisions 0 and 1, prior to updating the water budget analysis to include the severe drought years of 2007 and 2008, Duke estimated there would be on the order of one forced outage per the 81 year period of record due to a shortage of water. This frequency of forced outages related to a shortage of water was assumed by Duke to not be significant. However, upon revision of the water budget analysis to include the 2007 and 2008 drought years, the number of forced outages due to a water shortage (and relying just on Pond B for supplemental water) increased on the order of five per the 83 year period of record. The total number of days of each forced outage also increased with the inclusion of the recent drought. The duration and frequency of forced outages related to a shortage of water was unacceptable to Duke and drove the need for an additional supplemental water source. Duke did not have a clear threshold on the number of forced outages that would be acceptable or unacceptable. There also would be little-to-no flexibility in scheduling routine outages (e.g., for refueling or maintenance) so they could coincide with periods of low water availability.

2. Why did Duke rely on a single year for its alternative hybrid cooling system analysis? Why was this single year 2002?

   Duke Response: Both droughts and temperatures were considered in the hybrid cooling analysis. In 2002 Duke would have had to draw from Ponds B and C for the longest period of time—this was the most severe drought year on record. The hottest year in the last ten years was 2007. Considering the impact from both droughts and temperatures, 2002 was determined to be the worst year and was therefore presented as a bounding analysis.

3. Duke, in response to RAI 128, apparently performs all analyses based on mean daily temperatures. Wouldn't the hybrid system be able to adjust at smaller timescales (e.g., hourly) to changes in air temperature? Why was this analysis not run at sub-daily time scales?

Duke Response: Page 5 of the RAI 128 response explains that the consumptive water demand of the hybrid cooling system was calculated on an hourly basis, and these hourly demands were summed to daily water consumption demands.

4. Please explain Figure 3 – Control Philosophy for Hybrid Cooling System to Maximize Water Savings (Attachment 128-10, page 39, RAI 128 response).

   Duke Response: As an AP1000 design parameter, circulating water system supply temperature must be maintained at 91 degrees Fahrenheit or lower. However, Figure 3 of RAI 128 response appears to contain an error. The figure should illustrate that the circulating water system supply temperature would be maintained at 91° F when all three wet towers are operating. Duke agreed to evaluate the figure, and correct and resubmit it as necessary.

   Subsequent to the teleconference, Duke clarified that this figure, for its intent (to illustrate the control philosophy of the hybrid towers), is not in error. However Duke intends to provide additional information to explain this figure.

5. Please confirm that the statement on Page 2 of RAI 128 response, "The volume of Make-Up Pond A would be maintained for station shutdown cooling water needs" was not intended to imply that Pond A has a safety-related function.

   Duke Response: This is confirmed—there is no safety function for Pond A; Pond A would be maintained for a normal, non-emergency shutdown.

6. Why did the hybrid wet-dry cooling analysis not include the year 2009? (Page 2 of RAI 128 response, 83-year period of record, 1926 through 2008.)

   Duke Response: Duke used the 83-year period of record in the hybrid cooling analysis so that the analysis would be consistent with the time span/period of record for the water budget analysis contained in the Supplemental ER regarding Make-Up Pond C. Duke has 2009 and 2010 water data. These are not significant drought years and would not have impacted the analysis.

7. For the period of record for the Broad River, did Duke evaluate if the historical measurement to determine if upstream flows and diversions have results in changes in flow patterns?

   Duke Response: In the Broad River Study *(which was submitted to the NRC on October 14, 2010, ML103360421), Duke reviewed historical flow data, which correlated primarily with precipitation. The Broad River basin has very little upstream water storage; as such, the data is mostly run-of-the-river.*

8. On page 3 of RAI 128 response, what is the basis for the 20-day margin of safety in water supply?

   Duke Response: In sizing Make-Up Pond C, Duke applied a 25% design margin to account for uncertainty in the length and severity of future droughts. This design margin was carried through to the hybrid cooling analysis; the 20-day margin of water supply is intended to provide a buffer against a forced outage.

9. On page 4 of RAI 128 response, what was [the] rationale for dry cooling sized at 50% indirect dry at design dry bulb temperature?

   Duke Response: Duke wanted to maximize the water savings associated with using dry cooling in order to properly evaluate the hybrid cooling alternative. Duke looked at the largest footprint for dry cooling towers that the Lee site could accommodate.

10. On page 4 of RAI 128 response, Duke mentions "The potential for higher temperatures" in the future? Does this refer to extreme outlier events or systematic changes in climate (i.e., global climate change)?

    Duke Response: The potential for higher temperatures in the future refers to outlier events; this statement is not referring to uncertainty with regard to global climate change. The potential for higher temperatures in the future is not credited in the 25% design margin.

11. On page 9 of RAI 128 response, when Duke asserts that the impacts of dredging and raising pool elevation in Pond B would result in significant additional environmental impacts, does 'additional significant' imply relative to impacts associated with creating Pond C? Does Duke assert that Pond B is 'Waters of the United States'?

    Duke Response: 'Significant environmental impacts' was not meant as a comparison to the environmental impacts resulting from the creation of Make-Up Pond C; rather, this statement referred to the existing Pond B. During construction of the Pond B dam, virtually all available material (i.e., suitable soil) from the impounded area was used as fill material in the dam. To enlarge Pond B, the pond would have to be completely dewatered and then a combination of excavation/ripping and blasting (i.e., removal of rock) would be required. This would create significant environmental impacts at Pond B. The banks of this additional excavation would have to be sloped which would further enlarge the footprint of Pond B and its environmental impacts.

    Pond B is currently considered Waters of the United States pursuant to the 2007 U.S. Army Corps of Engineers (USACE) jurisdictional determination. Duke is working with USACE to confirm this is the appropriate determination given the history of the pond and its anticipated use at the Lee Nuclear Station.

12. What is the basis of the $1.04 billion cost estimate in Table 3 – Other Considerations Associated with a Hybrid Cooling System – Incremental Capital Costs – Dry Cooling Towers for Hybrid Cooling System – 2 Units (Attachment 128-15, page 51, RAI 128 response)?

    Duke Response: Duke has a more detailed breakdown of costs that correspond to the line items in Table 3. Duke will provide these costs as a supplement to the RAI 128 response. These costs are proprietary information and Duke will request withholding of that information from public disclosure.

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January 26, 2011

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Subject: Duke Energy Carolinas, LLC
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Responses to Request for Additional Information
Ltr# WLG2011.01-03

Reference: Letter from Sarah Lopas (NRC) to Bryan Dolan (Duke Energy), Request for Additional Information Regarding the Supplement to the Environmental Report for the William States Lee III Nuclear Station, Units 1 and 2 Combined License Application, dated June 22, 2010 (ML101370398)

This letter provides supplemental information for Duke Energy's response to the Nuclear Regulatory Commission's request for additional information (RAI) included in the referenced letter.

RAI 128 Supplement, Alternatives

The response to the NRC information request described in the referenced letter is addressed as a separate enclosure, which also identifies associated changes to the Combined License Application for the Lee Nuclear Station, when appropriate.

If you have any questions or need any additional information, please contact Peter S. Hastings, Nuclear Plant Development Licensing Manager, at 980-373-7820.

Bryan J. Dolan
Vice President
Nuclear Plant Development

Enclosure:

1) RAI 128 Supplement, Alternatives

AFFIDAVIT OF BRYAN J. DOLAN

Bryan J. Dolan, being duly sworn, states that he is Vice President, Nuclear Plant Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

Bryan J. Dolan

Subscribed and sworn to me on ______________________

Teresa D. Neely
Notary Public

My commission expires: 9/2/2015

SEAL

TERESA D. NEELY
NOTARY PUBLIC
GASTON COUNTY, NC
MY COMMISSION EXPIRES 09/02/2015

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Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter Dated: June 22, 2010

Reference NRC RAI Number: ER RAI 128 Supplement - Alternatives

NRC RAI:

Provide details of the quantitative analyses used to evaluate hybrid wet-dry tower options for cooling of the proposed Lee Nuclear Plant during periods of low river flow. Include alternatives considered for cooling water sources and cooling system technologies. Include in the metrics of the analyses foregone net power due to parasitic energy losses, reduced generation efficiency, and frequency of outages due to loss of water supply.

During follow-up conference calls held on November 17, 2010 and December 1, 2010, the NRC requested additional information pertaining to the hybrid cooling system sizing and control strategy described in Figure 3 – *Control Philosophy for Hybrid Cooling System to Maximize Water Savings*, Attachment 128-10 of Duke Energy's Response to Request for Additional Information (RAI) 128 (Reference 1).

Duke Energy Response:

Figure 3, as submitted with Duke Energy's response to ER RAI 128 (Reference 1), reflects a constant 100% relative humidity condition. While this condition allows the illustration of integrated operation of the dry and wet cooling towers to be displayed on a single temperature axis, this assumption and associated figure does not represent credible conditions for the Lee Nuclear site.

As part of this supplemental response, Figure 3 has been revised to display cooling tower operation under humidity and temperature conditions that are more representative of the site. Revision 1 of Figure 3 (Attachment 128S-01) reflects a constant 47.8% relative humidity (RH) that corresponds to a coincident 92°F dry bulb and 76°F wet bulb temperature (1% exceedance condition). These conditions were assumed during sizing of the hybrid cooling system. The requirements used in sizing the wet cooling towers for sequential operation as part of the hybrid cooling system are explained below.

When the hybrid cooling system is in maximum "water savings" mode, the dry cooling towers reject 100% of the heat load until the ambient dry bulb temperature exceeds 69°F. As dry bulb temperature increases, heat rejection from the dry cooling towers decreases and the wet cooling towers are sequentially started to ensure circulating water temperature is maintained below the

design temperature of 91°F. As the dry bulb temperature approaches 92°F, the dry cooling towers reject only 50% of the heat load.

The rationale for sizing the wet cooling towers for 100% heat rejection is apparent when the conditions for sequentially starting the first and second wet cooling towers on an increasing temperature trend are considered. Figure 3 (Attachment 128S-01) shows that when the site dry bulb temperature reaches 88°F, two of the 33-1/3% wet cooling towers are operating at full heat rejection capacity and the third must be started, even though the dry cooling towers are removing greater than 50% of the heat load. This seeming decrease in heat removal capability of the wet cooling towers is caused by the demands of sequential operation. When the first wet cooling tower is started, the temperature of the hot water it receives is lower than its design condition and the tower is only cooling one-third of the circulating water flow. However, the cool water exiting the tower must be cooled to a temperature that, when mixed with the remaining two-thirds, maintains a bulk water temperature below the 91°F design limit. As wet bulb temperature for the site increases with the dry bulb temperature and constant humidity, it limits the lowest cool water temperature that can be achieved by the first wet cooling tower. When the cool water temperature is reached and the first wet cooling tower can no longer maintain a bulk circulating water temperature below 91°F, the second wet cooling tower must be started. In summary, maintaining the bulk circulating water temperature below the 91°F design limit through sequential wet cooling operation results in the first and second wet cooling towers operating below their design heat rejection capacities. As a consequence, the sequential starting of the third wet cooling tower is anticipated during the hottest weather conditions (i.e., greater than 88°F dry bulb).

When in maximum "water savings" mode, the 100% wet cooling tower design allows the circulating water system (CWS) temperature to be maintained below the 91°F design limit during most weather conditions via operation of the dry cooling towers and the sequential operation of the first and second wet cooling towers. The wet cooling tower sizing also allows the hybrid cooling system to be operated in the "power savings" mode with dry cooling towers removed from service.

There are no other changes to the information provided in Reference 1 as a result of these updates.

Reference:

1. Letter from Bryan J. Dolan (Duke Energy) to Document Control Desk, U.S. Nuclear Regulatory Commission, Response to Request for Additional Information, Ltr# WLG2010.10-09 dated October 29, 2010 (ML103070311).

Associated Revisions to the Lee Nuclear Station Combined License Application:

None

Attachment:

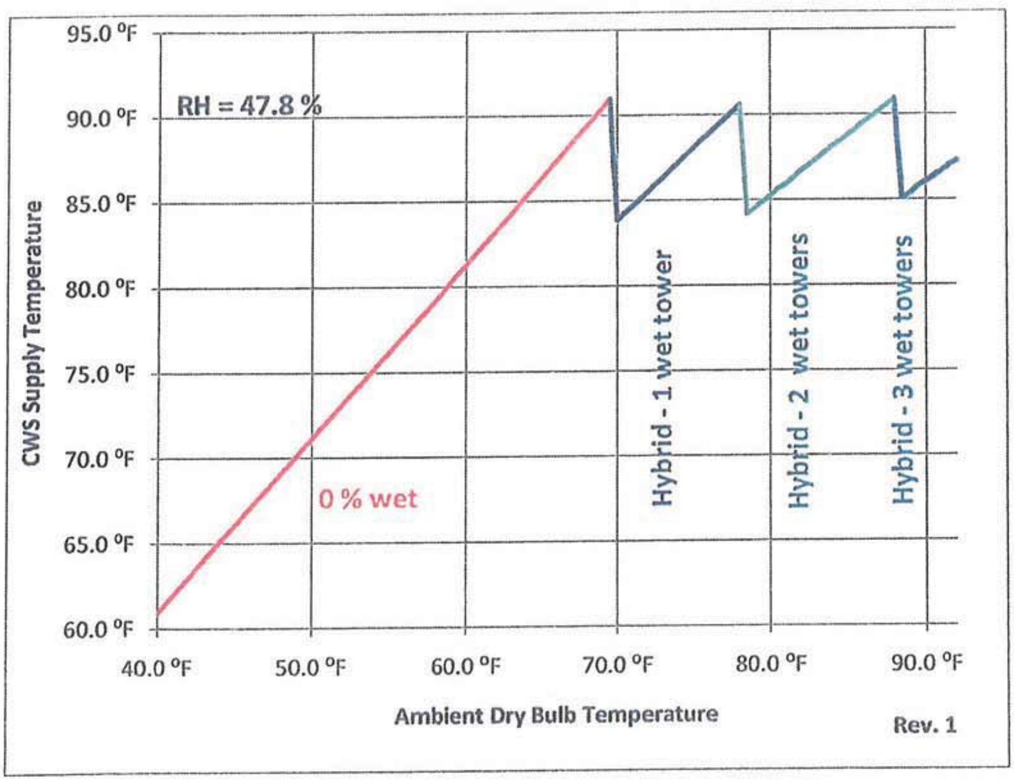
Attachment 128S-01 Figure 3 – Control Philosophy for Hybrid Cooling System to Maximize Water Savings

Lee Nuclear Station Response to Request for Additional Information (RAI)

Attachment 128S-01

**Control Philosophy for Hybrid Cooling System
to Maximize Water Savings**

Figure 3 - Control Philosophy for Hybrid Cooling System to Maximize Water Savings



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July 8, 2011

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Duke Energy Carolinas, LLC (Duke Energy)
William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019
AP1000 Combined License Application for the
William States Lee III Nuclear Station Units 1 and 2
Responses to Request for Additional Information
Ltr# WLG2011.07-04

References: Letter from Sarah Lopas (NRC) to Bryan Dolan (Duke Energy), *Request for Additional Information Regarding the Supplement to the Environmental Report for the William States Lee III Nuclear Station Units 1 and 2, Combined License Application*, dated September 14, 2010 (ML102371173)

Letter from Sarah Lopas (NRC) to Bryan Dolan (Duke Energy), *Request for Additional Information Regarding the Supplement to the Environmental Report for the William States Lee III Nuclear Station, Units 1 and 2*, Combined License Application, dated June 22, 2010 (ML101370398)

Letter from J.M. Muir (NRC) to B.J. Dolan (Duke Energy), *Request for Additional Information Regarding the Environmental Review* of the *Combined License Application for William States Lee Nuclear Station Units 1 and 2,* dated August 21, 2008 (ML082200509)

Letter from L.M. Tello (NRC) to B.J. Dolan (Duke Energy), *Request for Additional Information Regarding the Environmental Review of Combined License Application for William States Lee Nuclear Station Units 1 and 2,* dated January 21, 2009 (ML083120589)

This letter provides supplemental information to Duke Energy's responses to the Nuclear Regulatory Commission's request for additional information (RAI) included in the referenced letters.

RAI 206, Alternatives
RAI 216, Alternatives

RAI 128, Alternatives
RAIs 48, 114 and 123, Alternatives

The supplemental responses to these NRC information requests are addressed in the enclosures, which also identify associated changes to the Combined License Application for the Lee Nuclear Station, when appropriate.

If you have any questions or need any additional information, please contact Peter S. Hastings, Nuclear Plant Development Licensing Manager, at 980-373-7820.

John S. Thrasher for

Ronald A. Jones
Sr Vice President
Nuclear Development

Enclosures:

1) RAI 206 Supplement, Alternatives
2) RAI 216 Supplement, Alternatives
3) RAI 128 Supplement, Alternatives
4) RAIs 48, 114 and 123 Supplement, Alternatives

xc (w/o enclosures):

Loren Plisco, Deputy Regional Administrator, Region II
Allen Fetter, Branch Chief, DSER

xc (w/ enclosures):

Sarah Lopas, Project Manager, DSER
Brian Hughes, Senior Project Manager, DNRL
Terri Miley, PNNL
Lance Vail, PNNL

AFFIDAVIT OF JOHN S. THRASHER

John S. Thrasher, being duly sworn, states that he is Engineering Manager, Nuclear Development, Duke Energy Carolinas, LLC, that he is authorized on the part of said Company to sign and file with the U. S. Nuclear Regulatory Commission this supplement to the combined license application for the William States Lee III Nuclear Station and that all the matter and facts set forth herein are true and correct to the best of his knowledge.

John S. Thrasher

John S. Thrasher

Subscribed and sworn to me on July 8, 2011

Vickie M Prenatt

Notary Public

My commission expires: May 11, 2016

SEAL

VICKIE M PRENATT
Notary Public, North Carolina
Mecklenburg County
My Commission Expires
May 11, 2016

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter Dated: September 14, 2010

Reference NRC RAI Number: ER RAI 206 Supplement, Alternatives

NRC RAI:

Provide justification of the sizes and locations of cooling pond reservoirs at the Lee site and the alternative sites. Details should include: (l) calculations showing actual numbers and all the steps taken to come up with the final reservoir size estimates for the four sites (Lee, Perkins, Keowee, and Middleton Shoals). The analysis should also include a clear description justifying why 20 percent of the mean annual daily flow (MADF) in the Yadkin River was used as opposed to contacting the relevant water permitting agency for the drawdown limit; (2) area/volume tables and elevation/volume tables for the alternative site reservoirs; and (3) references that support the 20-ft depth being representative of the upper portion of the thermocline in the Piedmont region (if specific references are unavailable, explain how a 20-ft thermocline depth was derived).

NRC June 2 and 3, 2011 Audit - Request for Supplemental Information:

During the June 2 and 3, 2011 NRC audit, the NRC Staff requested that Duke Energy provide the following supplemental information:

- Present the water balance model/results for the most recent 10 year period of flow data for the Broad River (2001 through 2010)
- Present the water balance model/results based on the hypothetical condition that the seasonal flow release limits in the Federal Energy Regulatory Commission (FERC) license for the Ninety-Nine Islands Dam would apply as constraints on Lee Nuclear Station withdrawals (bounding evaluation)

Duke Energy Response:

Duke Energy is supplementing the previous response to this RAI based on the request for supplemental information identified above.

Several parameters associated with the water balance model used to determine the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts (sizing of Make-Up Pond C) were recently updated. First, the daily evaporation rates for Make-Up Ponds A, B and C were updated to consider average pan evaporation values from Clemson, South Carolina from July 1948 through 2010. Updated evaporation data tables are provided in the supplemental response to ER RAI 216 (Enclosure 2 to this letter). In addition, the design margin applied to account for uncertainty in the length/severity of future droughts was reduced slightly from the 25% margin applied in the initial sizing of Make-Up Pond C to a margin of 20 days of consumptive water storage so that a consistent margin was applied to each of the energy alternatives evaluated (nuclear with wet cooling towers, nuclear with hybrid cooling towers and natural gas combined cycle with wet cooling towers).

Because the Proportional Flow Limitation (5% mean annual flow) in regulations implementing Section 316(b) of the Federal Water Pollution Control Act (CWA) is susceptible to differing interpretations, Duke Energy has evaluated two values using the water balance model. First, a Proportional Flow Limitation (5% mean annual flow) of 125 cfs was applied in the water balance model, derived from the full period of record (1926 through 2010) for the Broad River at the Gaffney Station (No. 02153500). Second, a Proportional Flow Limitation (5% mean annual flow) of 98 cfs was applied in the water balance model, derived from the most recent 10 years (2001 through 2010) for the Broad River at the Gaffney Station. In comparing these two cases (98 cfs versus 125 cfs), very little difference is seen in the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts as reflected in the water balance model results summarized below.

The minimum flow release requirement of 483 cfs from the Ninety-Nine Islands Dam per its FERC License is described in more detail below. The majority of the water balance model evaluations that were performed apply this minimum flow release requirement. The seasonal flow release requirements from the Ninety-Nine Islands Dam per its FERC license are also described below. A hypothetical bounding evaluation of the water balance model, postulating constraints based on these seasonal flow release requirements, would result in a significant increase in the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts (results summarized below). Rather than postulating a larger Make-Up Pond C to support this increase in volume of required supplemental water, the volume and depth of the water layer preserved to protect the thermocline is reduced for the purposes of this evaluation. Duke Energy believes that reducing this water layer would result in less overall environmental impacts than increasing the size of Make-Up Pond C.

Different scenarios or cases of the water balance model were evaluated considering different energy alternatives, proportional flow limitations (125 cfs and 98 cfs) and flow release constraints for the Ninety-Nine Islands Dam (483 cfs and seasonal). Several sensitivity evaluations were also performed to justify the margins applied in sizing of Make-Up Pond C. The results of these different cases are presented in ER RAI supplemental responses as summarized below.

Description	**Case(s)**	**ER RAI Supplemental Response (Enclosure to Ltr. WLG2011.07-04)**
Energy Alternatives		
Nuclear with wet cooling towers	1 through 3	206 (Enclosure 1)
Nuclear with hybrid cooling towers	4 through 6	128 (Enclosure 3)
Natural gas combined cycle	7 through 9	48/114/123 (Enclosure 4)
Sensitivity Evaluations		
Combined worst evaporation	10	206 (Enclosure 1)
Synthetic drought	11 through 12	206 (Enclosure 1)

Data input tables and results are provided in the supplemental response to ER RAI 216 (ER RAI 216 Supplement, Enclosure 2 to this letter).

Make-Up Pond C Sizing Based on 5% of Mean Annual Flow of 125 cfs (Case 1)

Water balance model results based on a 5% mean annual flow of 125 cfs considering the entire 85-year period of record (1926-2010) are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 1. An 18-ft layer is preserved to protect the thermocline while maintaining the full pond elevation of Make-Up Pond C at 650 ft msl (a 20-ft layer was used in the initial sizing of Make-Up Pond C). This layer will be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	9,874 ac-ft	
• 20 days usable storage as margin (worse future droughts)	2,500 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	12,251 ac-ft	632 ft
• Volume and depth to protect thermocline	9,502 ac-ft	18 ft
• Full pond volume and elevation	22,023 ac-ft	650 ft

Additional details for Case 1 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Make-Up Pond C Sizing Based on 5% of Mean Annual Flow of 98 cfs (Case 2)

Water balance model results based on a 5% mean annual flow of 98 cfs considering the most recent 10 years (2001-2010) are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 2. A 17-ft layer is preserved to protect the thermocline while maintaining the full pond elevation of Make-Up Pond C at 650 ft msl. This layer will be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	10,270 ac-ft	
• 20 days usable storage as margin (worse future droughts)	2,500 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	12,917 ac-ft	633 ft
• Volume and depth to protect thermocline	9,106 ac-ft	17 ft
• Full pond volume and elevation	22,023 ac-ft	650 ft

Additional details for Case 2 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Sensitivity of Make-Up Pond C Sizing to Proportional Flow Limitation

A usable volume of 9,874 ac-ft is required in Make-Up Pond C to support station operations considering a Proportional Flow Limitation of 125 cfs based on the full period of record (1926-2010) as identified in Case 1. A usable volume of 10,270 ac-ft is required considering a Proportional Flow Limitation of 98 cfs based on the most recent 10 years as the period of record (2001-2010) as identified in Case 2. A negligible difference of only 396 ac-ft (volume of

consumptive water required to support approximately three days of station operations) results, with application of a Proportional Flow Limitation of 98 cfs yielding a slightly larger volume of supplemental water being required to support station operations.

Seasonal Flow Release Limits in FERC License from Ninety-Nine Islands Dam

During the June 2 and 3, 2011 audit, the NRC Staff requested that Duke Energy perform a bounding analysis and provide water balance model results with the withdrawal threshold from the Ninety-Nine Islands Reservoir based on the hypothetical condition that the seasonal flow release limits in the FERC license from Ninety-Nine Islands Dam would apply as constraints on Lee withdrawals. This bounding evaluation has been performed and the results are presented below as Case 3. Importantly, Duke Energy's FERC license for Ninety-Nine Islands Hydroelectric Station supports the water balance model evaluations for Cases 1 and 2 above, which consider maintaining a minimum flow of 483 cfs in the Broad River as the threshold flow to support withdrawals of makeup water from the Ninety-Nine Islands Reservoir (to support operations of Lee Nuclear Station and to support refill of Make-Up Ponds B and C [drought contingency ponds]). This perspective is also supported by South Carolina Water Withdrawal Law. Additional information on the FERC operating license for the Ninety-Nine Islands Hydroelectric Station is provided below.

The FERC operating license for Ninety-Nine Islands Hydroelectric Station includes seasonal limits on reservoir levels to one foot below full impoundment (511 feet above msl) from March through May, and two feet below full impoundment from June through February. This allows for a short-term potential of zero outflow (excluding a measured 53 cfs due to dam leakage) to occur, immediately followed by the required minimum flow release (Reference 2). Minimum flow requirements below the dam are 966 cfs (January through April); 725 cfs (May, June and December); and 483 cfs (July through November), when flow is available. If the above referenced flows cannot be maintained during December through June without dropping below the reservoir level restrictions described above, then at least 483 cfs is required to be released. If there is insufficient water to maintain at least 483 cfs of continuous flow release, the operating license provides that one hydroelectric unit can be operated at its minimum hydraulic output for that portion of every hour that is necessary to release the approximate accumulated inflow; inflow can be released at the trash gate, or the inflow can be spilled. Collectively, these limits are referred to as the "low flow protocol". Pursuant to South Carolina Water Withdrawal Law, only the lowest minimum flow identified above (i.e., 483 cfs) constrains withdrawals by Lee Nuclear Station. See South Carolina Water Withdrawal Law § 49-4-150(A)(4) (stating in part that water withdrawal from a licensed flow control impoundment are based on the lowest minimum flow specified in the license for that impoundment).

Make-Up Pond C Sizing Based on Ninety-Nine Islands Dam Seasonal Flow Release Constraints (Case 3)

Water balance model results based on the bounding evaluation of hypothetical constraints associated with Ninety-Nine Islands Dam seasonal flow release limits are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 3. A significant increase in usable volume to support station operations would be required under this scenario, resulting in only an

11-ft layer being preserved to protect the thermocline with a full pond elevation of 650 ft msl. This layer should be sufficient to avoid disruption of the natural thermal stratification or turnover pattern; however, there are increased risks of not protecting the thermocline for Case 3 as compared to Cases 1 and 2.

• Usable volume to support station operations (significant droughts)	12,928 ac-ft	
• 20 days usable storage as margin (worse future droughts)	2,500 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	15,575 ac-ft	639 ft
• Volume and depth to protect thermocline	6,448 ac-ft	11 ft
• Full pond volume and elevation	22,023 ac-ft	650 ft

Additional details for Case 3 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter). Daily results for Case 3 (Table 19) are also provided in the supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Justification of Margins (Usable Volume and Depth of Layer to Protect Thermocline)

During the June 2 and 3, 2011 audit, the NRC Staff asked whether the water balance model considered worst-case evaporation. To fully address this question, Duke Energy conducted a sensitivity evaluation based on the worst-case combined evaporation. The worst evaporation for each month of the year considering the full period of record of Clemson Pan Evaporation data from 07/01/1948 to 12/31/2010 were combined to create a conservative worst-case evaporation. The water balance model using this conservative worst-case evaporation was run as Case 10 and results are presented below.

Margin was added to the required usable storage when originally sizing Make-Up Pond C owing to uncertainty of the length/severity of future droughts. During the June 2 and 3, 2011 audit, the NRC Staff asked about the basis for the margin and if preserving the upper 20-ft layer of Make-Up Pond C to protect the thermocline provided additional margin. To address these questions, Duke Energy conducted two sensitivity evaluations using a synthetic drought to validate that the margins applied in sizing Make-Up Pond C are both prudent and reasonable. The synthetic drought used in these sensitivity evaluations considers 2002 flow data from January through mid-September and 2007 flow data for mid-September through December. (The last 3-½ months of 2002 included significant rainfall, which reduced the drought impact, while 2007 had little rainfall during this time resulting in extending the drought.) Cases 2 and 3 of the water balance model were re-run using the synthetic drought (with no margin added since worse-case drought being evaluated) and results are presented below as Cases 11 and 12 respectively.

Make-Up Pond C Sizing Based on Combined Worst Evaporation and Seasonal Flow Release Constraints (Case 10)

The sensitivity analysis consisting of water balance model results based on the combined hypothetical cases of worst-case evaporation and seasonal flow release constraints associated

with the Ninety-Nine Islands Dam FERC license is summarized below. This Make-Up Pond C sizing evaluation is designated as Case 10 (same as Case 3 with combined worst evaporation). As compared to Case 3, a small additional increase in usable volume to support station operations is realized from Case 10, resulting in only a 10-ft layer being preserved to protect the thermocline with a full pond elevation of 650 ft msl. This layer should be sufficient to avoid disruption of the natural thermal stratification or turnover pattern; however, there are increased risks of not protecting the thermocline for Case 10 as compared to Cases 1 and 2

- Usable volume to support station operations (significant droughts) 13,434 ac-ft
- 20 days usable storage as margin (worse future droughts) 2,500 ac-ft
- Dead storage volume below inlet of intake 147 ac-ft
- Volume and elevation (without protection for thermocline) 16,081 ac-ft 640 ft
- Volume and depth to protect thermocline 5,942 ac-ft 10 ft
- Full pond volume and elevation 22,023 ac-ft 650 ft

Additional details for Case 10 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

<u>Make-Up Pond C Sizing Based on Synthetic Drought and Minimum Flow Release Limit in FERC License from Ninety-Nine Islands Dam (Case 11)</u>

The sensitivity analysis consisting of water balance model results based on the hypothetical synthetic drought and minimum flow release limit associated with the Ninety-Nine Islands Dam FERC license is summarized below. This Make-Up Pond C sizing evaluation is designated as Case 11. A large increase in usable volume to support station operations results in only an 8-ft layer being preserved to protect the thermocline with a full pond elevation of 650 ft msl. This layer should be sufficient to avoid disruption of the natural thermal stratification or turnover pattern; however, there are increased risks of not protecting the thermocline for Case 11 as compared to Cases 1 and 2

- Usable volume to support station operations (synthetic drought) 17,013 ac-ft
- 0 days usable storage as margin (worse-case drought evaluated) 0 ac-ft
- Dead storage volume below inlet of intake 147 ac-ft
- Volume and elevation (without protection for thermocline) 17,160 ac-ft 642 ft
- Volume and depth to protect thermocline 4,863 ac-ft 8 ft
- Full pond volume and elevation 22,023 ac-ft 650 ft

Additional details for Case 11 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Make-Up Pond C Sizing Based on Synthetic Drought and Seasonal Flow Release Constraints (Case 12)

The sensitivity analysis consisting of water balance model results based on the combined hypothetical cases of synthetic drought and seasonal flow release constraints associated with the Ninety-Nine Islands Dam FERC license is summarized below. This Make-Up Pond C sizing evaluation is designated as Case 12. A significant increase in usable volume to support station operations is realized from Case 12 which results in only a 1-ft layer being preserved to protect the thermocline with a full pond elevation of 650 ft msl. This layer would not be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (synthetic drought)	21,216 ac-ft	
• 0 days usable storage as margin (worse-case drought evaluated)	0 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	21,363 ac-ft	649 ft
• Volume and depth to protect thermocline	660 ac-ft	1 ft
• Full pond volume and elevation	22,023 ac-ft	650 ft

Additional details for Case 12 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Margins Justified (Usable Volume and Depth of Layer to Protect the Thermocline)

The worst-case evaporation results (Case 10) reflect that approximately 500 ac-ft of additional supplemental water storage would be required in Make-Up Pond C to support station operations as compared with considering average evaporation results (Case 3). This change in assumed evaporation alone would erode the margin in usable storage of Make-Up Pond C by 20% (approximately four days of storage out of the 20 days of storage added as margin).

Synthetic drought evaluations (Cases 11 and 12) consider zero days of margin in usable storage in Make-Up Pond C because a hypothetical worse-case drought is being evaluated in both cases. The results from these cases reflect a large (Case 11) and significant (Case 12) increase in the usable storage volume required to support station operations through the worse-case drought and a shallow (Case 11) to insufficient (Case 12) layer being preserved to protect the thermocline through the worse-case drought.

The margins applied by Duke Energy in sizing the usable storage and in preserving a layer of water to protect the thermocline in Make-Up Pond C are both prudent and reasonable in light of water balance model results for sensitivity evaluations considering worst-case evaporation (Case 10) and considering a synthetic drought (Cases 11 and 12).

There are no other changes to the information provided in Reference 1 as a result of this update.

References:

1. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.10-04, dated October 14, 2010 (ML103360419)

2. U.S. Federal Energy Regulatory Commission (FERC), 1996, Order Issuing New License, Project No. 2331-002, June 17, 1996

Associated Revision to the Lee Nuclear Station Combined License Application:

None

Attachments:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter Dated: September 14, 2010

Reference NRC RAI Number: ER RAI 216 Supplement, Alternatives

NRC RAI:

Provide the following information that will be cited in the response to RAI 128 (to be received by NRC in October 2010):

1. Table of stage-volume and stage-area data used to model Ponds Band C;
2. Water balance model results including daily stage, volume, surface area, inflow and outflow for Ponds A, B, and C;
3. Broad River daily flows used as input and the computed daily discharge from Ninety-Nine Islands Dam;
4. Daily evaporation rates for each pond; and
5. Any assumptions such as sources and sinks of water, and other initial and boundary conditions for these ponds or the Ninety-Nine Islands Reservoir.

The requested information is to be repeated for any alternative cooling scenario evaluated.

NRC June 2 and 3, 2011 Audit - Request for Supplemental Information:

During the June 2 and 3, 2011 NRC audit, the NRC Staff requested that Duke Energy provide the following supplemental information:

- Present the water balance model/results for the most recent 10 year period of flow data for the Broad River (2001 through 2010)
- Present the water balance model/results based on the hypothetical condition that the seasonal flow release limits in the Federal Energy Regulatory Commission (FERC) license for the Ninety-Nine Islands Dam would apply as constraints on Lee Nuclear Station withdrawals (bounding evaluation)

Duke Energy Response:

Duke Energy is supplementing the previous response to this RAI based on the request for supplemental information identified above.

Because the Proportional Flow Limitation (5% mean annual flow) in regulations implementing Section 316(b) of the Federal Water Pollution Control Act (CWA) is susceptible to differing interpretations, Duke Energy has evaluated two values using the water balance model. First, a Proportional Flow Limitation (5% mean annual flow) of 125 cfs was applied in the water balance model, derived from the full period of record (1926 through 2010) for the Broad River at the Gaffney Station (No. 02153500). Second, a Proportional Flow Limitation (5% mean annual flow) of 98 cfs was applied in the water balance model, derived from the most recent 10 years (2001 through 2010) for the Broad River at the Gaffney Station. These Proportional Flow Limitation values are shown in Table 2 of Attachment 216S-01. In comparing these two cases

(98 cfs versus 125 cfs), very little difference is seen in the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts as reflected in the water balance model results for different cases/scenarios summarized in Table 16 of Attachment 216S-01.

Daily evaporation rates for Make-Up Ponds A, B and C used in the water balance model were updated to consider pan evaporation values from Clemson, South Carolina from July 1948 through 2010 (refer to Tables 6, 6a, 6b, 7, 8 and 9 in Attachment 216S-01).

The NRC Staff requested that Duke Energy perform a bounding evaluation of the water balance model considering hypothetical constraints associated with the seasonal flow release requirements from the Ninety-Nine Islands Dam per its FERC License. Inputs to the water balance model and results from this bounding evaluation are presented in Tables 17, 18 and 19 of Attachment 216S-01.

Attachment 216S-01 provides several tables that have been updated from Duke Energy's response to ER RAI 216 (Reference 1) and several new tables. These tables provide updated and new water balance model inputs and output results as summarized in the paragraphs below.

Table 2 provides an updated summary of water balance model inputs.

Table 6 provides updated daily evaporation rates for the Make-Up Ponds considering pan evaporation values from Clemson, South Carolina from July 1948 through 2010.

Table 6a provides daily evaporation rates for the Make-Up Ponds considering worst case monthly pan evaporation values from Clemson, South Carolina from July 1948 through 2010.

Table 6b provides monthly pan evaporation values from Clemson, South Carolina from July 1948 through 2010.

Table 7 provides updated daily evaporation for Make-Up Pond A assuming full pond elevation 547 ft msl.

Table 8 provides updated daily evaporation for Make-Up Pond B assuming full pond elevation 570 ft msl.

Table 9 provides updated daily evaporation for Make-Up Pond C assuming full pond elevation 650 ft msl.

Table 13 which provides water balance model results for a heat dissipation system evaluation using 100% wet cooling towers during the year 2002 was not updated due to negligible changes in the updated water balance model results. The updated water balance model results (refer to Case 1 on Table 16 for inputs and outputs) reflect that 9,874 ac-ft of additional supplemental water would be required to support station operations versus 9,847 ac-ft shown in Table 13 of Duke Energy's initial response to ER RAI 216 (Reference 1). This difference is less than one percent and is considered negligible.

Table 14 which provides water balance model results using the hybrid cooling system year-round during the year 2002 for the maximum "water savings" evaluation was not updated due to negligible changes in the updated water balance model results. The updated water balance model results (refer to Case 4 on Table 16 for inputs and outputs) reflect that 2,804 ac-ft of additional supplemental water would be required to support station operations versus 2,778 ac-ft shown in Duke Energy's initial response to ER RAI 128 (Reference 1). This difference is less than one percent and is considered negligible.

Table 16 provides a summary of inputs and outputs on Make-Up Pond C sizing for different scenarios (cases).

Table 17 provides Broad River monthly threshold flows used in the water balance model to support all consumptive withdrawals from the Broad River considering hypothetical constraints associated with FERC seasonal flow release limits from the Ninety-Nine Islands Dam.

Table 18 provides Broad River monthly threshold flows used in the water balance model to support maximum refill operations considering hypothetical constraints associated with FERC seasonal flow release limits from the Ninety-Nine Islands Dam.

Table 19 provides water balance model results for a heat dissipation system evaluation using 100% wet cooling towers considering hypothetical constraints associated with FERC seasonal flow release limits from the Ninety-Nine Islands Dam during the year 2002 including daily stage, volume, surface area, inflow and outflow for Make-Up Ponds A, B, and C. Table 19 also includes the Broad River daily flows used as input, and the Broad River flow at the Ninety-Nine Islands Dam. Table 19 provides input and output details for Case 3 shown on Table 16.

There are no other changes to the information provided in Reference 1 as a result of this update.

References:

1. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.10-09, dated October 29, 2010 (ML103070311)

2. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2011.06-04, dated June 23, 2011 (ML11179A079)

3. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and*

2, Response to Request for Additional Information, Ltr# WLG2010.12-01, dated December 17, 2010 (ML103550032)

4. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information,* Ltr# WLG2011.01-03, dated January 26, 2011 (ML110310017)

Associated Revision to the Lee Nuclear Station Combined License Application:

None

Attachment:

Attachment 216S-01	Table 2	Updated Summary of Water Balance Model Inputs
	Table 6	Updated Daily Evaporation Rates for the Make-Up Ponds
	Table 6a	Daily Evaporation Rates for the Make-Up Ponds Using Worst Case Pan Evaporation Combination
	Table 6b	Monthly Pan Evaporation Values from Clemson, South Carolina from July 1948 through 2010.
	Table 7	Updated Daily Evaporation for Make-Up Pond A Assuming Full Pond Elevation
	Table 8	Updated Daily Evaporation for Make-Up Pond B Assuming Full Pond Elevation
	Table 9	Updated Daily Evaporation for Make-Up Pond C Assuming Full Pond Elevation
	Table 16	Make-Up Pond C Sizing for Different Scenarios (Cases)
	Table 17	Broad River Monthly Threshold Flows in Water Balance Model to Support All Consumptive Withdrawal from the Broad River Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from the Ninety-Nine Islands Dam
	Table 18	Broad River Monthly Threshold Flows in Water Balance Model to Support Maximum Refill Operations Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from the Ninety-Nine Islands Dam
	Table 19	Water Balance Model Results Using 100% Wet Cooling Towers for Year 2002 Considering Hypothetical Constraints

Associated with FERC Seasonal Flow Release Limits from the Ninety-Nine Islands Dam

Attachment 216S-01

Table 2 Summary of Water Model Inputs

Water Withdrawals and Consumptive Use	**Range (Winter–Summer) Based on Monthly Evaporation Rates**		
Lee Nuclear Station Consumptive Water Use	51–63 cfs		
Intake Screen Wash + Cooling Tower Blowdown	4.5 cfs + 18.5 cfs = 23 cfs		
Maximum Make-Up Pond Refill Rates (varies based on fish spawning period)	40-47 cfs (Mar–Jun); 239-251 cfs (Jan–Feb and Jul–Dec)		
Mean Annual Daily Flow (MADF) 1926-2010 (85 years)	2,497 cfs (5% = 125 cfs)		
Mean Annual Daily Flow (MADF) 2001-2010 (most recent 10 years)	1,956 cfs (5% = 98 cfs)		
Broad River Pumping Capacity (125 cfs based on 5% MADF)	125-325 cfs		
Natural Evaporation Losses from Make-up Ponds	**Range (Winter–Summer) Based on Monthly Evaporation Rates and Full Pond Elevations**		
Make-Up Pond A	0.11–0.43 cfs		
Make-Up Pond B	0.26–1.04 cfs		
Make-Up Pond C	1.05–4.24 cfs		
Broad River Bypass Flow Requirements			
Ninety-Nine Islands Minimum Continuous Flow (Established by FERC in 1996)	483 cfs		
Future Water Demands (Estimated for Year 2060)	60 cfs		
Pond Stage/Area/Volume Information	**Make-Up Pond A**	**Make-Up Pond B**	**Make-Up Pond C**
Full Pond Elevation	547 ft msl	570 ft msl	650 ft msl
Full Pond Surface Area	62 ac	152 ac	618 ac
Full Pond Volume	1,425 ac-ft	3,991 ac-ft	22,023 ac-ft
Pond Elevation at Maximum Drawdown For Drought Needs	No Drawdown	540 ft msl	605 ft msl
Pond Area at Maximum Drawdown For Drought Needs	No Drawdown	63 ac	201 ac
Minimum Pond Volume (Dead Storage)	No Drawdown	835 ac-ft	4,530 ac-ft
Usable Pond Volume For Drought Contingency (30 ft drawdown on Make-Up Pond B and 45 ft drawdown on Make-Up Pond C)	0 ac-ft	3,156 ac-ft	17,493 ac-ft

Table 6 Daily Evaporation Rates for the Ponds

Month	Month	Daily Evap [ft/day]
January	1	0.00351
February	2	0.00512
March	3	0.00777
April	4	0.01081
May	5	0.01217
June	6	0.0135
July	7	0.01361
August	8	0.01245
September	9	0.00965
October	10	0.00708
November	11	0.00478
December	12	0.00337

Table 6a Daily Evaporation Rates for the Ponds Using Worst Case Pan Evaporation Combination

Month	Month	Daily Evap [ft/day]
January	1	0.0048
February	2	0.00656
March	3	0.01047
April	4	0.01434
May	5	0.01548
June	6	0.02096
July	7	0.01755
August	8	0.01786
September	9	0.01432
October	10	0.00981
November	11	0.00696
December	12	0.00447

Table 6b - Monthly Pan Evaporation Values from Clemson, South Carolina from July 1948 through 2010

Station: CLEMSON UNIV
State: SC
ID: 381770
Latitude: 34.66 degrees
Longitude: -82.82 degrees
Elevation: 824 feet
Station period of record: 07/01/1948-12/31/2010

CLIMOD product: Monthly Time Series
Creation time: 06/13/2011 08:28 EDT
Element: Evaporation
Units: inch

Analysis: Sum
Max allowable missing days: 3
Lowest acceptable quality of data: Raw data
Column delimiter: tab

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1948	z	z	z	z	z	z	5.81	5.16a	3.84	3.17	f	1.25c	g
1949	e	d	3.74	f	6.29	5.77	5.46c	4.92b	3.75c	d	2.40a	d	e
1950	d	d	3.97	5.16c	6.15	d	d	4.97	4.04b	3.70a	e	f	f
1951	1.75	h	3.80c	5.46b	7.47	6.44a	7.06	6.27a	4.16b	3.48b	1.82c	l	47.71b
1952	d	2.77a	f	5.11b	6.3	6.82c	z	z	z	z	z	w	h
1953	f	d	d	6.23a	6.72b	6.41	7.1	6.06c	d	3.67c	2.57a	k	e
1954	j	e	i	5.47	6.21b	7.12a	7.89	7.18a	6.62	5.07	f	f	e
1955	e	f	d	5.72b	6.01b	6.34	6.69a	6.02b	4.36	3.92a	2.83	1.48a	43.37c
1956	1.79c	d	3.92b	d	6.17a	8.11	6.79a	6.14	d	3.11	2.07c	1.91c	40.01c
1957	1.77a	2.26b	3.46a	5.09a	5.37b	5.07c	6.02c	7.21a	4.15c	2.71b	1.83c	f	44.94a
1958	h	l	g	5.31a	6.02	6.8	6.30a	d	5.27a	3.43c	3.04	g	e
1959	e	f	4.06c	5.96b	d	6.91a	6.57b	7.05a	4.22b	f	2.4	f	e
1960	k	g	h	5.81b	7.02a	6.51	6.14b	6.01	4.64a	d	2.32	s	e
1961	t	h	4.10a	5.62a	5.77	6.35b	7.11	i	z	z	i	d	g
1962	1.62b	d	3.88b	5.29b	7.79	6.19a	7.26	7.4	z	3.95b	2.87b	e	46.25c
1963	d	2.63a	4.86c	6.30b	6.83	5.57c	6.31a	6.84	4.82a	4.27a	2.26c	q	50.69b
1964	k	e	4.31c	f	6.68a	7.58a	e	5.65c	5.43	3.26a	2.75a	h	e
1965	1.89b	j	4.06b	5.33b	7.47	5.57c	6.27a	7.04	5.03	3.86b	2.37a	1.75	50.64a
1966	e	g	4.56a	4.52b	4.9	7.04	6.99	5.89a	4.78a	3.27a	2.03a	1.61b	45.59b
1967	2.01b	g	4.59	5.92b	d	6.14b	6.12a	5.25c	4.91	3.93	2.53	1.22	42.62b
1968	f	2.96	5.07	5.27	6.77	6.94	7.24	7.7	4.74	3.30a	1.81a	1.85	53.65a
1969	1.28	1.9	4.34	5.15a	6.56	7.53	8.29	6.94	4.62	3.72	2.47	1.69	54.49
1970	m	2.75b	3.72	5.3	6.83a	7.13	8.2	6.6	5.41	3.36	2.19	1.8	53.29a
1971	1.46	2.55	3.47	i	6.05a	5.77	6.05	5.95	4.92	3.98	2.55	1.94	44.69a
1972	1.83	2.4	3.93	5.52	5.42	6.85	6.95	7.13	6.63	3.87	z	1.79	52.32a
1973	1.71c	2.45	3.08	4.49	6.04	5.91	6.83	5.84	5.12a	3.54	2.09	h	47.10a
1974	1.14a	1.38a	3.04	4.27	5.37	6.09	6.95	4.93	4.11	3.68	2.23	1.58	44.77
1975	1.79c	2.19b	g	5.21	5.57	7.17	6.48	5.69	3.88	3.15	2.71	n	43.84b
1976	n	h	3.25	5.99	5.27	6.36	7.01a	6.17	3.68	2.76b	d	s	d
1977	x	q	3.26b	5.22	6.17	6.29	8.1	7.31	4.16a	3.27a	2.24	s	46.02c
1978	z	z	z	4.26	3.69b	6.07a	5.57	4.65	3.78a	3.90b	3.27	w	d
1979	z	z	4.25	5.36	5.58	5.87	5.73	7.54	z	4.33	d	w	e
1980	h	t	d	5.81	6.14	6.97	8.58	7.65	5.05	3.29a	d	q	e
1981	t	l	4.86a	6.03	6.57	7.71	7.2	6.12	5.79	4.72	2.31a	l	51.31c
1982	r	g	3.94	4.81	6.96	6.24	7.12	5.82a	4.39	3.16	2.38c	l	44.82c
1983	q	f	g	4.66	6.64	6.39	7.8	7.34	4.78a	3.76a	e	j	e
1984	z	i	i	4.28	6.51a	6.45b	5.67c	5.37	5.38	4.31	h	h	e
1985	1.91a	h	4.46	5.97	6.14	7.58	5.65b	5.58	5.63	3.95b	1.58	h	48.45b
1986	e	2.18	3.94	6.29	6.28	7.8	8.74	5.91	4.07	3.51b	1.48b	g	50.20b
1987	d	1.78b	3.09b	5.01	5.91	6.38	7.33	7.08	4.56	4.24	2.69a	1.48c	49.55a
1988	z	l	3.81	5.43	6.32a	7.83	6.35	6.55	4.02c	3.33	2.46	z	46.10c
1989	1.69	2.06c	3.14b	4.72	5.88	5.19b	5.05c	5.04c	4.34	3.29	d	z	40.40b
1990	d	2.53	3.35a	5.14a	5.95	6.87	7.15	5.75b	4.51	2.94a	2.72	z	46.91b
1991	1.11c	2.33	3.41a	4.16	4.55	5.20a	5.64a	4.72a	4.44	3.64	2.09	1.8	43.09
1992	f	2.52	3.43	4.64	5.18	5.17	7.05	4.82b	3.83a	2.83b	d	1.28a	40.75b
1993	1.37c	2.08	3.00c	5	4.99	6.31	8.29	6.04a	4.56a	3.29a	1.89b	1.64b	48.46
1994	j	g	4.21	5.00b	5.91	6.02	5.49a	4.67c	4	2.67	2.36c	1.59a	41.92b
1995	1.67b	f	3.66a	5.45	6	5.91	6.74	5.20a	3.81	3.43	1.86a	m	43.73b
1996	k	d	d	5.02	6.71	6.42	7	4.73	5.21	4.03a	3.19a	2.03c	44.34c
1997	j	2.05b	5.41	7.17	8	6.46	7.48b	7.3	5.46	3.81b	1.93b	1.43	56.50a
1998	e	2.33	4.14	4.53a	6.58	8.14	8.11	8.08	6.05	4.05	2.11	1.85	55.97a
1999	1.85	2.16	4.29	6.11	7.14	6.75	7.3	9.23	7.16	3.49	2.88	2.31	60.67
2000	2.03	2.92	4.77	5.2	7.96	8.9	9.07	7.22	4.61a	4.69	2.23	d	59.60a
2001	2.03	2.55	4.64a	6.06a	7.39	6.20b	7.43	6.99a	4.87	4.53	3.48	2.3	58.47
2002	1.85c	3.06	3.95	5.82	6.82	8.6	8.58	8.95	4.58	4.05a	2.08c	2.31	60.65
2003	2.48	2.41a	3.71a	4.56	5.36a	6.57a	7.19a	6.63	6.09	3.62	3.1	1.75	53.47
2004	d	1.90b	4.95	6.42	6.7	6.46	e	6.33a	4.86b	3.21a	2.14	2.01	44.98b
2005	2.17	z	4.49a	5.61	6.56	u	z	i	g	3.96	i	i	g
2006	2.18	2.26	5.12	6.6	g	h	8.51	7.02	4.37	3.62	2.01	2.02	43.71b
2007	2.25	2.99	4.85a	6.18	7.74	8.19	6.8	8.97	6.13	4.31	3.36	1.79a	63.56
2008	2.13	2.87	4.21	5.19	7.28	10.48	8.28	8.28	5.24	3.91	2.69	1.48	62.04
2009	2.14	2.76	3.38	5.91	5.72	8.04	8.14	7.72	4.47	2.52	2.16	1.56	54.52
2010	z	2.06a	3.75	6.48	6.59	8.42	8.73	6.89	6.77	4.44	2.29	m	56.42b
Max value	***2.48***	***3.06***	***5.41***	***7.17***	***8***	***10.48***	***9.07***	***9.23***	***7.16***	***5.07***	***3.48***	***2.31***	***63.56***
Min value	***1.11***	***1.38***	***3***	***4.16***	***3.69***	***5.07***	***5.05***	***4.65***	***3.68***	***2.52***	***1.48***	***1.22***	***43.09***
Mean	***1.81***	***2.39***	***4.01***	***5.41***	***6.29***	***6.75***	***7.03***	***6.43***	***4.82***	***3.66***	***2.39***	***1.74***	***54.93***
Median	***1.83***	***2.4***	***3.95***	***5.32***	***6.28***	***6.46***	***7.03***	***6.27***	***4.63***	***3.66***	***2.32***	***1.75***	***54.52***
# years	***27***	***31***	***50***	***58***	***59***	***59***	***58***	***59***	***56***	***58***	***49***	***29***	***11***

FLAGS:
a = 1, b = 2, c = 3, ..., or z = 26 or more missing days in a month or missing months in a year.
A = Accumulation over more than one day, S = Subsequent

NOTES:
- Long-term means based on columns. Thus, the sum (or average) of the monthly values may not equal the annual value.
- Requested start time is earlier than beginning of record.

Table 7

Daily Evaporation for Make-Up Pond A Assuming Full Pond Elevation (Elev. 547 ft and Surface Area 62 ac.)

Month	Month	Daily Evap [ft/day]	Pond A Surface Area [ac]	Pond A Evap. [ac-ft/day]	Pond A Evap. [cfs]
January	1	0.00351	62	0.22	0.11
February	2	0.00512	62	0.32	0.16
March	3	0.00777	62	0.48	0.24
April	4	0.01081	62	0.67	0.34
May	5	0.01217	62	0.75	0.38
June	6	0.0135	62	0.84	0.42
July	7	0.01361	62	0.84	0.43
August	8	0.01245	62	0.77	0.39
September	9	0.00965	62	0.60	0.30
October	10	0.00708	62	0.44	0.22
November	11	0.00478	62	0.30	0.15
December	12	0.00337	62	0.21	0.11

Table 8
Daily Evaporation for Make-Up Pond B Assuming Full Pond Elevation
(Elev. 570 ft and Surface Area 152 ac.)

Month	Month	Daily Evap [ft/day]	Pond B Surface Area [ac]	Pond B Evap. [ac-ft/day]	Pond B Evap. [cfs]
January	1	0.00351	152	0.53	0.27
February	2	0.00512	152	0.78	0.39
March	3	0.00777	152	1.18	0.60
April	4	0.01081	152	1.64	0.83
May	5	0.01217	152	1.85	0.93
June	6	0.0135	152	2.05	1.03
July	7	0.01361	152	2.07	1.04
August	8	0.01245	152	1.89	0.95
September	9	0.00965	152	1.47	0.74
October	10	0.00708	152	1.08	0.54
November	11	0.00478	152	0.73	0.37
December	12	0.00337	152	0.51	0.26

Table 9
Daily Evaporation for Make-Up Pond C Assuming Full Pond Elevation
(Elev. 650 ft and Surface Area 618 ac.)

Month	Month	Daily Evap [ft/day]	Pond C Surface Area [ac]	Pond C Evap. [ac-ft/day]	Pond C Evap. [cfs]
January	1	0.00351	618	2.17	1.09
February	2	0.00512	618	3.16	1.59
March	3	0.00777	618	4.80	2.42
April	4	0.01081	618	6.68	3.37
May	5	0.01217	618	7.52	3.79
June	6	0.0135	618	8.34	4.21
July	7	0.01361	618	8.41	4.24
August	8	0.01245	618	7.69	3.88
September	9	0.00965	618	5.96	3.01
October	10	0.00708	618	4.38	2.21
November	11	0.00478	618	2.95	1.49
December	12	0.00337	618	2.08	1.05

Table 16 - Make-Up Pond C Sizing for Different Scenarios

Case	Generation Type	MADF Record	MADF (cfs)	5% of MADF (cfs)	Drought Considered	Consumptive Use Year	Pan Evaporation	Dry Cooling Degradation Considered	Cooling Type	Non-Spawn Additional Refill (cfs)	99 Islands FERC Flow Requirements(s) (cfs)	Pond B Maximum Drawdown (ft)	Pond C Maximum Drawdown (ft)	Volume Used in Pond C (ac-ft)	20 Days of Additional Margin (ac-ft)	Dead Storage Below Intake Inlet (ac-ft)	Volume of Pond C Without 316 b Considerations (ac-ft)	Pond Elev Without Additional Storage for 316 b Considerations (ft)	Additional Pond Depth Available for 316 b Considerations (ft)	Full Pond Elevation with 316 b Considerations (ft)	Volume of Pond C Available for 316 b Considerations (ft)	Total Volume of Pond C With 316 b Considerations (ac-ft)
1	Nuclear	1926-2010	2497	125	Historic	2002	New Avg	n/a	Wet	200	483	30	45	9874	2500	147	12521	632	18	650	9502	22023
2	Nuclear	2001-2010	1956	98	Historic	2002	New Avg	n/a	Wet	200	483	30	45	10270	2500	147	12917	633	17	650	9106	22023
3	Nuclear	2001-2010	1956	98	Historic	2002	New Avg	n/a	Wet	200	966/725/483	30	45	12928	2500	147	15575	639	11	650	6448	22023
4	Nuclear/Hybrid	1926-2010	2497	125	Historic	2002	New Avg	25 percent	Hybrid	0	483	30	30	2804	2500	147	5451	610	20	630	6439	11890
5	Nuclear/Hybrid	2001-2010	1956	98	Historic	2002	New Avg	25 percent	Hybrid	0	483	30	30	2927	2500	147	5574	610	20	630	6316	11890
6	Nuclear/Hybrid	2001-2010	1956	98	Historic	2002	New Avg	25 percent	Hybrid	0	966/725/483	30	30	3443	2500	147	6090	612	18	630	5800	11890
7	Combined Cycle	1926-2010	2497	125	Historic	2002	New Avg	n/a	Wet	200	483	30	30	3277	1200	147	4624	606	20	626	5737	10361
8	Combined Cycle	2001-2010	1956	98	Historic	2002	New Avg	n/a	Wet	200	483	30	30	3380	1200	147	4727	606	20	626	5634	10361
9	Combined Cycle	2001-2010	1956	98	Historic	2002	New Avg	n/a	Wet	200	966/725/483	30	30	4279	1200	147	5626	610	16	626	4735	10361

Sensitivity Runs

Case	Generation Type	MADF Record	MADF (cfs)	5% of MADF (cfs)	Drought Considered	Consumptive Use Year	Pan Evaporation	Dry Cooling Degradation Considered	Cooling Type	Non-Spawn Additional Refill (cfs)	99 Islands FERC Flow Requirements(s) (cfs)	Pond B Maximum Drawdown (ft)	Pond C Maximum Drawdown (ft)	Volume Used in Pond C (ac-ft)	20 Days of Additional Margin (ac-ft)	Dead Storage Below Intake Inlet (ac-ft)	Volume of Pond C Without 316 b Considerations (ac-ft)	Pond Elev Without Additional Storage for 316 b Considerations (ft)	Additional Pond Depth Available for 316 b Considerations (ft)	Full Pond Elevation with 316 b Considerations (ft)	Volume of Pond C Available for 316 b Considerations (ft)	Total Volume of Pond C With 316 b Considerations (ac-ft)
10	Nuclear	2001-2010	1956	98	Historic	2002	Comb Worst	n/a	Wet	200	966/725/483	30	45	13434	2500	147	16081	640	10	650	5942	22023
* 11	Nuclear	2001-2010	1956	98	Synthetic	2002/2007	New Avg	n/a	Wet	200	483	30	45	17013	0	147	17160	642	8	650	4863	22023
* 12	Nuclear	2001-2010	1956	98	Synthetic	2002/2007	New Avg	n/a	Wet	200	966/725/483	30	76	21216	0	147	21363	649	1	650	660	22023

Days of Pond C useage are not necessarily consecutive.

Hybrid cooling was used exclusively all year round ("Water Savings" mode with dry cooling towers operating year round).

Synthetic drought used 2002 river flows through mid-September and then used river flow data from 2007 from mid-September to December 31.

New Avg includes pan evaporation from July 1948 to 2010 at Clemson.

Combined Worst Evaporation - The worst evaporation for each month of the year considering the full period of record of Clemson Pan Evaporation from 7/1/1948 to 12/31/2010 was combined together for a very conservative worst case to determine the additional storage that would be used in Pond C.

* Since Cases 11 and 12 evaluate a synthetic drought, no margin is applied in sizing Pond C.

Table 17 Broad River Monthly Threshold Flows in Water Model to Support All Consumptive Withdrawal from the Broad River Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits (not considering pond evaporation) from the Ninety-Nine Islands Dam

	Broad River Minimum Low Flow	Total Plant Consumptive 2 Units	Future Water Demand	Water Model Broad River Threshold Flows
Month	cfs	cfs	cfs	cfs
Jan	966	50.9	60	1076.9
Feb	966	52.1	60	1078.1
Mar	966	55.2	60	1081.2
Apr	966	58.2	60	1084.2
May	725	60.1	60	845.1
Jun	725	61.9	60	846.9
Jul	483	63.0	60	606.0
Aug	483	62.3	60	605.3
Sep	483	60.4	60	603.4
Oct	483	57.4	60	600.4
Nov	483	54.6	60	597.6
Dec	725	51.9	60	836.9

Table 18 Broad River Monthly Threshold Flows in Water Model to Support Maximum Refill Operations Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

Month	Broad River Minimum Low Flow cfs	Total Plant Consumptive 2 Units cfs	Maximum Refill Rate for Make-Up Ponds cfs	Future Water Demand cfs	Water Model Broad River Threshold Flows cfs
Jan	966	50.9	224.1	60	1301
Feb	966	52.1	222.9	60	1301
Mar	966	55.2	219.8	60	1301
Apr	966	58.2	216.8	60	1301
May	725	60.1	214.9	60	1060
Jun	725	61.9	213.1	60	1060
Jul	483	63.0	212.0	60	818
Aug	483	62.3	212.7	60	818
Sep	483	60.4	214.6	60	818
Oct	483	57.4	217.6	60	818
Nov	483	54.6	220.4	60	818
Dec	725	51.9	223.1	60	1060

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond A						Pond B						Pond C					
						Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)
1/1/2002	771.57	711.57	23.00	23	711.57	547	1425	62	0.11	69.40	69.51	568.61	3,784.90	145.83	0.26	51.01	0.00	649.98	22,017.12	618.39	1.09	0.00	0.00
1/2/2002	690.71	630.71	23.00	23	630.71	547	1425	62	0.11	69.40	69.51	567.9	3,683.18	143.73	0.26	51.01	0.00	649.98	22,014.95	618.39	1.09	0.00	0.00
1/3/2002	593.69	533.69	23.00	23	533.69	547	1425	62	0.11	69.40	69.51	567.19	3,581.46	141.60	0.25	51.01	0.00	649.98	22,012.78	618.39	1.09	0.00	0.00
1/4/2002	929.81	869.81	23.00	23	869.81	547	1425	62	0.11	69.40	69.51	566.47	3,479.75	139.74	0.25	51.01	0.00	649.97	22,010.61	618.28	1.09	0.00	0.00
1/5/2002	874.36	814.36	23.00	23	814.36	547	1425	62	0.11	69.40	69.51	565.73	3,378.05	137.62	0.25	51.01	0.00	649.97	22,008.45	618.28	1.09	0.00	0.00
1/6/2002	906.71	846.71	23.00	23	846.71	547	1425	62	0.11	69.40	69.51	564.99	3,276.35	135.25	0.24	51.01	0.00	649.97	22,006.28	618.28	1.09	0.00	0.00
1/7/2002	1037.22	977.22	34.22	23	966.00	547	1425	62	0.11	69.40	69.51	564.4	3,196.93	133.33	0.24	39.79	0.00	649.96	22,004.11	618.18	1.09	0.00	0.00
1/8/2002	1305.19	1245.19	298.00	23	970.19	547	1425	62	0.11	293.39	293.50	567.61	3,640.85	142.88	0.24	0.00	223.99	649.96	22,001.95	618.18	1.09	0.00	0.00
1/9/2002	1073.03	1013.03	70.03	23	966.00	547	1425	62	0.11	69.40	69.51	567.55	3,632.45	142.69	0.25	3.98	0.00	649.96	21,999.78	618.18	1.09	0.00	0.00
1/10/2002	982.94	922.94	23.00	23	922.94	547	1425	62	0.11	69.40	69.51	566.83	3,530.74	140.69	0.25	51.01	0.00	649.95	21,997.61	618.07	1.09	0.00	0.00
1/11/2002	1099.60	1039.60	96.60	23	966.00	547	1425	62	0.11	91.99	92.10	567.14	3,575.05	141.48	0.25	0.00	22.58	649.95	21,995.45	618.07	1.09	0.00	0.00
1/12/2002	1076.50	1016.50	73.50	23	966.00	547	1425	62	0.11	69.40	69.51	567.13	3,573.52	141.45	0.25	0.52	0.00	649.95	21,993.28	618.07	1.09	0.00	0.00
1/13/2002	930.96	870.96	23.00	23	870.96	547	1425	62	0.11	69.40	69.51	566.41	3,471.81	139.57	0.25	51.01	0.00	649.94	21,991.11	617.97	1.09	0.00	0.00
1/14/2002	780.81	720.81	23.00	23	720.81	547	1425	62	0.11	69.40	69.51	565.68	3,370.11	137.47	0.25	51.01	0.00	649.94	21,988.95	617.97	1.09	0.00	0.00
1/15/2002	671.08	611.08	23.00	23	611.08	547	1425	62	0.11	69.40	69.51	564.93	3,268.42	135.05	0.24	51.01	0.00	649.94	21,986.78	617.97	1.09	0.00	0.00
1/16/2002	743.84	683.84	23.00	23	683.84	547	1425	62	0.11	69.40	69.51	564.17	3,166.73	132.57	0.24	51.01	0.00	649.93	21,984.61	617.86	1.09	0.00	0.00
1/17/2002	845.49	785.49	23.00	23	785.49	547	1425	62	0.11	69.40	69.51	563.4	3,065.05	129.88	0.23	51.01	0.00	649.93	21,982.45	617.86	1.09	0.00	0.00
1/18/2002	835.09	775.09	23.00	23	775.09	547	1425	62	0.11	69.40	69.51	562.6	2,963.38	127.07	0.23	51.01	0.00	649.93	21,980.28	617.86	1.09	0.00	0.00
1/19/2002	1201.24	1141.24	198.24	23	966.00	547	1425	62	0.11	193.63	193.74	564.49	3,209.40	133.63	0.22	0.00	124.23	649.92	21,978.12	617.75	1.09	0.00	0.00
1/20/2002	1813.41	1753.41	298.00	23	1478.41	547	1425	62	0.11	293.39	293.50	567.69	3,653.32	143.13	0.24	0.00	223.99	649.92	21,975.95	617.75	1.09	0.00	0.00
1/21/2002	1443.80	1383.80	268.14	23	1138.66	547	1425	62	0.11	263.53	263.64	569.99	3,990.45	151.33	0.25	0.00	170.18	649.99	22,021.29	618.50	1.09	0.00	23.95
1/22/2002	1894.26	1834.26	75.31	23	1781.95	547	1425	62	0.11	70.70	70.81	569.99	3,990.33	151.33	0.27	0.00	0.21	649.99	22,021.29	618.50	1.09	0.00	1.09
1/23/2002	2760.54	2700.54	75.38	23	2648.17	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/24/2002	3811.63	3751.63	75.38	23	3699.25	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/25/2002	3615.27	3555.27	75.38	23	3502.90	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/26/2002	3222.56	3162.56	75.38	23	3110.18	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/27/2002	1801.86	1741.86	75.38	23	1689.49	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/28/2002	1674.81	1614.81	75.38	23	1562.43	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/29/2002	1905.81	1845.81	75.38	23	1793.44	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/30/2002	1570.85	1510.85	75.38	23	1458.48	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
1/31/2002	1547.75	1487.75	75.38	23	1435.38	547	1425	62	0.11	70.77	70.88	569.99	3,990.33	151.33	0.27	0.00	0.27	649.99	22,021.29	618.50	1.09	0.00	1.09
2/1/2002	1397.60	1337.60	76.64	23	1283.96	547	1425	62	0.16	71.97	72.14	569.99	3,990.08	151.33	0.39	0.00	0.27	649.99	22,020.29	618.50	1.60	0.00	1.09
2/2/2002	1305.19	1245.19	77.27	23	1190.93	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/3/2002	971.39	911.39	23.00	23	911.39	547	1425	62	0.16	70.61	70.78	569.29	3,885.59	148.04	0.39	52.28	0.00	649.98	22,017.12	618.39	1.60	0.00	0.00
2/4/2002	890.53	830.53	23.00	23	830.53	547	1425	62	0.16	70.61	70.78	568.58	3,781.11	145.73	0.38	52.28	0.00	649.98	22,013.96	618.39	1.60	0.00	0.00
2/5/2002	939.05	879.05	23.00	23	879.05	547	1425	62	0.16	70.61	70.78	567.86	3,676.64	143.62	0.38	52.28	0.00	649.97	22,010.79	618.28	1.60	0.00	0.00
2/6/2002	1178.14	1118.14	175.14	23	966.00	547	1425	62	0.16	170.47	170.64	569.21	3,874.02	147.76	0.37	0.00	99.86	649.97	22,007.63	618.28	1.60	0.00	0.00
2/7/2002	1593.95	1533.95	142.16	23	1414.79	547	1425	62	0.16	137.49	137.66	569.99	3,990.13	151.33	0.38	0.00	58.90	649.99	22,020.29	618.50	1.60	0.00	7.98
2/8/2002	2529.53	2469.53	77.24	23	2415.29	547	1425	62	0.16	72.57	72.74	569.99	3,990.08	151.33	0.39	0.00	0.37	649.99	22,020.29	618.50	1.60	0.00	1.60
2/9/2002	1998.22	1938.22	77.27	23	1883.95	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/10/2002	1547.75	1487.75	77.27	23	1433.49	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/11/2002	1201.24	1141.24	77.27	23	1086.97	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/12/2002	1501.55	1441.55	77.27	23	1387.28	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/13/2002	1397.60	1337.60	77.27	23	1283.33	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/14/2002	1443.80	1383.80	77.27	23	1329.53	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/15/2002	1270.54	1210.54	77.27	23	1156.28	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/16/2002	1224.34	1164.34	77.27	23	1110.08	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60
2/17/2002	1081.12	1021.12	77.27	23	966.85	547	1425	62	0.16	72.60	72.77	569.99	3,990.08	151.33	0.39	0.00	0.39	649.99	22,020.29	618.50	1.60	0.00	1.60

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

						Pond A						Pond B						Pond C					
Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)
2/18/2002	927.50	867.50	23.00	23	867.50	547	1425	62	0.16	70.61	70.78	569.29	3,885.59	148.04	0.39	52.28	0.00	649.98	22,017.12	618.39	1.60	0.00	0.00
2/19/2002	1045.31	985.31	42.31	23	966.00	547	1425	62	0.16	70.61	70.78	568.84	3,819.42	146.56	0.38	32.97	0.00	649.98	22,013.96	618.39	1.60	0.00	0.00
2/20/2002	1051.09	991.09	48.09	23	966.00	547	1425	62	0.16	70.61	70.78	568.47	3,764.71	145.38	0.38	27.19	0.00	649.97	22,010.79	618.28	1.60	0.00	0.00
2/21/2002	1166.59	1106.59	163.59	23	966.00	547	1425	62	0.16	158.92	159.09	569.65	3,939.18	149.39	0.38	0.00	88.31	649.97	22,007.63	618.28	1.60	0.00	0.00
2/22/2002	1155.04	1095.04	109.31	23	1008.73	547	1425	62	0.16	104.64	104.81	569.99	3,990.11	151.33	0.39	0.00	26.06	649.99	22,020.29	618.50	1.60	0.00	7.98
2/23/2002	1201.24	1141.24	77.25	23	1086.99	547	1425	62	0.16	72.58	72.75	569.99	3,990.08	151.33	0.39	0.00	0.38	649.99	22,020.29	618.50	1.60	0.00	1.60
2/24/2002	746.16	686.16	23.00	23	686.16	547	1425	62	0.16	70.61	70.78	569.29	3,885.59	148.04	0.39	52.28	0.00	649.98	22,017.12	618.39	1.60	0.00	0.00
2/25/2002	808.53	748.53	23.00	23	748.53	547	1425	62	0.16	70.61	70.78	568.58	3,781.11	145.73	0.38	52.28	0.00	649.98	22,013.96	618.39	1.60	0.00	0.00
2/26/2002	1029.14	969.14	26.14	23	966.00	547	1425	62	0.16	70.61	70.78	567.9	3,682.87	143.73	0.38	49.14	0.00	649.97	22,010.79	618.28	1.60	0.00	0.00
2/27/2002	1054.55	994.55	51.55	23	966.00	547	1425	62	0.16	70.61	70.78	567.57	3,635.05	142.76	0.37	23.73	0.00	649.97	22,007.63	618.28	1.60	0.00	0.00
2/28/2002	882.45	822.45	23.00	23	822.45	547	1425	62	0.16	70.61	70.78	566.83	3,530.60	140.69	0.37	52.28	0.00	649.96	22,004.47	618.18	1.60	0.00	0.00
3/1/2002	952.91	892.91	23.00	23	892.91	547	1425	62	0.24	73.73	73.97	566.03	3,419.45	138.51	0.55	55.47	0.00	649.96	21,999.66	618.18	2.42	0.00	0.00
3/2/2002	1282.09	1222.09	98.00	23	1147.09	547	1425	62	0.24	93.26	93.50	566.3	3,457.12	139.27	0.54	0.00	19.53	649.95	21,994.86	618.07	2.42	0.00	0.00
3/3/2002	1409.15	1349.15	98.00	23	1274.15	547	1425	62	0.24	93.26	93.50	566.57	3,494.78	140.01	0.55	0.00	19.53	649.94	21,990.06	617.97	2.42	0.00	0.00
3/4/2002	1478.45	1418.45	98.00	23	1343.45	547	1425	62	0.24	93.26	93.50	566.84	3,532.44	140.71	0.55	0.00	19.53	649.93	21,985.26	617.86	2.42	0.00	0.00
3/5/2002	1732.56	1672.56	98.00	23	1597.56	547	1425	62	0.24	93.26	93.50	567.11	3,570.09	141.40	0.55	0.00	19.53	649.93	21,980.46	617.86	2.42	0.00	0.00
3/6/2002	1443.80	1383.80	98.00	23	1308.80	547	1425	62	0.24	93.26	93.50	567.38	3,607.73	142.14	0.55	0.00	19.53	649.92	21,975.66	617.75	2.42	0.00	0.00
3/7/2002	1328.29	1268.29	98.00	23	1193.29	547	1425	62	0.24	93.26	93.50	567.64	3,645.37	142.97	0.56	0.00	19.53	649.91	21,970.86	617.65	2.42	0.00	0.00
3/8/2002	1374.50	1314.50	98.00	23	1239.50	547	1425	62	0.24	93.26	93.50	567.9	3,683.00	143.73	0.56	0.00	19.53	649.9	21,966.06	617.54	2.42	0.00	0.00
3/9/2002	1270.54	1210.54	98.00	23	1135.54	547	1425	62	0.24	93.26	93.50	568.16	3,720.63	144.49	0.56	0.00	19.53	649.89	21,961.27	617.44	2.42	0.00	0.00
3/10/2002	1039.53	979.53	36.53	23	966.00	547	1425	62	0.24	73.73	73.97	567.58	3,636.30	142.79	0.57	41.94	0.00	649.89	21,956.47	617.44	2.42	0.00	0.00
3/11/2002	833.94	773.94	23.00	23	773.94	547	1425	62	0.24	73.73	73.97	566.79	3,525.14	140.58	0.56	55.47	0.00	649.88	21,951.67	617.33	2.42	0.00	0.00
3/12/2002	978.32	918.32	23.00	23	918.32	547	1425	62	0.24	73.73	73.97	565.99	3,413.99	138.39	0.55	55.47	0.00	649.87	21,946.88	617.22	2.42	0.00	0.00
3/13/2002	2621.94	2561.94	98.00	23	2486.94	547	1425	62	0.24	93.26	93.50	566.27	3,451.66	139.19	0.54	0.00	19.53	649.86	21,942.08	617.12	2.42	0.00	0.00
3/14/2002	2298.53	2238.53	98.00	23	2163.53	547	1425	62	0.24	93.26	93.50	566.54	3,489.32	139.92	0.55	0.00	19.53	649.86	21,937.29	617.12	2.42	0.00	0.00
3/15/2002	1975.12	1915.12	98.00	23	1840.12	547	1425	62	0.24	93.26	93.50	566.8	3,526.98	140.61	0.55	0.00	19.53	649.85	21,932.49	617.01	2.42	0.00	0.00
3/16/2002	1801.86	1741.86	98.00	23	1666.86	547	1425	62	0.24	93.26	93.50	567.07	3,564.63	141.30	0.55	0.00	19.53	649.84	21,927.70	616.91	2.42	0.00	0.00
3/17/2002	1478.45	1418.45	98.00	23	1343.45	547	1425	62	0.24	93.26	93.50	567.34	3,602.28	142.02	0.55	0.00	19.53	649.83	21,922.91	616.80	2.42	0.00	0.00
3/18/2002	1940.47	1880.47	98.00	23	1805.47	547	1425	62	0.24	93.26	93.50	567.6	3,639.92	142.85	0.56	0.00	19.53	649.82	21,918.12	616.70	2.42	0.00	0.00
3/19/2002	2437.13	2377.13	98.00	23	2302.13	547	1425	62	0.24	93.26	93.50	567.86	3,677.55	143.62	0.56	0.00	19.53	649.82	21,913.33	616.70	2.42	0.00	0.00
3/20/2002	1894.26	1834.26	98.00	23	1759.26	547	1425	62	0.24	93.26	93.50	568.12	3,715.18	144.38	0.56	0.00	19.53	649.81	21,908.54	616.59	2.42	0.00	0.00
3/21/2002	1882.71	1822.71	98.00	23	1747.71	547	1425	62	0.24	93.26	93.50	568.38	3,752.80	145.11	0.57	0.00	19.53	649.8	21,903.75	616.49	2.41	0.00	0.00
3/22/2002	1917.36	1857.36	98.00	23	1782.36	547	1425	62	0.24	93.26	93.50	568.64	3,790.42	145.93	0.57	0.00	19.53	649.79	21,898.96	616.38	2.41	0.00	0.00
3/23/2002	1790.31	1730.31	98.00	23	1655.31	547	1425	62	0.24	93.26	93.50	568.9	3,828.03	146.75	0.57	0.00	19.53	649.79	21,894.17	616.38	2.41	0.00	0.00
3/24/2002	1201.24	1141.24	98.00	23	1066.24	547	1425	62	0.24	93.26	93.50	569.16	3,865.63	147.59	0.57	0.00	19.53	649.78	21,889.38	616.28	2.41	0.00	0.00
3/25/2002	1224.34	1164.34	98.00	23	1089.34	547	1425	62	0.24	93.26	93.50	569.41	3,903.23	148.47	0.58	0.00	19.53	649.77	21,884.59	616.17	2.41	0.00	0.00
3/26/2002	1490.00	1430.00	98.00	23	1355.00	547	1425	62	0.24	93.26	93.50	569.66	3,940.82	149.43	0.58	0.00	19.53	649.76	21,879.81	616.06	2.41	0.00	0.00
3/27/2002	1570.85	1510.85	98.00	23	1435.85	547	1425	62	0.24	93.26	93.50	569.91	3,978.40	150.67	0.59	0.00	19.53	649.75	21,875.02	615.96	2.41	0.00	0.00
3/28/2002	1524.65	1464.65	98.00	23	1389.65	547	1425	62	0.24	93.26	93.50	569.99	3,989.69	151.33	0.59	0.00	6.28	649.79	21,896.52	616.38	2.41	0.00	13.25
3/29/2002	1628.60	1568.60	98.00	23	1493.60	547	1425	62	0.24	93.26	93.50	569.99	3,989.68	151.33	0.59	0.00	0.59	649.84	21,929.31	616.91	2.41	0.00	18.94
3/30/2002	1755.66	1695.66	98.00	23	1620.66	547	1425	62	0.24	93.26	93.50	569.99	3,989.68	151.33	0.59	0.00	0.59	649.9	21,962.08	617.54	2.42	0.00	18.94
3/31/2002	1247.44	1187.44	98.00	23	1112.44	547	1425	62	0.24	93.26	93.50	569.99	3,989.68	151.33	0.59	0.00	0.59	649.95	21,994.85	618.07	2.42	0.00	18.94
4/1/2002	1443.80	1383.80	96.54	23	1310.26	547	1425	62	0.34	91.70	92.04	569.98	3,989.22	151.16	0.83	0.00	0.59	649.98	22,016.77	618.39	3.37	0.00	14.42
4/2/2002	1559.30	1499.30	85.72	23	1436.58	547	1425	62	0.34	80.88	81.22	569.98	3,989.22	151.16	0.82	0.00	0.82	649.98	22,016.77	618.39	3.37	0.00	3.37
4/3/2002	1478.45	1418.45	85.72	23	1355.73	547	1425	62	0.34	80.88	81.22	569.98	3,989.22	151.16	0.82	0.00	0.82	649.98	22,016.77	618.39	3.37	0.00	3.37
4/4/2002	1362.95	1302.95	85.72	23	1240.22	547	1425	62	0.34	80.88	81.22	569.98	3,989.22	151.16	0.82	0.00	0.82	649.98	22,016.77	618.39	3.37	0.00	3.37
4/5/2002	1455.35	1395.35	85.72	23	1332.63	547	1425	62	0.34	80.88	81.22	569.98	3,989.22	151.16	0.82	0.00	0.82	649.98	22,016.77	618.39	3.37	0.00	3.37
4/6/2002	1270.54	1210.54	85.72	23	1147.82	547	1425	62	0.34	80.88	81.22	569.98	3,989.22	151.16	0.82	0.00	0.82	649.98	22,016.77	618.39	3.37	0.00	3.37

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond A: Pond Elev. (ft)	Pond A: Pond Vol. (ac-ft)	Pond A: Pond Surface Area (ac)	Pond A: Pond Evap. (cfs)	Pond A: Flow Pumped Out of Pond (cfs)	Pond A: Flow Pumped In To Pond (cfs)	Pond B: Pond Elev. (ft)	Pond B: Pond Vol. (ac-ft)	Pond B: Pond Surface Area (ac)	Pond B: Pond Evap. (cfs)	Pond B: Flow Pumped Out of Pond (cfs)	Pond B: Flow Pumped In To Pond (cfs)	Pond C: Pond Elev. (ft)	Pond C: Pond Vol. (ac-ft)	Pond C: Pond Surface Area (ac)	Pond C: Pond Evap. (cfs)	Pond C: Flow Pumped Out of Pond (cfs)	Pond C: Flow Pumped In To Pond (cfs)
4/7/2002	1017.59	957.59	23.00	23	957.59	547	1425	62	0.34	76.69	77.03	569.2	3,871.47	147.73	0.82	58.53	0.00	649.97	22,010.08	618.28	3.37	0.00	0.00
4/8/2002	986.40	926.40	23.00	23	926.40	547	1425	62	0.34	76.69	77.03	568.39	3,753.75	145.14	0.81	58.53	0.00	649.96	22,003.39	618.18	3.37	0.00	0.00
4/9/2002	1351.40	1291.40	98.00	23	1216.40	547	1425	62	0.34	93.16	93.50	568.61	3,784.86	145.83	0.79	0.00	16.47	649.95	21,996.71	618.07	3.37	0.00	0.00
4/10/2002	1282.09	1222.09	98.00	23	1147.09	547	1425	62	0.34	93.16	93.50	568.82	3,815.97	146.49	0.80	0.00	16.47	649.94	21,990.03	617.97	3.37	0.00	0.00
4/11/2002	1432.25	1372.25	98.00	23	1297.25	547	1425	62	0.34	93.16	93.50	569.03	3,847.06	147.16	0.80	0.00	16.47	649.93	21,983.34	617.86	3.37	0.00	0.00
4/12/2002	1478.45	1418.45	98.00	23	1343.45	547	1425	62	0.34	93.16	93.50	569.24	3,878.15	147.86	0.80	0.00	16.47	649.92	21,976.66	617.75	3.37	0.00	0.00
4/13/2002	1778.76	1718.76	98.00	23	1643.76	547	1425	62	0.34	93.16	93.50	569.45	3,909.23	148.61	0.81	0.00	16.47	649.91	21,969.98	617.65	3.37	0.00	0.00
4/14/2002	1131.94	1071.94	98.00	23	996.94	547	1425	62	0.34	93.16	93.50	569.66	3,940.30	149.43	0.81	0.00	16.47	649.9	21,963.30	617.54	3.37	0.00	0.00
4/15/2002	1082.27	1022.27	79.27	23	966.00	547	1425	62	0.34	76.69	77.03	569.62	3,934.21	149.27	0.81	2.26	0.00	649.89	21,956.62	617.44	3.37	0.00	0.00
4/16/2002	1432.25	1372.25	98.00	23	1297.25	547	1425	62	0.34	93.16	93.50	569.83	3,965.28	150.24	0.81	0.00	16.47	649.88	21,949.95	617.33	3.37	0.00	0.00
4/17/2002	1316.74	1256.74	98.00	23	1181.74	547	1425	62	0.34	93.16	93.50	569.98	3,989.24	151.16	0.82	0.00	12.90	649.88	21,950.37	617.33	3.37	0.00	3.58
4/18/2002	1386.05	1326.05	98.00	23	1251.05	547	1425	62	0.34	93.16	93.50	569.98	3,989.22	151.16	0.82	0.00	0.82	649.92	21,974.75	617.75	3.37	0.00	15.66
4/19/2002	1570.85	1510.85	98.00	23	1435.85	547	1425	62	0.34	93.16	93.50	569.98	3,989.22	151.16	0.82	0.00	0.82	649.96	21,999.12	618.18	3.37	0.00	15.65
4/20/2002	1443.80	1383.80	94.62	23	1312.18	547	1425	62	0.34	89.78	90.12	569.98	3,989.22	151.16	0.82	0.00	0.82	649.98	22,016.77	618.39	3.37	0.00	12.27
4/21/2002	989.87	929.87	23.00	23	929.87	547	1425	62	0.34	76.69	77.03	569.2	3,871.47	147.73	0.82	58.53	0.00	649.97	22,010.08	618.28	3.37	0.00	0.00
4/22/2002	902.09	842.09	23.00	23	842.09	547	1425	62	0.34	76.69	77.03	568.39	3,753.75	145.14	0.81	58.53	0.00	649.96	22,003.40	618.18	3.37	0.00	0.00
4/23/2002	1030.29	970.29	27.29	23	966.00	547	1425	62	0.34	76.69	77.03	567.63	3,644.58	142.94	0.79	54.23	0.00	649.95	21,996.71	618.07	3.37	0.00	0.00
4/24/2002	1235.89	1175.89	98.00	23	1100.89	547	1425	62	0.34	93.16	93.50	567.85	3,675.72	143.59	0.78	0.00	16.47	649.94	21,990.03	617.97	3.37	0.00	0.00
4/25/2002	1002.57	942.57	23.00	23	942.57	547	1425	62	0.34	76.69	77.03	567.02	3,558.04	141.17	0.78	58.53	0.00	649.93	21,983.35	617.86	3.37	0.00	0.00
4/26/2002	1559.30	1499.30	98.00	23	1424.30	547	1425	62	0.34	93.16	93.50	567.24	3,589.20	141.73	0.77	0.00	16.47	649.92	21,976.66	617.75	3.37	0.00	0.00
4/27/2002	1443.80	1383.80	98.00	23	1308.80	547	1425	62	0.34	93.16	93.50	567.46	3,620.35	142.39	0.77	0.00	16.47	649.91	21,969.98	617.65	3.37	0.00	0.00
4/28/2002	784.27	724.27	23.00	23	724.27	547	1425	62	0.34	76.69	77.03	566.63	3,502.69	140.16	0.78	58.53	0.00	649.9	21,963.31	617.54	3.37	0.00	0.00
4/29/2002	739.22	679.22	23.00	23	679.22	547	1425	62	0.34	76.69	77.03	565.78	3,385.05	137.77	0.76	58.53	0.00	649.89	21,956.63	617.44	3.37	0.00	0.00
4/30/2002	675.70	615.70	23.00	23	615.70	547	1425	62	0.34	76.69	77.03	564.92	3,267.44	135.02	0.75	58.53	0.00	649.88	21,949.95	617.33	3.37	0.00	0.00
5/1/2002	822.39	762.39	60.39	23	725.00	547	1425	62	0.38	78.61	78.98	564.57	3,219.99	133.89	0.83	23.09	0.00	649.86	21,942.44	617.12	3.79	0.00	0.00
5/2/2002	1152.73	1092.73	98.00	23	1017.73	547	1425	62	0.38	93.13	93.50	564.77	3,247.17	134.53	0.82	0.00	14.52	649.85	21,934.93	617.01	3.79	0.00	0.00
5/3/2002	1055.71	995.71	98.00	23	920.71	547	1425	62	0.38	93.13	93.50	564.97	3,274.35	135.18	0.83	0.00	14.52	649.84	21,927.42	616.91	3.79	0.00	0.00
5/4/2002	1801.86	1741.86	98.00	23	1666.86	547	1425	62	0.38	93.13	93.50	565.17	3,301.51	135.92	0.83	0.00	14.52	649.83	21,919.91	616.80	3.79	0.00	0.00
5/5/2002	1096.13	1036.13	98.00	23	961.13	547	1425	62	0.38	93.13	93.50	565.37	3,328.67	136.53	0.83	0.00	14.52	649.82	21,912.40	616.70	3.78	0.00	0.00
5/6/2002	1118.08	1058.08	98.00	23	983.08	547	1425	62	0.38	93.13	93.50	565.57	3,355.82	137.14	0.84	0.00	14.52	649.8	21,904.90	616.49	3.78	0.00	0.00
5/7/2002	1063.79	1003.79	98.00	23	928.79	547	1425	62	0.38	93.13	93.50	565.77	3,382.97	137.74	0.84	0.00	14.52	649.79	21,897.40	616.38	3.78	0.00	0.00
5/8/2002	1305.19	1245.19	98.00	23	1170.19	547	1425	62	0.38	93.13	93.50	565.97	3,410.10	138.33	0.85	0.00	14.52	649.78	21,889.90	616.28	3.78	0.00	0.00
5/9/2002	1305.19	1245.19	98.00	23	1170.19	547	1425	62	0.38	93.13	93.50	566.16	3,437.23	138.88	0.85	0.00	14.52	649.77	21,882.40	616.17	3.78	0.00	0.00
5/10/2002	1178.14	1118.14	98.00	23	1043.14	547	1425	62	0.38	93.13	93.50	566.36	3,464.36	139.44	0.85	0.00	14.52	649.75	21,874.90	615.96	3.78	0.00	0.00
5/11/2002	894.00	834.00	98.00	23	759.00	547	1425	62	0.38	93.13	93.50	566.55	3,491.47	139.95	0.86	0.00	14.52	649.74	21,867.40	615.85	3.78	0.00	0.00
5/12/2002	1066.10	1006.10	98.00	23	931.10	547	1425	62	0.38	93.13	93.50	566.74	3,518.58	140.45	0.86	0.00	14.52	649.73	21,859.91	615.74	3.78	0.00	0.00
5/13/2002	780.81	720.81	23.00	23	720.81	547	1425	62	0.38	78.61	78.98	565.87	3,396.89	138.04	0.86	60.48	0.00	649.72	21,852.41	615.64	3.78	0.00	0.00
5/14/2002	1055.71	995.71	98.00	23	920.71	547	1425	62	0.38	93.13	93.50	566.07	3,424.02	138.62	0.85	0.00	14.52	649.71	21,844.92	615.53	3.78	0.00	0.00
5/15/2002	1513.10	1453.10	98.00	23	1378.10	547	1425	62	0.38	93.13	93.50	566.26	3,451.14	139.16	0.85	0.00	14.52	649.69	21,837.43	615.32	3.78	0.00	0.00
5/16/2002	1104.22	1044.22	98.00	23	969.22	547	1425	62	0.38	93.13	93.50	566.46	3,478.26	139.71	0.85	0.00	14.52	649.68	21,829.94	615.21	3.78	0.00	0.00
5/17/2002	1101.91	1041.91	98.00	23	966.91	547	1425	62	0.38	93.13	93.50	566.65	3,505.38	140.22	0.86	0.00	14.52	649.67	21,822.46	615.10	3.77	0.00	0.00
5/18/2002	1022.21	962.21	98.00	23	887.21	547	1425	62	0.38	93.13	93.50	566.84	3,532.48	140.71	0.86	0.00	14.52	649.66	21,814.97	615.00	3.77	0.00	0.00
5/19/2002	731.14	671.14	23.00	23	671.14	547	1425	62	0.38	78.61	78.98	565.97	3,410.78	138.33	0.86	60.48	0.00	649.64	21,807.49	614.78	3.77	0.00	0.00
5/20/2002	831.63	771.63	69.63	23	725.00	547	1425	62	0.38	78.61	78.98	565.76	3,381.62	137.71	0.85	13.85	0.00	649.63	21,800.00	614.67	3.77	0.00	0.00
5/21/2002	468.95	408.95	23.00	23	408.95	547	1425	62	0.38	78.61	78.98	564.87	3,259.96	134.85	0.84	60.48	0.00	649.62	21,792.52	614.57	3.77	0.00	0.00
5/22/2002	613.33	553.33	23.00	23	553.33	547	1425	62	0.38	78.61	78.98	563.96	3,138.33	131.85	0.83	60.48	0.00	649.61	21,785.05	614.46	3.77	0.00	0.00
5/23/2002	806.22	746.22	44.22	23	725.00	547	1425	62	0.38	78.61	78.98	563.35	3,058.83	129.70	0.81	39.26	0.00	649.6	21,777.57	614.35	3.77	0.00	0.00
5/24/2002	729.98	669.98	23.00	23	669.98	547	1425	62	0.38	78.61	78.98	562.4	2,937.27	126.38	0.80	60.48	0.00	649.58	21,770.09	614.14	3.77	0.00	0.00

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

						Pond A						Pond B						Pond C					
Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)
5/25/2002	802.75	742.75	40.75	23	725.00	547	1425	62	0.38	78.61	78.98	561.71	2,850.96	124.03	0.78	42.73	0.00	649.57	21,762.62	614.03	3.77	0.00	0.00
5/26/2002	732.29	672.29	23.00	23	672.29	547	1425	62	0.38	78.61	78.98	560.72	2,729.47	120.74	0.76	60.48	0.00	649.56	21,755.14	613.92	3.77	0.00	0.00
5/27/2002	569.43	509.43	23.00	23	509.43	547	1425	62	0.38	78.61	78.98	559.7	2,608.01	117.57	0.74	60.48	0.00	649.55	21,747.67	613.81	3.77	0.00	0.00
5/28/2002	462.02	402.02	23.00	23	402.02	547	1425	62	0.38	78.61	78.98	558.65	2,486.59	114.63	0.72	60.48	0.00	649.54	21,740.20	613.70	3.77	0.00	0.00
5/29/2002	693.02	633.02	23.00	23	633.02	547	1425	62	0.38	78.61	78.98	557.58	2,365.21	111.57	0.70	60.48	0.00	649.52	21,732.74	613.49	3.77	0.00	0.00
5/30/2002	792.36	732.36	30.36	23	725.00	547	1425	62	0.38	78.61	78.98	556.61	2,258.46	108.85	0.68	53.12	0.00	649.51	21,725.27	613.38	3.76	0.00	0.00
5/31/2002	701.11	641.11	23.00	23	641.11	547	1425	62	0.38	78.61	78.98	555.48	2,137.15	105.68	0.67	60.48	0.00	649.5	21,717.81	613.27	3.76	0.00	0.00
6/1/2002	854.73	794.73	92.73	23	725.00	547	1425	62	0.42	87.81	88.23	555.6	2,150.35	106.01	0.72	0.00	7.37	649.49	21,709.52	613.16	4.18	0.00	0.00
6/2/2002	766.95	706.95	23.00	23	706.95	547	1425	62	0.42	80.44	80.86	554.4	2,025.20	102.61	0.72	62.36	0.00	649.47	21,701.24	612.95	4.17	0.00	0.00
6/3/2002	562.50	502.50	23.00	23	502.50	547	1425	62	0.42	80.44	80.86	553.17	1,900.10	99.39	0.70	62.36	0.00	649.46	21,692.97	612.84	4.17	0.00	0.00
6/4/2002	300.31	240.31	23.00	23	240.31	547	1425	62	0.42	80.44	80.86	551.89	1,775.05	96.01	0.68	62.36	0.00	649.44	21,684.69	612.62	4.17	0.00	0.00
6/5/2002	907.86	847.86	98.00	23	772.86	547	1425	62	0.42	93.08	93.50	552.13	1,798.84	96.66	0.65	0.00	12.64	649.43	21,676.42	612.51	4.17	0.00	0.00
6/6/2002	865.12	805.12	98.00	23	730.12	547	1425	62	0.42	93.08	93.50	552.38	1,822.62	97.33	0.66	0.00	12.64	649.42	21,668.15	612.40	4.17	0.00	0.00
6/7/2002	734.60	674.60	23.00	23	674.60	547	1425	62	0.42	80.44	80.86	551.07	1,697.59	93.83	0.66	62.36	0.00	649.4	21,659.88	612.19	4.17	0.00	0.00
6/8/2002	1077.65	1017.65	98.00	23	942.65	547	1425	62	0.42	93.08	93.50	551.32	1,721.41	94.48	0.64	0.00	12.64	649.39	21,651.61	612.08	4.17	0.00	0.00
6/9/2002	895.16	835.16	98.00	23	760.16	547	1425	62	0.42	93.08	93.50	551.57	1,745.22	95.12	0.64	0.00	12.64	649.38	21,643.34	611.97	4.17	0.00	0.00
6/10/2002	704.57	644.57	23.00	23	644.57	547	1425	62	0.42	80.44	80.86	550.23	1,620.22	91.53	0.65	62.36	0.00	649.36	21,635.08	611.75	4.17	0.00	0.00
6/11/2002	515.15	455.15	23.00	23	455.15	547	1425	62	0.42	80.44	80.86	548.84	1,495.27	87.09	0.62	62.36	0.00	649.35	21,626.82	611.64	4.16	0.00	0.00
6/12/2002	549.80	489.80	23.00	23	489.80	547	1425	62	0.42	80.44	80.86	547.37	1,370.38	82.75	0.59	62.36	0.00	649.34	21,618.56	611.53	4.16	0.00	0.00
6/13/2002	457.40	397.40	23.00	23	397.40	547	1425	62	0.42	80.44	80.86	545.81	1,245.55	78.13	0.56	62.36	0.00	649.32	21,610.30	611.32	4.16	0.00	0.00
6/14/2002	548.64	488.64	23.00	23	488.64	547	1425	62	0.42	80.44	80.86	544.17	1,120.78	73.71	0.53	62.36	0.00	649.31	21,602.04	611.21	4.16	0.00	0.00
6/15/2002	347.67	287.67	23.00	23	287.67	547	1425	62	0.42	80.44	80.86	542.43	996.07	69.22	0.50	62.36	0.00	649.3	21,593.79	611.10	4.16	0.00	0.00
6/16/2002	392.71	332.71	23.00	23	332.71	547	1425	62	0.42	80.44	80.86	540.56	871.42	64.39	0.47	62.36	0.00	649.28	21,585.54	610.88	4.16	0.00	0.00
6/17/2002	529.01	469.01	23.00	23	469.01	547	1425	62	0.42	80.43	80.85	540	835.45	62.89	0.44	18.13	0.00	649.13	21,489.59	609.23	4.16	44.22	0.00
6/18/2002	315.33	255.33	23.00	23	255.33	547	1425	62	0.42	80.44	80.86	539.98	834.60	62.84	0.43	0.00	0.00	648.91	21,357.68	606.80	4.15	62.36	0.00
6/19/2002	330.34	270.34	23.00	23	270.34	547	1425	62	0.42	80.44	80.86	539.97	833.75	62.81	0.43	0.00	0.00	648.69	21,225.80	604.40	4.13	62.36	0.00
6/20/2002	339.58	279.58	23.00	23	279.58	547	1425	62	0.42	80.44	80.86	539.95	832.90	62.76	0.43	0.00	0.00	648.47	21,093.95	601.99	4.11	62.36	0.00
6/21/2002	331.50	271.50	23.00	23	271.50	547	1425	62	0.42	80.44	80.86	539.94	832.06	62.73	0.43	0.00	0.00	648.25	20,962.14	599.55	4.10	62.36	0.00
6/22/2002	323.41	263.41	23.00	23	263.41	547	1425	62	0.42	80.44	80.86	539.93	831.21	62.71	0.43	0.00	0.00	648.03	20,830.36	597.06	4.08	62.36	0.00
6/23/2002	328.03	268.03	23.00	23	268.03	547	1425	62	0.42	80.44	80.86	539.91	830.36	62.65	0.43	0.00	0.00	647.81	20,698.62	594.54	4.06	62.36	0.00
6/24/2002	319.95	259.95	23.00	23	259.95	547	1425	62	0.42	80.44	80.86	539.9	829.52	62.63	0.43	0.00	0.00	647.59	20,566.90	592.00	4.05	62.36	0.00
6/25/2002	319.95	259.95	23.00	23	259.95	547	1425	62	0.42	80.44	80.86	539.89	828.67	62.60	0.43	0.00	0.00	647.37	20,435.23	589.45	4.03	62.36	0.00
6/26/2002	315.33	255.33	23.00	23	255.33	547	1425	62	0.42	80.44	80.86	539.87	827.82	62.55	0.43	0.00	0.00	647.14	20,303.58	586.81	4.01	62.36	0.00
6/27/2002	315.33	255.33	23.00	23	255.33	547	1425	62	0.42	80.44	80.86	539.86	826.98	62.52	0.43	0.00	0.00	646.92	20,171.98	584.30	4.00	62.36	0.00
6/28/2002	361.53	301.53	23.00	23	301.53	547	1425	62	0.42	80.44	80.86	539.85	826.14	62.50	0.43	0.00	0.00	646.69	20,040.40	581.70	3.98	62.36	0.00
6/29/2002	710.35	650.35	23.00	23	650.35	547	1425	62	0.42	80.44	80.86	539.83	825.29	62.44	0.43	0.00	0.00	646.47	19,908.87	579.16	3.96	62.36	0.00
6/30/2002	791.20	731.20	29.20	23	725.00	547	1425	62	0.42	80.44	80.86	539.82	824.45	62.42	0.43	0.00	0.00	646.26	19,789.66	576.76	3.94	56.16	0.00
7/1/2002	390.40	330.40	23.00	23	330.40	547	1425	62	0.42	81.49	81.90	539.81	823.60	62.39	0.43	0.00	0.00	646.03	19,656.07	574.14	3.96	63.40	0.00
7/2/2002	398.49	338.49	23.00	23	338.49	547	1425	62	0.42	81.49	81.90	539.79	822.75	62.34	0.43	0.00	0.00	645.79	19,522.51	571.39	3.94	63.40	0.00
7/3/2002	382.32	322.32	23.00	23	322.32	547	1425	62	0.42	81.49	81.90	539.78	821.90	62.31	0.43	0.00	0.00	645.56	19,388.99	568.78	3.92	63.40	0.00
7/4/2002	464.33	404.33	23.00	23	404.33	547	1425	62	0.42	81.49	81.90	539.76	821.05	62.26	0.43	0.00	0.00	645.32	19,255.50	566.06	3.90	63.40	0.00
7/5/2002	502.44	442.44	23.00	23	442.44	547	1425	62	0.42	81.49	81.90	539.75	820.21	62.23	0.43	0.00	0.00	645.09	19,122.06	563.45	3.88	63.40	0.00
7/6/2002	473.57	413.57	23.00	23	413.57	547	1425	62	0.42	81.49	81.90	539.74	819.36	62.20	0.43	0.00	0.00	644.85	18,988.64	560.69	3.87	63.40	0.00
7/7/2002	436.60	376.60	23.00	23	376.60	547	1425	62	0.42	81.49	81.90	539.72	818.51	62.15	0.43	0.00	0.00	644.61	18,855.27	557.89	3.85	63.40	0.00
7/8/2002	378.85	318.85	23.00	23	318.85	547	1425	62	0.42	81.49	81.90	539.71	817.67	62.12	0.43	0.00	0.00	644.37	18,721.93	555.11	3.83	63.40	0.00
7/9/2002	340.74	280.74	23.00	23	280.74	547	1425	62	0.42	81.49	81.90	539.7	816.82	62.10	0.43	0.00	0.00	644.13	18,588.63	552.33	3.81	63.40	0.00
7/10/2002	314.17	254.17	23.00	23	254.17	547	1425	62	0.42	81.49	81.90	539.68	815.98	62.04	0.43	0.00	0.00	643.89	18,455.37	549.51	3.79	63.40	0.00
7/11/2002	296.84	236.84	23.00	23	236.84	547	1425	62	0.42	81.49	81.90	539.67	815.13	62.02	0.43	0.00	0.00	643.65	18,322.15	546.76	3.77	63.40	0.00

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond A: Pond Elev. (ft)	Pond A: Pond Vol. (ac-ft)	Pond A: Pond Surface Area (ac)	Pond A: Pond Evap. (cfs)	Pond A: Flow Pumped Out of Pond (cfs)	Pond A: Flow Pumped In To Pond (cfs)	Pond B: Pond Elev. (ft)	Pond B: Pond Vol. (ac-ft)	Pond B: Pond Surface Area (ac)	Pond B: Pond Evap. (cfs)	Pond B: Flow Pumped Out of Pond (cfs)	Pond B: Flow Pumped In To Pond (cfs)	Pond C: Pond Elev. (ft)	Pond C: Pond Vol. (ac-ft)	Pond C: Pond Surface Area (ac)	Pond C: Pond Evap. (cfs)	Pond C: Flow Pumped Out of Pond (cfs)	Pond C: Flow Pumped In To Pond (cfs)
7/12/2002	294.53	234.53	23.00	23	234.53	547	1425	62	0.42	81.49	81.90	539.66	814.29	61.99	0.43	0.00	0.00	643.4	18,188.96	543.92	3.75	63.40	0.00
7/13/2002	322.26	262.26	23.00	23	262.26	547	1425	62	0.42	81.49	81.90	539.64	813.45	61.93	0.43	0.00	0.00	643.16	18,055.81	541.19	3.73	63.40	0.00
7/14/2002	363.84	303.84	23.00	23	303.84	547	1425	62	0.42	81.49	81.90	539.63	812.60	61.91	0.42	0.00	0.00	642.91	17,922.70	538.33	3.71	63.40	0.00
7/15/2002	317.64	257.64	23.00	23	257.64	547	1425	62	0.42	81.49	81.90	539.62	811.76	61.88	0.42	0.00	0.00	642.66	17,789.63	535.42	3.69	63.40	0.00
7/16/2002	389.25	329.25	23.00	23	329.25	547	1425	62	0.42	81.49	81.90	539.6	810.92	61.82	0.42	0.00	0.00	642.41	17,656.60	532.46	3.67	63.40	0.00
7/17/2002	435.45	375.45	23.00	23	375.45	547	1425	62	0.42	81.49	81.90	539.59	810.08	61.80	0.42	0.00	0.00	642.16	17,523.61	529.49	3.65	63.40	0.00
7/18/2002	427.36	367.36	23.00	23	367.36	547	1425	62	0.42	81.49	81.90	539.57	809.24	61.74	0.42	0.00	0.00	641.91	17,390.66	526.56	3.63	63.40	0.00
7/19/2002	351.13	291.13	23.00	23	291.13	547	1425	62	0.42	81.49	81.90	539.56	808.40	61.71	0.42	0.00	0.00	641.66	17,257.75	523.70	3.61	63.40	0.00
7/20/2002	316.48	256.48	23.00	23	256.48	547	1425	62	0.42	81.49	81.90	539.55	807.56	61.69	0.42	0.00	0.00	641.41	17,124.88	520.89	3.59	63.40	0.00
7/21/2002	303.78	243.78	23.00	23	243.78	547	1425	62	0.42	81.49	81.90	539.53	806.72	61.63	0.42	0.00	0.00	641.15	16,992.04	517.97	3.57	63.40	0.00
7/22/2002	294.53	234.53	23.00	23	234.53	547	1425	62	0.42	81.49	81.90	539.52	805.88	61.60	0.42	0.00	0.00	640.89	16,859.25	515.01	3.55	63.40	0.00
7/23/2002	282.98	222.98	23.00	23	222.98	547	1425	62	0.42	81.49	81.90	539.51	805.04	61.58	0.42	0.00	0.00	640.63	16,726.50	512.05	3.53	63.40	0.00
7/24/2002	279.52	219.52	23.00	23	219.52	547	1425	62	0.42	81.49	81.90	539.49	804.20	61.52	0.42	0.00	0.00	640.37	16,593.78	509.02	3.51	63.40	0.00
7/25/2002	294.53	234.53	23.00	23	234.53	547	1425	62	0.42	81.49	81.90	539.48	803.37	61.50	0.42	0.00	0.00	640.11	16,461.11	505.91	3.49	63.40	0.00
7/26/2002	317.64	257.64	23.00	23	257.64	547	1425	62	0.42	81.49	81.90	539.47	802.53	61.47	0.42	0.00	0.00	639.85	16,328.48	502.84	3.47	63.40	0.00
7/27/2002	337.27	277.27	23.00	23	277.27	547	1425	62	0.42	81.49	81.90	539.45	801.69	61.41	0.42	0.00	0.00	639.59	16,195.89	499.75	3.45	63.40	0.00
7/28/2002	354.60	294.60	23.00	23	294.60	547	1425	62	0.42	81.49	81.90	539.44	800.86	61.39	0.42	0.00	0.00	639.32	16,063.35	496.58	3.43	63.40	0.00
7/29/2002	339.58	279.58	23.00	23	279.58	547	1425	62	0.42	81.49	81.90	539.42	800.02	61.33	0.42	0.00	0.00	639.05	15,930.84	493.48	3.41	63.40	0.00
7/30/2002	325.72	265.72	23.00	23	265.72	547	1425	62	0.42	81.49	81.90	539.41	799.19	61.30	0.42	0.00	0.00	638.78	15,798.38	490.41	3.39	63.40	0.00
7/31/2002	314.17	254.17	23.00	23	254.17	547	1425	62	0.42	81.49	81.90	539.4	798.35	61.27	0.42	0.00	0.00	638.51	15,665.96	487.34	3.36	63.40	0.00
8/1/2002	308.40	248.40	23.00	23	248.40	547	1425	62	0.39	80.83	81.20	539.39	797.59	61.24	0.38	0.00	0.00	638.24	15,535.53	484.32	3.06	62.70	0.00
8/2/2002	284.14	224.14	23.00	23	224.14	547	1425	62	0.39	80.83	81.20	539.37	796.83	61.18	0.38	0.00	0.00	637.97	15,405.14	481.36	3.04	62.70	0.00
8/3/2002	271.43	211.43	23.00	23	211.43	547	1425	62	0.39	80.83	81.20	539.36	796.07	61.15	0.38	0.00	0.00	637.7	15,274.79	478.45	3.02	62.70	0.00
8/4/2002	241.40	181.40	23.00	23	181.40	547	1425	62	0.39	80.83	81.20	539.35	795.30	61.12	0.38	0.00	0.00	637.43	15,144.47	475.53	3.00	62.70	0.00
8/5/2002	213.68	153.68	23.00	23	153.68	547	1425	62	0.39	80.83	81.20	539.34	794.54	61.09	0.38	0.00	0.00	637.15	15,014.19	472.54	2.98	62.70	0.00
8/6/2002	192.89	132.89	23.00	23	132.89	547	1425	62	0.39	80.83	81.20	539.32	793.78	61.03	0.38	0.00	0.00	636.88	14,883.95	469.71	2.97	62.70	0.00
8/7/2002	191.74	131.74	23.00	23	131.74	547	1425	62	0.39	80.83	81.20	539.31	793.02	61.00	0.38	0.00	0.00	636.6	14,753.74	466.77	2.95	62.70	0.00
8/8/2002	192.89	132.89	23.00	23	132.89	547	1425	62	0.39	80.83	81.20	539.3	792.26	60.97	0.38	0.00	0.00	636.32	14,623.57	463.84	2.93	62.70	0.00
8/9/2002	152.47	92.47	23.00	23	92.47	547	1425	62	0.39	80.83	81.20	539.29	791.51	60.94	0.38	0.00	0.00	636.04	14,493.43	460.93	2.91	62.70	0.00
8/10/2002	110.88	50.88	23.00	23	50.88	547	1425	62	0.39	80.83	81.20	539.27	790.75	60.89	0.38	0.00	0.00	635.75	14,363.33	457.92	2.89	62.70	0.00
8/11/2002	73.92	13.92	23.00	23	13.92	547	1425	62	0.39	80.83	81.20	539.26	789.99	60.86	0.38	0.00	0.00	635.47	14,233.27	455.06	2.87	62.70	0.00
8/12/2002	47.36	-12.64	23.00	23	-12.64	547	1425	62	0.39	80.83	81.20	539.25	789.23	60.83	0.38	0.00	0.00	635.18	14,103.24	452.11	2.86	62.70	0.00
8/13/2002	94.71	34.71	23.00	23	34.71	547	1425	62	0.39	80.83	81.20	539.24	788.47	60.81	0.38	0.00	0.00	634.89	13,973.25	449.17	2.84	62.70	0.00
8/14/2002	102.80	42.80	23.00	23	42.80	547	1425	62	0.39	80.83	81.20	539.22	787.72	60.75	0.38	0.00	0.00	634.6	13,843.30	446.23	2.82	62.70	0.00
8/15/2002	147.84	87.84	23.00	23	87.84	547	1425	62	0.39	80.83	81.20	539.21	786.96	60.73	0.38	0.00	0.00	634.31	13,713.39	443.30	2.80	62.70	0.00
8/16/2002	212.53	152.53	23.00	23	152.53	547	1425	62	0.39	80.83	81.20	539.2	786.20	60.70	0.38	0.00	0.00	634.02	13,583.51	440.38	2.78	62.70	0.00
8/17/2002	211.37	151.37	23.00	23	151.37	547	1425	62	0.39	80.83	81.20	539.19	785.45	60.67	0.38	0.00	0.00	633.72	13,453.66	437.40	2.76	62.70	0.00
8/18/2002	244.87	184.87	23.00	23	184.87	547	1425	62	0.39	80.83	81.20	539.17	784.69	60.62	0.38	0.00	0.00	633.43	13,323.86	434.55	2.75	62.70	0.00
8/19/2002	273.74	213.74	23.00	23	213.74	547	1425	62	0.39	80.83	81.20	539.16	783.94	60.59	0.38	0.00	0.00	633.13	13,194.08	431.63	2.73	62.70	0.00
8/20/2002	418.12	358.12	23.00	23	358.12	547	1425	62	0.39	80.83	81.20	539.15	783.18	60.57	0.38	0.00	0.00	632.82	13,064.35	428.61	2.71	62.70	0.00
8/21/2002	274.90	214.90	23.00	23	214.90	547	1425	62	0.39	80.83	81.20	539.14	782.43	60.54	0.38	0.00	0.00	632.52	12,934.65	425.73	2.69	62.70	0.00
8/22/2002	262.19	202.19	23.00	23	202.19	547	1425	62	0.39	80.83	81.20	539.12	781.68	60.49	0.38	0.00	0.00	632.21	12,804.99	422.71	2.67	62.70	0.00
8/23/2002	243.71	183.71	23.00	23	183.71	547	1425	62	0.39	80.83	81.20	539.11	780.92	60.46	0.38	0.00	0.00	631.91	12,675.37	419.83	2.65	62.70	0.00
8/24/2002	213.68	153.68	23.00	23	153.68	547	1425	62	0.39	80.83	81.20	539.1	780.17	60.43	0.38	0.00	0.00	631.6	12,545.78	416.88	2.64	62.70	0.00
8/25/2002	190.58	130.58	23.00	23	130.58	547	1425	62	0.39	80.83	81.20	539.09	779.42	60.41	0.38	0.00	0.00	631.29	12,416.23	413.90	2.62	62.70	0.00
8/26/2002	177.88	117.88	23.00	23	117.88	547	1425	62	0.39	80.83	81.20	539.07	778.67	60.35	0.38	0.00	0.00	630.97	12,286.72	410.81	2.60	62.70	0.00
8/27/2002	210.22	150.22	23.00	23	150.22	547	1425	62	0.39	80.83	81.20	539.06	777.91	60.33	0.38	0.00	0.00	630.66	12,157.24	407.84	2.58	62.70	0.00
8/28/2002	215.99	155.99	23.00	23	155.99	547	1425	62	0.39	80.83	81.20	539.05	777.16	60.30	0.38	0.00	0.00	630.34	12,027.80	404.76	2.56	62.70	0.00

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond A: Pond Elev. (ft)	Pond A: Pond Vol. (ac-ft)	Pond A: Pond Surface Area (ac)	Pond A: Pond Evap. (cfs)	Pond A: Flow Pumped Out of Pond (cfs)	Pond A: Flow Pumped In To Pond (cfs)	Pond B: Pond Elev. (ft)	Pond B: Pond Vol. (ac-ft)	Pond B: Pond Surface Area (ac)	Pond B: Pond Evap. (cfs)	Pond B: Flow Pumped Out of Pond (cfs)	Pond B: Flow Pumped In To Pond (cfs)	Pond C: Pond Elev. (ft)	Pond C: Pond Vol. (ac-ft)	Pond C: Pond Surface Area (ac)	Pond C: Pond Evap. (cfs)	Pond C: Flow Pumped Out of Pond (cfs)	Pond C: Flow Pumped In To Pond (cfs)
8/29/2002	287.60	227.60	23.00	23	227.60	547	1425	62	0.39	80.83	81.20	539.04	776.41	60.27	0.38	0.00	0.00	630.02	11,898.40	401.70	2.54	62.70	0.00
8/30/2002	197.51	137.51	23.00	23	137.51	547	1425	62	0.39	80.83	81.20	539.02	775.66	60.22	0.38	0.00	0.00	629.69	11,769.04	398.56	2.52	62.70	0.00
8/31/2002	202.13	142.13	23.00	23	142.13	547	1425	62	0.39	80.83	81.20	539.01	774.91	60.19	0.38	0.00	0.00	629.37	11,639.72	395.60	2.50	62.70	0.00
9/1/2002	210.22	150.22	23.00	23	150.22	547	1425	62	0.3	78.95	79.24	539	774.33	60.16	0.29	0.00	0.00	629.05	11,515.42	392.64	1.92	60.74	0.00
9/2/2002	210.22	150.22	23.00	23	150.22	547	1425	62	0.3	78.95	79.24	538.99	773.75	60.14	0.29	0.00	0.00	628.73	11,391.14	389.56	1.91	60.74	0.00
9/3/2002	214.84	154.84	23.00	23	154.84	547	1425	62	0.3	78.95	79.24	538.98	773.17	60.11	0.29	0.00	0.00	628.41	11,266.90	386.58	1.89	60.74	0.00
9/4/2002	339.58	279.58	23.00	23	279.58	547	1425	62	0.3	78.95	79.24	538.97	772.59	60.08	0.29	0.00	0.00	628.09	11,142.69	383.62	1.88	60.74	0.00
9/5/2002	118.97	58.97	23.00	23	58.97	547	1425	62	0.3	78.95	79.24	538.96	772.01	60.05	0.29	0.00	0.00	627.77	11,018.50	379.82	1.87	60.74	0.00
9/6/2002	143.22	83.22	23.00	23	83.22	547	1425	62	0.3	78.95	79.24	538.95	771.43	60.02	0.29	0.00	0.00	627.44	10,894.36	376.63	1.85	60.74	0.00
9/7/2002	145.53	85.53	23.00	23	85.53	547	1425	62	0.3	78.95	79.24	538.94	770.85	60.00	0.29	0.00	0.00	627.11	10,770.24	373.49	1.83	60.74	0.00
9/8/2002	140.91	80.91	23.00	23	80.91	547	1425	62	0.3	78.95	79.24	538.93	770.27	59.97	0.29	0.00	0.00	626.77	10,646.15	370.27	1.82	60.74	0.00
9/9/2002	166.33	106.33	23.00	23	106.33	547	1425	62	0.3	78.95	79.24	538.92	769.70	59.94	0.29	0.00	0.00	626.44	10,522.09	367.15	1.80	60.74	0.00
9/10/2002	168.64	108.64	23.00	23	108.64	547	1425	62	0.3	78.95	79.24	538.92	769.12	59.94	0.29	0.00	0.00	626.1	10,398.07	364.02	1.79	60.74	0.00
9/11/2002	144.38	84.38	23.00	23	84.38	547	1425	62	0.3	78.95	79.24	538.91	768.54	59.91	0.29	0.00	0.00	625.75	10,274.07	360.86	1.77	60.74	0.00
9/12/2002	127.05	67.05	23.00	23	67.05	547	1425	62	0.3	78.95	79.24	538.9	767.96	59.88	0.29	0.00	0.00	625.41	10,150.11	357.85	1.75	60.74	0.00
9/13/2002	114.35	54.35	23.00	23	54.35	547	1425	62	0.3	78.95	79.24	538.89	767.38	59.85	0.29	0.00	0.00	625.06	10,026.17	354.80	1.74	60.74	0.00
9/14/2002	113.19	53.19	23.00	23	53.19	547	1425	62	0.3	78.95	79.24	538.88	766.81	59.82	0.29	0.00	0.00	624.71	9,902.26	351.74	1.73	60.74	0.00
9/15/2002	161.71	101.71	23.00	23	101.71	547	1425	62	0.3	78.95	79.24	538.87	766.23	59.79	0.29	0.00	0.00	624.36	9,778.39	348.66	1.71	60.74	0.00
9/16/2002	720.74	660.74	200.74	23	483.00	547	1425	62	0.3	195.95	196.24	542.45	997.78	69.27	0.29	0.00	117.00	624.35	9,775.02	348.57	1.70	0.00	0.00
9/17/2002	1009.50	949.50	298.00	23	674.50	547	1425	62	0.3	293.21	293.50	547.99	1,422.20	84.59	0.34	0.00	214.26	624.34	9,771.66	348.48	1.70	0.00	0.00
9/18/2002	745.00	685.00	225.00	23	483.00	547	1425	62	0.3	220.21	220.50	551.11	1,701.64	93.93	0.41	0.00	141.26	624.33	9,768.30	348.39	1.69	0.00	0.00
9/19/2002	507.06	447.06	23.00	23	447.06	547	1425	62	0.3	78.95	79.24	551.1	1,700.73	93.91	0.46	0.00	0.00	623.97	9,644.45	345.26	1.69	60.74	0.00
9/20/2002	561.35	501.35	41.35	23	483.00	547	1425	62	0.3	78.95	79.24	551.09	1,699.82	93.88	0.46	0.00	0.00	623.72	9,557.03	343.07	1.68	42.40	0.00
9/21/2002	568.28	508.28	48.28	23	483.00	547	1425	62	0.3	78.95	79.24	551.08	1,698.92	93.86	0.46	0.00	0.00	623.5	9,483.38	341.17	1.67	35.46	0.00
9/22/2002	656.06	596.06	136.06	23	483.00	547	1425	62	0.3	131.27	131.56	552.16	1,801.81	96.74	0.46	0.00	52.32	623.49	9,480.09	341.08	1.66	0.00	0.00
9/23/2002	510.53	450.53	23.00	23	450.53	547	1425	62	0.3	78.95	79.24	552.15	1,800.88	96.72	0.47	0.00	0.00	623.13	9,356.31	338.00	1.66	60.74	0.00
9/24/2002	381.16	321.16	23.00	23	321.16	547	1425	62	0.3	78.95	79.24	552.14	1,799.95	96.69	0.47	0.00	0.00	622.76	9,232.57	334.81	1.64	60.74	0.00
9/25/2002	225.23	165.23	23.00	23	165.23	547	1425	62	0.3	78.95	79.24	552.13	1,799.02	96.66	0.47	0.00	0.00	622.39	9,108.85	331.59	1.63	60.74	0.00
9/26/2002	889.38	829.38	298.00	23	554.38	547	1425	62	0.3	293.21	293.50	556.28	2,223.17	107.89	0.47	0.00	214.26	622.38	9,105.66	331.51	1.61	0.00	0.00
9/27/2002	1998.22	1938.22	298.00	23	1663.22	547	1425	62	0.3	293.21	293.50	560.03	2,647.21	118.55	0.52	0.00	214.26	622.37	9,102.46	331.42	1.61	0.00	0.00
9/28/2002	2818.29	2758.29	298.00	23	2483.29	547	1425	62	0.3	293.21	293.50	563.44	3,071.15	130.03	0.58	0.00	214.26	622.36	9,099.26	331.33	1.61	0.00	0.00
9/29/2002	2009.77	1949.77	298.00	23	1674.77	547	1425	62	0.3	293.21	293.50	566.58	3,494.98	140.03	0.63	0.00	214.26	622.35	9,096.06	331.24	1.61	0.00	0.00
9/30/2002	1305.19	1245.19	298.00	23	970.19	547	1425	62	0.3	293.21	293.50	569.51	3,918.72	148.84	0.68	0.00	214.26	622.34	9,092.87	331.16	1.61	0.00	0.00
10/1/2002	1224.34	1164.34	298.00	23	889.34	547	1425	62	0.22	293.28	293.50	569.99	3,989.82	151.33	0.53	0.00	36.37	623.4	9,449.65	340.31	1.18	0.00	181.06
10/2/2002	913.64	853.64	281.14	23	595.49	547	1425	62	0.22	276.42	276.64	569.99	3,989.78	151.33	0.54	0.00	0.52	624.55	9,843.93	350.32	1.22	0.00	200.00
10/3/2002	972.54	912.54	281.16	23	654.38	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	625.66	10,238.14	360.05	1.25	0.00	200.00
10/4/2002	538.25	478.25	23.00	23	478.25	547	1425	62	0.22	75.90	76.12	569.22	3,874.39	147.79	0.54	57.62	0.00	625.65	10,235.59	359.96	1.29	0.00	0.00
10/5/2002	613.33	553.33	93.33	23	483.00	547	1425	62	0.22	88.61	88.83	569.38	3,898.55	148.36	0.53	0.00	12.70	625.64	10,233.04	359.88	1.29	0.00	0.00
10/6/2002	594.84	534.84	74.84	23	483.00	547	1425	62	0.22	75.90	76.12	569.29	3,886.04	148.04	0.53	5.78	0.00	625.63	10,230.49	359.79	1.29	0.00	0.00
10/7/2002	720.74	660.74	200.74	23	483.00	547	1425	62	0.22	196.02	196.24	569.99	3,989.84	151.33	0.53	0.00	52.84	626	10,361.43	363.12	1.28	0.00	67.30
10/8/2002	462.02	402.02	23.00	23	402.02	547	1425	62	0.22	75.90	76.12	569.22	3,874.45	147.79	0.54	57.62	0.00	625.99	10,358.86	363.03	1.30	0.00	0.00
10/9/2002	182.50	122.50	23.00	23	122.50	547	1425	62	0.22	75.90	76.12	568.43	3,759.08	145.26	0.53	57.62	0.00	625.98	10,356.29	362.93	1.30	0.00	0.00
10/10/2002	254.11	194.11	23.00	23	194.11	547	1425	62	0.22	75.90	76.12	567.63	3,643.73	142.94	0.52	57.62	0.00	625.98	10,353.71	362.93	1.30	0.00	0.00
10/11/2002	816.61	756.61	296.61	23	483.00	547	1425	62	0.22	291.89	292.11	569.99	3,989.94	151.33	0.51	0.00	175.01	626.19	10,432.45	364.85	1.30	0.00	40.99
10/12/2002	769.26	709.26	249.26	23	483.00	547	1425	62	0.22	244.54	244.76	569.99	3,989.78	151.33	0.54	0.00	0.46	627.09	10,763.52	373.30	1.30	0.00	168.22
10/13/2002	701.11	641.11	181.11	23	483.00	547	1425	62	0.22	176.39	176.61	569.99	3,989.78	151.33	0.54	0.00	0.54	627.61	10,959.17	378.30	1.33	0.00	99.97
10/14/2002	594.84	534.84	74.84	23	483.00	547	1425	62	0.22	75.90	76.12	569.9	3,977.25	150.61	0.54	5.78	0.00	627.6	10,956.49	378.20	1.35	0.00	0.00
10/15/2002	727.67	667.67	207.67	23	483.00	547	1425	62	0.22	202.95	203.17	569.99	3,989.79	151.33	0.54	0.00	6.86	628.22	11,192.28	384.83	1.35	0.00	120.23

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

						Pond A						Pond B						Pond C					
Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)
10/16/2002	3823.18	3763.18	281.16	23	3505.02	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	629.23	11,586.25	394.30	1.37	0.00	200.00
10/17/2002	3730.78	3670.78	281.16	23	3412.61	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	630.22	11,980.15	403.61	1.41	0.00	200.00
10/18/2002	2171.47	2111.47	281.16	23	1853.31	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	631.18	12,373.99	412.83	1.44	0.00	200.00
10/19/2002	1755.66	1695.66	281.16	23	1437.50	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	632.13	12,767.76	421.94	1.47	0.00	200.00
10/20/2002	1038.38	978.38	281.16	23	720.22	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	633.05	13,161.46	430.86	1.51	0.00	200.00
10/21/2002	810.84	750.84	281.16	23	492.67	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	633.95	13,555.10	439.68	1.54	0.00	200.00
10/22/2002	977.16	917.16	281.16	23	659.00	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	634.84	13,948.68	448.66	1.57	0.00	200.00
10/23/2002	1098.44	1038.44	281.16	23	780.28	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	635.71	14,342.20	457.51	1.60	0.00	200.00
10/24/2002	743.84	683.84	223.84	23	483.00	547	1425	62	0.22	219.12	219.34	569.99	3,989.78	151.33	0.54	0.00	0.54	636.32	14,622.04	463.84	1.63	0.00	142.72
10/25/2002	868.59	808.59	281.16	23	550.43	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	637.16	15,015.45	472.65	1.66	0.00	200.00
10/26/2002	1123.85	1063.85	281.16	23	805.69	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	637.98	15,408.80	481.46	1.69	0.00	200.00
10/27/2002	930.96	870.96	281.16	23	612.80	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	638.79	15,802.08	490.52	1.72	0.00	200.00
10/28/2002	770.41	710.41	250.41	23	483.00	547	1425	62	0.22	245.69	245.91	569.99	3,989.78	151.33	0.54	0.00	0.54	639.46	16,134.40	498.22	1.75	0.00	169.29
10/29/2002	1432.25	1372.25	281.16	23	1114.09	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	640.24	16,527.57	507.46	1.78	0.00	200.00
10/30/2002	1605.50	1545.50	281.16	23	1287.34	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	641.01	16,920.67	516.38	1.81	0.00	200.00
10/31/2002	1166.59	1106.59	281.16	23	848.43	547	1425	62	0.22	276.44	276.66	569.99	3,989.78	151.33	0.54	0.00	0.54	641.77	17,313.70	524.94	1.84	0.00	200.00
11/1/2002	1166.59	1106.59	278.28	23	851.30	547	1425	62	0.15	273.62	273.78	569.99	3,990.13	151.33	0.36	0.00	0.54	642.51	17,707.89	533.65	1.27	0.00	200.00
11/2/2002	1282.09	1222.09	278.11	23	966.98	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	643.24	18,102.03	542.10	1.29	0.00	200.00
11/3/2002	735.76	675.76	215.76	23	483.00	547	1425	62	0.15	211.10	211.26	569.99	3,990.13	151.33	0.36	0.00	0.36	643.74	18,372.54	547.79	1.31	0.00	137.69
11/4/2002	880.14	820.14	278.11	23	565.03	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	644.45	18,766.62	556.04	1.32	0.00	200.00
11/5/2002	719.59	659.59	199.59	23	483.00	547	1425	62	0.15	194.93	195.09	569.99	3,990.13	151.33	0.36	0.00	0.36	644.88	19,004.98	561.04	1.34	0.00	121.51
11/6/2002	1420.70	1360.70	278.11	23	1105.59	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	645.58	19,398.99	569.01	1.35	0.00	200.00
11/7/2002	1293.64	1233.64	278.11	23	978.53	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	646.27	19,792.96	576.88	1.37	0.00	200.00
11/8/2002	1077.65	1017.65	278.11	23	762.54	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	646.94	20,186.90	584.53	1.39	0.00	200.00
11/9/2002	1201.24	1141.24	278.11	23	886.13	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	647.61	20,580.80	592.23	1.41	0.00	200.00
11/10/2002	1029.14	969.14	278.11	23	714.03	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	648.27	20,974.66	599.77	1.43	0.00	200.00
11/11/2002	1001.42	941.42	278.11	23	686.31	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	648.93	21,368.49	607.03	1.45	0.00	200.00
11/12/2002	3211.01	3151.01	278.11	23	2895.90	547	1425	62	0.15	273.45	273.61	569.99	3,990.13	151.33	0.36	0.00	0.36	649.57	21,762.28	614.03	1.46	0.00	200.00
11/13/2002	3338.06	3278.06	209.78	23	3091.28	547	1425	62	0.15	205.12	205.28	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.52	618.50	1.48	0.00	131.67
11/14/2002	2668.14	2608.14	79.59	23	2551.55	547	1425	62	0.15	74.93	75.09	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.48
11/15/2002	2113.72	2053.72	79.60	23	1997.12	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/16/2002	2541.09	2481.09	79.60	23	2424.49	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/17/2002	4539.30	4479.30	79.60	23	4422.70	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/18/2002	3811.63	3751.63	79.60	23	3695.03	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/19/2002	2783.64	2723.64	79.60	23	2667.04	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/20/2002	2183.02	2123.02	79.60	23	2066.42	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/21/2002	1721.01	1661.01	79.60	23	1604.41	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/22/2002	1824.96	1764.96	79.60	23	1708.36	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/23/2002	1790.31	1730.31	79.60	23	1673.71	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/24/2002	1084.58	1024.58	79.60	23	967.98	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/25/2002	1111.15	1051.15	79.60	23	994.55	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/26/2002	1374.50	1314.50	79.60	23	1257.90	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/27/2002	1640.16	1580.16	79.60	23	1523.56	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/28/2002	1374.50	1314.50	79.60	23	1257.90	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/29/2002	1018.74	958.74	79.60	23	902.15	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
11/30/2002	1247.44	1187.44	79.60	23	1130.84	547	1425	62	0.15	74.94	75.10	569.99	3,990.13	151.33	0.36	0.00	0.36	649.99	22,020.50	618.50	1.49	0.00	1.49
12/1/2002	1049.93	989.93	76.87	23	936.06	547	1425	62	0.1	72.26	72.37	569.99	3,990.35	151.33	0.26	0.00	0.36	649.99	22,021.37	618.50	1.05	0.00	1.49
12/2/2002	839.71	779.71	76.33	23	726.39	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05

Table 19

Water Model Results Using 100% Wet Cooling Towers for Year 2002 Based on 98 cfs and Considering Hypothetical Constraints Associated with FERC Seasonal Flow Release Limits from Ninety-Nine Islands Dam

Date	2002 Broad River flow At Lee Nuclear Site (cfs)	2002 Broad River Flow At Lee Nuclear Site Less 60 cfs For Future Upstream Demand (cfs)	Lee Nuclear Plant Withdrawal From Broad River (cfs)	Lee Nuclear Plant Discharge To Broad River (cfs)	2002 Broad River Flow At Ninety Nine Islands Dam (cfs)	Pond A						Pond B						Pond C					
						Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To (cfs)	Pond Elev. (ft)	Pond Vol. (ac-ft)	Pond Surface Area (ac)	Pond Evap. (cfs)	Flow Pumped Out of Pond (cfs)	Flow Pumped In To Pond (cfs)
12/3/2002	974.85	914.85	76.33	23	861.53	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/4/2002	1247.44	1187.44	76.33	23	1134.12	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/5/2002	2517.98	2457.98	76.33	23	2404.66	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/6/2002	3372.71	3312.71	76.33	23	3259.39	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/7/2002	2679.69	2619.69	76.33	23	2566.36	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/8/2002	2079.07	2019.07	76.33	23	1965.74	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/9/2002	1975.12	1915.12	76.33	23	1861.79	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/10/2002	1686.36	1626.36	76.33	23	1573.03	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/11/2002	2564.19	2504.19	76.33	23	2450.86	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/12/2002	3661.47	3601.47	76.33	23	3548.15	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/13/2002	3904.03	3844.03	76.33	23	3790.70	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/14/2002	6075.50	6015.50	76.33	23	5962.18	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/15/2002	3938.68	3878.68	76.33	23	3825.36	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/16/2002	2991.55	2931.55	76.33	23	2878.22	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/17/2002	2541.09	2481.09	76.33	23	2427.76	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/18/2002	2206.12	2146.12	76.33	23	2092.80	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/19/2002	2240.78	2180.78	76.33	23	2127.45	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/20/2002	3026.20	2966.20	76.33	23	2912.87	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/21/2002	3673.02	3613.02	76.33	23	3559.70	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/22/2002	2772.09	2712.09	76.33	23	2658.77	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/23/2002	2414.03	2354.03	76.33	23	2300.70	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/24/2002	5532.64	5472.64	76.33	23	5419.31	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/25/2002	10349.15	10289.15	76.33	23	10235.82	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/26/2002	5266.98	5206.98	76.33	23	5153.65	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/27/2002	3938.68	3878.68	76.33	23	3825.36	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/28/2002	3511.32	3451.32	76.33	23	3397.99	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/29/2002	2887.60	2827.60	76.33	23	2774.27	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/30/2002	2725.89	2665.89	76.33	23	2612.56	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05
12/31/2002	2829.84	2769.84	76.33	23	2716.52	547	1425	62	0.1	71.72	71.83	569.99	3,990.35	151.33	0.26	0.00	0.26	649.99	22,021.37	618.50	1.05	0.00	1.05

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letter Dated: June 22, 2010

Reference NRC RAI Number: ER RAI 128 Supplement, Alternatives

NRC RAI:

Provide details of the quantitative analyses used to evaluate hybrid wet-dry tower options for cooling of the proposed Lee Nuclear Plant during periods of low river flow. Include alternatives considered for cooling water sources and cooling system technologies. Include in the metrics of the analyses foregone net power due to parasitic energy losses, reduced generation efficiency, and frequency of outages due to loss of water supply.

NRC June 2 and 3, 2011 Audit - Request for Supplemental Information:

During the June 2 and 3, 2011 NRC audit, the NRC Staff requested that Duke Energy provide the following supplemental information:

- Present the water balance model/results for the most recent 10 year period of flow data for the Broad River (2001 through 2010)
- Present the water balance model/results based on the hypothetical condition that the seasonal flow release limits in the Federal Energy Regulatory Commission (FERC) license for the Ninety-Nine Islands Dam would apply as constraints on Lee Nuclear Station withdrawals (bounding evaluation)

Duke Energy Response:

Duke Energy is supplementing the previous response to this RAI based on the request for supplemental information identified above. Previous evaluations of hybrid (wet-dry) cooling towers as the heat dissipation system for Lee Nuclear Station also have been updated based on the changes noted below.

Several parameters associated with the water balance model used to determine the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts (sizing of Make-Up Pond C) were recently updated. First, the daily evaporation rates for Make-Up Ponds A, B and C were updated to consider average pan evaporation values from Clemson, South Carolina from July 1948 through 2010. Updated evaporation data tables are provided in the supplemental response to ER RAI 216 (Enclosure 2 to this letter). In addition, the design margin applied to account for uncertainty in the length/severity of future droughts was reduced slightly from the 25% margin applied in the initial sizing of Make-Up Pond C to a margin of 20 days of consumptive water storage so that a consistent margin was applied to each of the energy alternatives evaluated (nuclear with wet cooling towers, nuclear with hybrid cooling towers and natural gas combined cycle with wet cooling towers).

Because the Proportional Flow Limitation (5% mean annual flow) in regulations implementing Section 316(b) of the Federal Water Pollution Control Act (CWA) is susceptible to differing

interpretations, Duke Energy has evaluated two values using the water balance model. First, a Proportional Flow Limitation (5% mean annual flow) of 125 cfs was applied in the water balance model, derived from the full period of record (1926 through 2010) for the Broad River at the Gaffney Station (No. 02153500). Second, a Proportional Flow Limitation (5% mean annual flow) of 98 cfs was applied in the water balance model, derived from the most recent 10 years (2001 through 2010) for the Broad River at the Gaffney Station. In comparing these two cases (98 cfs versus 125 cfs), very little difference is seen in the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts as reflected in the water balance model results summarized below.

The minimum flow release requirement of 483 cfs from the Ninety-Nine Islands Dam per its FERC License is described in more detail below. The majority of the water balance model evaluations that were performed apply this minimum flow release requirement. The seasonal flow release requirements from the Ninety-Nine Islands Dam per its FERC license are also described below. A hypothetical bounding evaluation of the water balance model, postulating constraints based on these seasonal flow release requirements, would result in an increase in the volume of supplemental water required to support operations of Lee Nuclear Station through significant droughts (results summarized below). Rather than postulating a larger Make-Up Pond C to support this increase in volume of required supplemental water, the volume and depth of the water layer preserved to protect the thermocline is reduced for the purposes of this evaluation. Duke Energy believes that reducing this water layer would result in less overall environmental impacts than increasing the size of Make-Up Pond C.

Different scenarios or cases of the water balance model were evaluated considering different energy alternatives, proportional flow limitations (125 cfs and 98 cfs) and flow release constraints for the Ninety-Nine Islands Dam (483 cfs and seasonal). Several sensitivity evaluations were also performed to justify the margins applied in sizing of Make-Up Pond C. The results of these different cases are presented in ER RAI supplemental responses as summarized below.

Description	**Case(s)**	**ER RAI Supplemental Response (Enclosure to Ltr. WLG2011.07-04)**
Energy Alternatives		
Nuclear with wet cooling towers	1 through 3	206 (Enclosure 1)
Nuclear with hybrid cooling towers	4 through 6	128 (Enclosure 3)
Natural gas combined cycle	7 through 9	48/114/123 (Enclosure 4)
Sensitivity Evaluations		
Combined worst evaporation	10	206 (Enclosure 1)
Synthetic drought	11 through 12	206 (Enclosure 1)

Data input tables and results are provided in the supplemental response to ER RAI 216 (ER RAI 216 Supplement, Enclosure 2 to this letter).

Make-Up Pond C Sizing Based on Hybrid (Wet-Dry) Cooling and 5% of Mean Annual Flow of 125 cfs (Case 4)

Water balance model results based on Hybrid Cooling and a 5% mean annual flow of 125 cfs considering the entire 85 year period of record (1926-2010) are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 4. A 20-ft layer is preserved to protect the thermocline while maintaining the full pond elevation of Make-Up Pond C at 630 ft msl (same depth of layer was used in the initial sizing of Make-Up Pond C with Hybrid Cooling). This layer will be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	2,804 ac-ft	
• 20 days usable storage as margin (worse future droughts)	2,500 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	5,451 ac-ft	610 ft
• Volume and depth to protect thermocline	6,439 ac-ft	20 ft
• Full pond volume and elevation	11,890 ac-ft	630 ft

Additional details for Case 4 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Make-Up Pond C Sizing Based on Hybrid (Wet-Dry) Cooling and 5% of Mean Annual Flow of 98 cfs (Case 5)

Water balance model results based on Hybrid Cooling and a 5% mean annual flow of 98 cfs considering the most recent 10 years (2001-2010) are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 5. A 20-ft layer is preserved to protect the thermocline while maintaining the full pond elevation of Make-Up Pond C at 630 ft msl (same depth of layer was used in the initial sizing of Make-Up Pond C with Hybrid Cooling). This layer will be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	2,927 ac-ft	
• 20 days usable storage as margin (worse future droughts)	2,500 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	5,574 ac-ft	610 ft
• Volume and depth to protect thermocline	6,316 ac-ft	20 ft
• Full pond volume and elevation	11,890 ac-ft	630 ft

Additional details for Case 5 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Sensitivity of Make-Up Pond C Sizing to Proportional Flow Limitation

A usable volume of 2,804 ac-ft is required in Make-Up Pond C to support station operations considering Hybrid Cooling and a Proportional Flow Limitation of 125 cfs based on the full period of record (1926-2010) as identified in Case 4. A usable volume of 2,927 ac-ft is required considering Hybrid Cooling and a Proportional Flow Limitation of 98 cfs based on the most recent 10 years as the period of record (2001-2010) as identified in Case 5. A negligible difference of only 123 ac-ft (volume of consumptive water required to support approximately one day of station operations) results, with application of a Proportional Flow Limitation of 98 cfs yielding a slightly larger volume of supplemental water being required to support station operations.

Seasonal Flow Release Limits in FERC License from Ninety-Nine Islands Dam

During the June 2 and 3, 2011 audit, the NRC Staff requested that Duke Energy perform a bounding analysis and provide water balance model results with the withdrawal threshold from the Ninety-Nine Islands Reservoir based on the hypothetical condition that the seasonal flow release limits in the FERC license from Ninety-Nine Islands Dam would apply as constraints on Lee withdrawals. This bounding evaluation has been performed and the results are presented below as Case 6. Importantly, Duke Energy's FERC license for Ninety-Nine Islands Hydroelectric Station supports the water balance model evaluations for Cases 4 and 5 above, which consider maintaining a minimum flow of 483 cfs in the Broad River as the threshold flow to support withdrawals of makeup water from the Ninety-Nine Islands Reservoir (to support operations of Lee Nuclear Station and to support refill of Make-Up Ponds B and C [drought contingency ponds]). This perspective is also supported by South Carolina Water Withdrawal Law. Additional information on the FERC operating license for the Ninety-Nine Islands Hydroelectric Station is provided below.

The FERC operating license for Ninety-Nine Islands Hydroelectric Station includes seasonal limits on reservoir levels to one foot below full impoundment (511 feet above msl) from March through May, and two feet below full impoundment from June through February. This allows for a short-term potential of zero outflow (excluding a measured 53 cfs due to dam leakage) to occur, immediately followed by the required minimum flow release (Reference 4). Minimum flow requirements below the dam are 966 cfs (January through April); 725 cfs (May, June and December); and 483 cfs (July through November), when flow is available. If the above referenced flows cannot be maintained during December through June without dropping below the reservoir level restrictions described above, then at least 483 cfs is required to be released. If there is insufficient water to maintain at least 483 cfs of continuous flow release, the operating license provides that one hydroelectric unit can be operated at its minimum hydraulic output for that portion of every hour that is necessary to release the approximate accumulated inflow; inflow can be released at the trash gate, or the inflow can be spilled. Collectively, these limits are referred to as the "low flow protocol". Pursuant to South Carolina Water Withdrawal Law, only the lowest minimum flow identified above (i.e., 483 cfs) constrains withdrawals by Lee Nuclear Station. See South Carolina Water Withdrawal Law § 49-4-150(A)(4) (stating in part that water withdrawal from a licensed flow control impoundment are based on the lowest minimum flow specified in the license for that impoundment).

Make-Up Pond C Sizing Based on Hybrid Cooling and Ninety-Nine Islands Dam Seasonal Flow Release Constraints (Case 6)

Water balance model results based on the bounding evaluation of Hybrid Cooling and hypothetical constraints associated with Ninety-Nine Islands Dam seasonal flow release limits are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 6. An increase in usable volume to support station operations would be required under this scenario, resulting in an 18-ft layer being preserved to protect the thermocline with a full pond elevation of 630 ft msl. This layer should be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	3,443 ac-ft	
• 20 days usable storage as margin (worse future droughts)	2,500 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	6,090 ac-ft	612 ft
• Volume and depth to protect thermocline	5,800 ac-ft	18 ft
• Full pond volume and elevation	11,890 ac-ft	630 ft

Additional details for Case 6 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

There are no other changes to the information provided in Reference 1 as a result of this update.

Reference:

1. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.10-09, dated October 29, 2010 (ML103070311)

2. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.12-01, dated December 17, 2010 (ML103550032)

3. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information,* Ltr# WLG2011.01-03, dated January 26, 2011 (ML110310017)

4. U.S. Federal Energy Regulatory Commission (FERC), 1996, Order Issuing New License, Project No. 2331-002, June 17, 1996

Associated Revision to the Lee Nuclear Station Combined License Application:

None

Attachment:

None

Lee Nuclear Station Response to Request for Additional Information (RAI)

RAI Letters Dated: August 21, 2008; January 21, 2009; and June 22, 2010

Reference NRC RAI Numbers: ER RAI 48 Supplement, Alternatives
ER RAI 114 Supplement, Alternatives
ER RAI 123 Supplement, Alternatives

NRC RAI 48:

Provide a quantified evaluation of natural gas-combined cycle power generation as an alternative to the proposed action.

NRC RAI 114:

Provide calculations, references, and the selected control strategies for the natural gas fired emissions.

In the RAI-48 response, applicant provides emissions estimates for (5) natural gas fired combined cycle units in Table 9.2-4. Applicant then includes a reference to EPA AP-42 (5^{th} Ed.) section 1.4 as a reference. It is unclear if the emissions are calculated from this reference; if they are, the applicant should use Section 3.1 for stationary gas turbines, and select the appropriate control strategies they would intend to deploy assuming 114,847,104 MMBtu input per year.

NRC RAI 123:

Provide additional details for the Alternative Energy analysis at the Lee Nuclear Station regarding consumptive make-up water requirements for a combined cycle natural gas-fired power plant. Specifically, provide analysis to describe whether Pond C would be required for this alternative.

NRC June 2 and 3, 2011 Audit – Request for Supplemental Information:

During the audit held on June 2 and 3, 2011, the NRC Staff requested that Duke Energy provide the following supplemental information:

- Present the water balance model/results for the most recent 10 year period of flow data for the Broad River (2001 through 2010)
- Present the water balance model/results based on the hypothetical condition that the seasonal flow release limits in the Federal Energy Regulatory Commission (FERC) license for the Ninety-Nine Islands Dam would apply as constraints on Lee Nuclear Station withdrawals (bounding evaluation)
- Provide land use and ecology impacts for supplemental water options of (a) building a smaller Make-Up Pond C and (b) expanding Make-Up Pond B to support operation of a four unit natural gas combined cycle station at the Lee Nuclear Station site.

Duke Energy Response:

Duke Energy is supplementing the previous responses to these RAIs based on the request for supplemental information identified above.

Natural Gas Combined Cycle Probable Design Change

Duke Energy’s response to ER RAI 48 (Reference 1) involved the evaluation of a natural gas combined cycle generation alternative that consisted of five 482 MWe natural gas fired units. Duke Energy's response to ER RAI 114 (Reference 2) provided updates to air emissions anticipated from these units. During the development of the response to ER RAI 123 (Reference 3) Duke Energy determined that 620 MWe natural gas fired units would be more appropriate for comparison of a natural gas combined cycle baseload option, given that Duke Energy is currently constructing one 620 MWe natural gas combined cycle unit at Buck Steam and Dan River Steam Stations, albeit as intermediate, not baseload units. Note that Duke Energy does not currently operate any baseload natural gas combined cycle units. The new natural gas combined cycle units being built at Buck Steam and Dan River Steam Stations are considered intermediate units in Duke Energy's Integrated Resource Planning (IRP) report and these units will not be dispatched as baseload generating units.

Accordingly, Duke Energy's response to ER RAI 123 (Reference 3) provided the projected monthly average consumptive water use for a hypothetical natural gas combined cycle plant providing the same total energy output as the proposed Lee Nuclear Station. This scenario involved power produced by 3.6 units generating 620 MWe per unit. Since a partial unit cannot be constructed, four 620 MWe units would be required in order to replace the generation capacity of the Lee Nuclear Station. This alternative would provide 2480 MWe, which is slightly more than the 2234 MWe provided by the Lee Nuclear Station.

Revisions to Subsection 9.2.2 in the Environmental Report (ER) are provided in Attachment 48S-01. Revised monthly average consumptive water use for a 2480 MWe natural gas combined cycle plant is provided in Table 1 below. The increased net generating capacity resulting from the probable standard design change for a natural gas combined cycle alternative results in increased air quality impacts. In addition, a capacity factor of 0.8 was previously assumed; however, the capacity factor applied has been updated to 0.9 to align with capacity factor projections used in Duke Energy's IRP for baseload generating units. These changes (net generating capacity and capacity factor) result in an increase in the annual BTU input for the natural gas combined cycle generation alternative. Revisions to air quality impacts resulting from the four 620 MWe natural gas combined cycle units and assumed capacity factor are provided as updates to ER text and tables in Attachments 114S-01 through Attachment 114S-03.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Lee Nuclear Station	50.9	52.1	55.2	58.2	60.1	61.9	63.0	62.3	60.4	57.4	54.6	51.9
Combined Cycle (four 620 MWe units)	24.2	24.8	26.3	27.7	28.6	29.5	30.0	29.7	28.8	27.3	26.0	24.7

Table 1. Comparison of Monthly Average Consumptive Water Use (cfs)

Supplemental Water Requirements

Broad River flow data indicate that supplemental water would be required for the operation of a coal-fired generation facility and natural gas combined cycle facility during periods of extended drought. Consumptive water use for the coal-fired alternative would be very similar to that of the Lee Nuclear Station; therefore, the coal-fired alternative would require a similarly sized Make-Up Pond C. Revisions to impacts from the coal-fired alternative to include the addition of Make-Up Pond C are provided as updates to ER text in Attachment 123S-01.

Several parameters associated with the water balance model used to determine the volume of supplemental water required to support operations of Lee Nuclear Station or other baseload generation alternatives through significant droughts (sizing of Make-Up Pond C) were recently updated. First, the daily evaporation rates for Make-Up Ponds A, B and C were updated to consider average pan evaporation values from Clemson, South Carolina from July 1948 through 2010. Updated evaporation data tables are provided in the supplemental response to ER RAI 216 (Enclosure 2 to this letter). In addition, the design margin applied to account for uncertainty in the length/severity of future droughts was reduced slightly from the 25% margin applied in the initial sizing of Make-Up Pond C to a margin of 20 days of consumptive water storage so that a consistent margin was applied to each of the energy alternatives evaluated (nuclear with wet cooling towers, nuclear with hybrid cooling towers and natural gas combined cycle with wet cooling towers).

Because the Proportional Flow Limitation (5% mean annual flow) in regulations implementing Section 316(b) of the Federal Water Pollution Control Act (CWA) is susceptible to differing interpretations, Duke Energy has evaluated two values using the water balance model. First, a Proportional Flow Limitation (5% mean annual flow) of 125 cfs was applied in the water balance model, derived from the full period of record (1926 through 2010) for the Broad River at the Gaffney Station (No. 02153500). Second, a Proportional Flow Limitation (5% mean annual flow) of 98 cfs was applied in the water balance model, derived from the most recent 10 years (2001 through 2010) for the Broad River at the Gaffney Station. In comparing these two cases (98 cfs versus 125 cfs), very little difference is seen in the volume of supplemental water required to support operations of a 2480 MWe natural gas combined cycle plant through significant droughts as reflected in the water balance model results summarized below.

The minimum flow release requirement of 483 cfs from the Ninety-Nine Islands Dam per its FERC License is described in more detail below. The majority of the water balance model evaluations that were performed apply this minimum flow release requirement. The seasonal flow release requirements from the Ninety-Nine Islands Dam per its FERC license are also described below. A hypothetical bounding evaluation of the water balance model, postulating constraints based on these seasonal flow release requirements, would result in an increase in the volume of supplemental water required to support operations of a 2480 MWe natural gas combined cycle plant through significant droughts (results summarized below). Rather than postulating a larger Make-Up Pond C to support this increase in volume of required supplemental water, the volume and depth of the water layer preserved to protect the thermocline is reduced for the purposes of this evaluation. Duke Energy believes that reducing this water layer would result in less overall environmental impacts than increasing the size of Make-Up Pond C.

Different scenarios or cases of the water balance model were evaluated considering different energy alternatives, proportional flow limitations (125 cfs and 98 cfs) and flow release constraints for the Ninety-Nine Islands Dam (483 cfs and seasonal). Several sensitivity evaluations were also performed to justify the margins applied in sizing of Make-Up Pond C. The results of these different cases are presented in ER RAI supplemental responses as summarized below.

Description	Case(s)	ER RAI Supplemental Response (Enclosure to Ltr. WLG2011.07-04)
Energy Alternatives		
Nuclear with wet cooling towers	1 through 3	206 (Enclosure 1)
Nuclear with hybrid cooling towers	4 through 6	128 (Enclosure 3)
Natural gas combined cycle	7 through 9	48/114/123 (Enclosure 4)
Sensitivity Evaluations		
Combined worst evaporation	10	206 (Enclosure 1)
Synthetic drought	11 through 12	206 (Enclosure 1)

Data input tables and results are provided in the supplemental response to ER RAI 216 (ER RAI 216 Supplement, Enclosure 2 to this letter).

Make-Up Pond C Sizing Based on Natural Gas Combined Cycle and 5% of Mean Annual Flow of 125 cfs (Case 7)

Water balance model results based on Natural Gas Combined Cycle and a 5% mean annual flow of 125 cfs considering the entire 85 year period of record (1926-2010) are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 7. A 20-ft layer is preserved to protect the thermocline while maintain the full pond elevation of Make-Up Pond C at 626 ft msl[1] (same depth of layer used in the initial sizing of Make-Up Pond C). This layer will be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	3,277 ac-ft	
• 20 days usable storage as margin (worse future droughts)	1,200 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	4,624 ac-ft	606 ft
• Volume and depth to protect thermocline	5,737 ac-ft	20 ft
• Full pond volume and elevation	10,361 ac-ft	626 ft

Additional details for Case 7 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2

[1] The full pond elevation of 626 ft msl used in this response differs from the 617 ft msl full pond elevation presented during the June 2 and 3, 2011 NRC audit. The 617 ft msl full pond elevation was based on the supplemental water required for 3.6 units generating 620 MW per unit rather than the supplemental water required for the four 620 MWe units that would actually be built under this scenario.

to this letter). Histograms showing drawdowns of Make-Up Pond B and Make-Up Pond C for this scenario, originally provided in Duke Energy's response to ER RAI 123 (Reference 3) have been revised and are provided as Attachments 123S-02 through 123S-05.

Make-Up Pond C Sizing Based on Natural Gas Combined Cycle and 5% of Mean Annual Flow of 98 cfs (Case 8)

Water balance model results based on Natural Gas Combined Cycle and a 5% mean annual flow of 98 cfs considering the most recent 10 years (2001-2010) are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 8. A 20-ft layer is preserved to protect the thermocline while maintaining the full pond elevation of Make-Up Pond C at 626 ft msl (same depth of layer used in the initial sizing of Make-Up Pond C). This layer will be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	3,380 ac-ft	
• 20 days usable storage as margin (worse future droughts)	1,200 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	4,727 ac-ft	606 ft
• Volume and depth to protect thermocline	5,634 ac-ft	20 ft
• Full pond volume and elevation	10,361 ac-ft	626 ft

Additional details for Case 8 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Sensitivity of Make-Up Pond C Sizing to Proportional Flow Limitation

A usable volume of 3,277 ac-ft is required in Make-Up Pond C to support station operations considering Natural Gas Combined Cycle and a Proportional Flow Limitation of 125 cfs based on the full period of record (1926-2010) as identified in Case 7. A usable volume of 3,380 ac-ft is required considering Natural Gas Combined Cycle and a Proportional Flow Limitation of 98 cfs based on the most recent 10 years as the period of record (2001-2010) as identified in Case 8. A negligible difference of only 103 ac-ft (volume of consumptive water required to support approximately one day of station operations) results, with application of a Proportional Flow Limitation of 98 cfs yielding a slightly larger volume of supplemental water being required to support station operations.

Seasonal Flow Release Limits in FERC License from Ninety-Nine Islands Dam

During the June 2 and 3, 2011 audit, the NRC Staff requested that Duke Energy perform a bounding analysis and provide water balance model results with the withdrawal threshold from the Ninety-Nine Islands Reservoir based on the hypothetical condition that the seasonal flow release limits in the FERC license from Ninety-Nine Islands Dam would apply as constraints on withdrawals. This bounding evaluation has been performed and the results are presented below

as Case 9. Importantly, Duke Energy's FERC license for Ninety-Nine Islands Hydroelectric Station supports the water balance model evaluations for Cases 7 and 8 above, which consider maintaining a minimum flow of 483 cfs in the Broad River as the threshold flow to support withdrawals of makeup water from the Ninety-Nine Islands Reservoir (to support operations of a 2480 MWe natural gas combined cycle plant and to support refill of Make-Up Ponds B and C [drought contingency ponds]). This perspective is also supported by South Carolina Water Withdrawal Law. Additional information on the FERC operating license for the Ninety-Nine Islands Hydroelectric Station is provided below.

The FERC operating license for Ninety-Nine Islands Hydroelectric Station includes seasonal limits on reservoir levels to one foot below full impoundment (511 feet above msl) from March through May, and two feet below full impoundment from June through February. This allows for a short-term potential of zero outflow (excluding a measured 53 cfs due to dam leakage) to occur, immediately followed by the required minimum flow release (Reference 7). Minimum flow requirements below the dam are 966 cfs (January through April); 725 cfs (May, June and December); and 483 cfs (July through November), when flow is available. If the above referenced flows cannot be maintained during December through June without dropping below the reservoir level restrictions described above, then at least 483 cfs is required to be released. If there is insufficient water to maintain at least 483 cfs of continuous flow release, the operating license provides that one hydroelectric unit can be operated at its minimum hydraulic output for that portion of every hour that is necessary to release the approximate accumulated inflow; inflow can be released at the trash gate, or the inflow can be spilled. Collectively, these limits are referred to as the "low flow protocol". Pursuant to South Carolina Water Withdrawal Law, only the lowest minimum flow identified above (i.e., 483 cfs) constrains withdrawals by the natural gas combined cycle plant. See South Carolina Water Withdrawal Law § 49-4-150(A)(4) (stating in part that water withdrawal from a licensed flow control impoundment are based on the lowest minimum flow specified in the license for that impoundment).

Make-Up Pond C Sizing Based on Natural Gas Combined Cycle and Ninety-Nine Islands Dam Seasonal Flow Release Constraints (Case 9)

Water balance model results based on the bounding evaluation of a natural gas combined cycle plant and hypothetical constraints associated with Ninety-Nine Islands Dam seasonal flow release limits are summarized below. This Make-Up Pond C sizing evaluation is designated as Case 9. An increase in usable volume to support station operations would be required under this scenario, resulting in only a 16-ft layer being preserved to protect the thermocline with a full pond elevation of 626 ft msl. This layer should be sufficient to avoid disruption of the natural thermal stratification or turnover pattern.

• Usable volume to support station operations (significant droughts)	4,279 ac-ft	
• 20 days usable storage as margin (worse future droughts)	1,200 ac-ft	
• Dead storage volume below inlet of intake	147 ac-ft	
• Volume and elevation (without protection for thermocline)	5,626 ac-ft	610 ft
• Volume and depth to protect thermocline	4,735 ac-ft	16 ft
• Full pond volume and elevation	10,361 ac-ft	626 ft

Additional details for Case 9 are provided in a data table on Make-Up Pond C Sizing for Different Scenarios (Table 16) submitted as supplemental response to ER RAI 216 (Enclosure 2 to this letter).

Expansion of Make-Up Pond B Based on Natural Gas Combined Cycle and 5% Mean Annual Flow of 125 cfs

At the June 2 and 3, 2011 NRC audit, the NRC Staff requested that Duke Energy evaluate enlarging Make-Up Pond B to provide supplemental cooling water for a Natural Gas Combined Cycle generation alternative. Duke Energy's response to ER RAI 128 (Reference 4) concluded that expanding Make-Up Pond B to provide supplemental cooling water for a hybrid (wet-dry) cooling alternative was not an environmentally superior alternative. Water balance model results based on Natural Gas Combined Cycle and 5% Mean Annual Flow of 125 cfs relative to expansion of Make-Up Pond B are summarized below. Note that these results reflect only the additional volume of supplemental water required to support station operations through significant droughts beyond the usable storage volume of 3,156 ac-ft of storage used from existing Make-Up Pond B.

Under this scenario, the intake for Make-Up Pond B would need to be placed at a lower elevation than what is proposed for Lee Nuclear Station. This elevation has not been calculated; therefore, the dead storage of Make-Up Pond B is assumed to be equal to the dead storage of Make-Up Pond C for comparison. A maximum drawdown of 30 ft on Make-Up Pond B has been considered in the water balance model evaluations. This maximum drawdown results in only a 6-ft layer being preserved at the top of Make-Up Pond B to protect the thermocline. This same 6-ft layer would also need to be preserved at the top of an expanded Make-Up Pond B. Results from thermal modeling to support permitting activities reflect that this 6-ft layer would be sufficient to avoid disruption of the natural thermal stratification or turnover pattern in Make-Up Pond B; however, the thermocline will be significantly lowered in the pond during the infrequent maximum drawdowns of Make-Up Pond B.

- Usable volume to support station operations (significant droughts) 3,277 ac-ft
- 20 days usable storage as margin (worse future droughts) 1,200 ac-ft
- Dead storage volume below inlet of intake 147 ac-ft
- Volume (and depth) to protect thermocline 487 ac-ft (6 ft)
- Additional volume required in Make-Up Pond B 5,111 ac-ft

The increase in usable volume and maintaining a 6-ft protection layer at the top of the pond would be obtained by excavating much of Make-Up Pond B and adjacent land to the north to an elevation of 510 ft msl as shown in Attachment 123S-08.

Environmental Impacts

Natural Gas Combined Cycle Plant and Pipeline Upgrades

The construction of a natural gas combined cycle plant could be sited on less than 200 ac on the Lee Nuclear Station site. A majority of the plant construction could be accomplished within the

area previously disturbed during construction of the Cherokee Nuclear Station. Additional area would be required for site-specific structures, systems and components such as intake structures, refill structures, raw water and refill pipelines, cooling tower blowdown and discharge pipelines, switchyard, and transmission lines. Additional area would be impacted during construction to provide construction laydown areas, spoil areas, and borrow areas. Vegetation impacted due to the construction of the natural gas combined cycle plant, four 620 MWe units, is summarized in Attachment 123S-06.

The natural gas combined cycle plant would require a new four mile pipeline to be constructed within a 70-ft wide permanent right-of-way corridor. Routing for a pipeline was not selected; therefore, impacts have not been quantified. Construction of the pipeline would require new right-of-way to be acquired from private land owners and then clearing of vegetation during construction. Temporary right-of-way of an additional 30-ft to 50-ft width would be required during construction. The pipe would be trenched into the ground, temporarily impacting streams and wetlands within the right-of-way. The 70-ft right-of-way would be maintained in an herbaceous or scrub-shrub state, permanently converting forested vegetation types, including forested wetland, to other habitat. The pipeline could fragment habitat and provide corridors for invasive species.

Additionally, the main natural gas trunkline that serves the region does not have current capacity to provide enough natural gas to operate a baseload natural gas combined cycle plant of 2480 MWe at the Lee Nuclear Site. Therefore, impacts to vegetation, wetlands, and streams would result from the 50 to 60 miles of required upgrades to trunkline pipes. This pipeline runs from the natural gas producing states along the Gulf of Mexico to the Northeast. Segments in Alabama and Georgia would need to be upgraded. Specific impacts resulting from the trunkline piping upgrades are not known. Additional piping should be able to be located within the existing right-of-way. Temporary impacts to vegetation, wetlands, and streams would result from trenching in the piping and the additional laydown areas needed for construction.

Make-Up Pond C

Construction of a Make-Up Pond C at a full pond elevation of 626 ft msl would have impacts similar in nature to those for the Lee Nuclear Station Make-Up Pond C at a full pond elevation of 650 ft msl. Make-Up Pond C at a full pond elevation of 626 ft msl would have a surface area of approximately 363 ac as shown in Attachment 123S-07. All existing man-made ponds would be drained due to dam safety issues. A dam would be constructed on London Creek at the location proposed for the Lee Nuclear Station Make-Up Pond C dam to provide the maximum volume storage to pond surface area ratio. Areas required for construction related infrastructure (spoil areas, borrow areas, etc.) would be smaller than what would be required for a pond at 650 ft msl, but would likely be on the same scale. Detailed design on these features has not been conducted, so this evaluation assumed the same construction layout as the Make-Up Pond C for the 650 ft msl pond. Impacts to vegetation, wetlands, streams, and open water due to the construction of a Make-Up Pond C for continued operation of a natural gas combined cycle plant during periods of extended drought are provided in Attachment 123S-06. Impacts to the land use and ecology

would be somewhat less than those for the Lee Nuclear Station Make-Up Pond C, but would still be SMALL to MODERATE overall.

Make-Up Pond B Excavation

Expanding existing Make-Up Pond B to provide supplemental make-up water during times of drought for the Lee Nuclear Station was evaluated in the ER Supplement and Duke Energy's response to ER RAI 128 (Reference 4). Raising the height of the Make-Up Pond B dam and excavating the entire pond were evaluated to provide the supplemental storage volume. These evaluations identified flood protection concerns with raising the Make-Up Pond B dam to increase storage. Upon further evaluation, Duke Energy determined that it would not be possible to obtain the volume of storage required for the natural gas combined cycle plant while maintaining 3:1 slopes within the existing pond footprint. Therefore, Duke Energy evaluated an option to excavate the land adjacent to the northern and western shore of the pond to obtain the required storage volume. With this approach, the northern portion of Make-Up Pond B and the adjacent uplands would be excavated to 510 ft msl while maintaining 3:1 slopes. To accomplish this expansion, Make-Up Pond B would be completely drained and excavators used to obtain the required depth. Approximately 69 ac of Make-Up Pond B and 81 ac of additional area would be excavated as shown in Attachment 123S-08. Approximately 11 million cubic yards of unconsolidated material would be excavated.

If Make-Up Pond B were excavated to provide supplemental make-up water, the pond would be completely dewatered. Existing fish and other aquatic communities would be eliminated during the excavation. Removal of the surface water would substantially reduce hydrology of wetlands adjacent to Make-Up Pond B and would lead to temporary impacts. Excavation into the uplands would impact forested and non-forested communities. Impacts to vegetation due to the Make-Up Pond B excavation are provided in Attachment 123S-06.

Permanent storage would be required for the excavated material. Approximately 264 ac would be needed to place the material. Duke Energy considered whether spoil material could be placed on the Lee Nuclear Site; however, topography and proposed infrastructure constraints significantly limit the area available for stockpiling spoil materials. Owing to the large volume of spoil material (11 million cubic yards), transporting the material to offsite locations was determined to not be practical considering potential impact to traffic, local roadways, and cost. Therefore, Duke Energy evaluated stockpiling the material on the proposed Make-Up Pond C site.

Since the presentation of the spoil areas during the June 2 and 3, 2011 NRC audit, Duke Energy conducted further evaluation on the size and location of the spoil piles to account for existing site topography. Duke Energy first evaluated locating the spoil material only in uplands on the Make-Up Pond C site; however, steep onsite topography limits the use of many upland areas when considering the requirement for a minimum of 3:1 slopes. Therefore, the old agricultural fields and more disturbed streams north of London Creek (relative to those south of London Creek) were considered for stockpiling as shown in Attachment 123S-09. Additional space for laydown areas or other work space may be required in addition to the permanent spoil pile area, but have not been included for this conceptual layout. Erosion and sediment control best

management practices (BMPs), such as sediment traps and basins, would need to be constructed in accordance with NPDES permit requirements.

In order to place the excavated material at the Make-Up Pond C site, a temporary haul road would need to be constructed from the Make-Up Pond B area and then cross London Creek via a temporary road crossing. A portion of the existing Rolling Mill Road could be upgraded to minimize impacts. A haul road has not been designed for this alternative. In areas where excavated material would be placed, vegetation would be cleared and topsoil would be removed to serve as cover for the spoil material. Excavated material would be placed primarily within uplands, but would also need to be placed within open water areas, streams, and wetlands due to site topography. Impacts to vegetation, wetlands, streams, and open water are summarized in Attachment 123S-06. The significant altering of the site topography and removal of forested areas would have observable effects within the watershed such as increased runoff and altered catchment areas. This could lead to changes in hydrology of the onsite streams, including London Creek. Additional incising and stream instability would likely occur.

Erosion and sediment control measures such as sediment traps and basins would be required in accordance with NPDES permits. Although such BMPs have not been designed for this alternative, they would need to be placed at the downslope areas of the stockpiles, likely within existing streams and wetlands, and potentially increasing the acreage of impact.

Impacts to land use and ecology resulting from the expansion and dredging of Make-Up Pond B and stockpiling material at the Make-Up Pond C site would be less than constructing a Make-Up Pond C for the Lee Nuclear Station, but would still be SMALL to MODERATE overall.

Summary and Conclusion

A natural gas combined cycle plant with either a Make-Up Pond C or an expanded Make-Up Pond B would have impacts to land use and ecology of SMALL to MODERATE. Creation of Make-Up Pond C and expansion of Make-Up Pond B have impacts of a similar scale, albeit somewhat different in nature. Creation of a Make-Up Pond C would have greater acreage of impact to vegetation, wetlands, and streams; however, excavating Make-Up Pond B would have greater impacts to open waters, aquatic communities and greater watershed impacts. Additionally, according to the Charleston District of the U.S. Army Corps of Engineers SOP for mitigation (Reference 8), fill impacts, such as the stockpile placement, have a greater impact to wetlands and streams than flooding due to open water creation. Duke Energy believes that the impacts to aquatic resources from the dewatering of Make-Up Pond B and watershed impacts from the placement of spoil material on the Make-Up Pond C site would have greater overall impact to land use and ecological resources than creating Make-Up Pond C. Therefore, Duke Energy is including a Make-Up Pond C at full pond elevation 626 ft msl for supporting a natural gas combined cycle alternative in revisions to the ER (Attachment 114S-01).

Additional environmental impacts (e.g. air quality, socioeconomics) from the construction of a natural gas combined cycle alternative are discussed in the revisions to the ER (Attachment 114S-01). As shown on Table 9.2-3 (Attachment 123S-10), the scale of impacts for land use and ecology are the same for the Lee Nuclear Station and the natural gas combined cycle alternative.

Air quality impacts for the natural gas combined cycle alternative are MODERATE, while air quality impacts for the Lee Nuclear Station are SMALL. The natural gas combined cycle alternative has a less beneficial socioeconomic effect, MODERATE (Beneficial), than the Lee Nuclear Station, LARGE (Beneficial). Therefore, the natural gas combined cycle alternative would not result in an appreciable reduction in environmental impacts and would not be an environmentally preferable alternative.

References:

1. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2008.12-11, dated December 12, 2008 (ML083510883)

2. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2009.03-14, dated March 18, 2009 (ML090790314)

3. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.07-08, dated July 22, 2010 (ML102070357)

4. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.10-09, dated October 29, 2010 (ML103070311)

5. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2010.12-01, dated December 17, 2010 (ML103550032)

6. Letter from B.J. Dolan to Document Control Desk, Duke Energy Carolinas, LLC, William States Lee III Nuclear Station - Docket Nos. 52-018 and 52-019, *AP1000 Combined License Application for the William States Lee III Nuclear Station Units 1 and 2, Response to Request for Additional Information*, Ltr# WLG2011.01-03, dated January 26, 2011 (ML110310017)

7. U.S. Federal Energy Regulatory Commission (FERC). 1996. Order Issuing New License. Project No. 2331-002, June 17, 1996

8. U.S. Army Corps of Engineers, Charleston District. 2010. Guidelines for Preparing a Compensatory Mitigation Plan (Working Draft). October 7, 2010

Associated Revisions to the Lee Nuclear Station Combined License Application:

1. Revisions to Environmental Report, Subsection 9.2.2
2. Revisions to Environmental Report, Subsection 9.2.3.2
3. Revisions to Environmental Report, Table 9.2-4
4. Revisions to Environmental Report, Table 9.2-5
5. Revisions to Environmental Report, Subsection 9.2.3.1
6. Revisions to Environmental Report, Table 9.2-3

Attachments:

Attachment 48S-01	Revisions to Environmental Report, Subsection 9.2.2
Attachment 114S-01	Revisions to Environmental Report, Subsection 9.2.3.2
Attachment 114S-02	Revisions to Environmental Report, Table 9.2-4
Attachment 114S-03	Revisions to Environmental Report, Table 9.2-5
Attachment 123S-01	Revisions to Environmental Report, Subsection 9.2.3.1
Attachment 123S-02	Figure 1. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make-Up Ponds with Refill from the Broad River (85-year record) with Future Water Demands
Attachment 123S-03	Figure 2. 2480 MW Combined Cycle Plant Water Usage on Water Surface Elevations of Make-Up Ponds with Refill from the Broad River (1954 – 1956 drought) with Future Water Demands
Attachment 123S-04	Figure 3. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make-Up Ponds with Refill from the Broad River (1999 – 2002 drought) with Future Water Demands
Attachment 123S-05	Figure 4. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make-Up Ponds with Refill from the Broad River (2007 – 2009 drought) with Future Water Demands
Attachment 123S-06	Table 2. Environmental Impacts Considering a Natural Gas Combined Cycle Plant.
Attachment 123S-07	Figure 5. Make-Up Pond C Full Pond Elevation 626 Ft. MSL – Footprint and Water Depths
Attachment 123S-08	Figure 6. Make-Up Pond B Excavation
Attachment 123S-09	Figure 7. Possible Spoil Locations at Make-Up Pond C Site.
Attachment 123S-10	Revisions to Environmental Report, Table 9.2-3

Attachment 48S-01

Revisions to Environmental Report

Subsection 9.2.2

1. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.2, Page 9.2-5, as follows:

<u>Conventional Technologies (technologies in common use):</u>

<u>Baseload Technologies</u>

800 MW class Supercritical Coal (Greenfield)

2-1117 MW Nuclear units, AP1000

~~2410~~ <u>2480</u> MW Natural Gas Combined Cycle

Peak / Intermediate Technologies

4-160 MW Combustion Turbines – GE 7FA

460 MW Unfired + 40 MW Inlet Chilling Combined Cycle - 7FA

460 MW Unfired + 120 MW Duct Fired + 40 MW Inlet Chilling Combined Cycle – 7FA

2. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.2, Page 9.2-7, as follows:

Existing manufacturers' standard-sized units include a natural-gas-fired combined-cycle plant of ~~482~~ <u>620</u> MW net capacity, consisting of two ~~172~~ <u>160</u> MW natural gas turbines ~~(e.g., General Electric Frame 7FA)~~ and ~~138~~ <u>300</u> MW of heat recovery capacity. Duke Energy assumed ~~five 482~~ <u>four 620</u> MWe units, having a total capacity of ~~2410~~ <u>2480</u> MWe, as the natural-gas-fired alternative at the Lee Nuclear Site capacity of two AP1000 units. The total generation from this replacement power source is ~~2410~~ <u>2480</u> MWe and would only slightly overestimate the impacts from an exact replacement of Lee Nuclear Station Units 1 and 2. Table 9.2-4 shows the amounts of the ~~2410~~ <u>2480</u> MWe natural gas-fired plant emissions. Table 9.2-5 presents the assumed basic operational characteristics of the natural-gas-fired units. For the purposes of analysis, Duke Energy has assumed that there would be sufficient natural gas availability.

Attachment 114S-01

Revisions to Environmental Report

Subsection 9.2.3.2

1. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.3.2 as follows:

9.2.3.2 Natural Gas Generation (Combined Cycle)

A ~~482~~ 620 MWe NGCC unit has been identified as a probable standard size unit to be used. This alternative would require ~~five 482~~ four 620 MWe units to adequately replace the Lee Nuclear Station's generating capacity. The total generation from this replacement power source is ~~2410~~ 2480 MWe and would ~~only~~ slightly overestimate the impacts from an exact replacement of the Lee Nuclear Station's ~~2400~~ 2234 MWe. A combined cycle natural gas plant would require supplemental make-up water during times of extended drought. In order to supply this make-up water, the combined cycle natural gas plant would require a Make-Up Pond C approximately half the surface area of that required for the operation of the Lee Nuclear Station.

The economics of combined cycle technology are largely dependent on the price of natural gas, which is highly volatile. As noted in Subsection 9.2.2, the overall cost of generating electricity from natural gas is currently higher than the costs for nuclear generation ($0.0353/kWh vs. $0.0266/kWh).

Construction of a natural gas pipeline from the plant location to a supply point where a firm supply of gas is available would be needed. There is currently no gas pipeline to the Lee Nuclear Site. A combined cycle natural gas plant would require the construction of approximately 4 miles of pipeline in a new corridor. Additionally, the existing trunkline in the region does not currently have enough capacity to support the operation of a natural gas combined cycle plant. Pipeline upgrades would be necessary and would likely include looping in approximately 50 to 60 mi of new pipe within the existing corridor. The existing right-of-way would likely be able to accommodate this line. It is anticipated that the environmental impacts of constructing a gas pipeline to the Lee Nuclear Site would be similar to those associated with constructing a new transmission line right-of-way. Soil impacts from construction of the natural gas pipeline are considered ~~MODERATE~~ SMALL because of the disturbance to the topsoil along its route.

The overall impacts associated with the construction and operation of the natural-gas-fired alternative using a closed-cycle cooling system are summarized in Table 9.2-3 and discussed in the following subsections.

9.2.3.2.1 Water Use and Quality

A trade-off of water quality impacts would be associated with a large baseload NGCC plant. Though water requirements are less for combined cycle plants than for conventional steam electric plants, the site would require the construction of a new intake structure to provide water needs for the facility. New base gas combined cycle units would likely utilize closed-loop cooling towers. Because water requirements for combined cycle generation are less than for conventional steam electric generation, evaporation from combined cycle cooling towers would be less than the anticipated evaporation associated with the Lee Nuclear Station's cooling tower system. Sediment caused by construction activities ~~would~~ could impact adjacent waters. Plant discharges would comply with all appropriate permits. No

low-level radioactive waste discharges to surface water are associated with a combined cycle unit. The overall impacts are characterized as SMALL.

9.2.3.2.2 Waste Management

The solid waste generated from this type of facility would be minimal. The only significant waste would be from spent SCR catalyst used for NO_x control. The SCR process would generate approximately 1500 cubic feet (cu. ft.) of spent catalyst material per year. The overall impacts are characterized as SMALL.

9.2.3.2.3 Air Quality

Natural gas is a relatively clean-burning fuel. The combined-cycle operation is highly efficient (60 percent versus 33 percent for the coal-fired alternative) because the heat recovery steam generator does not receive supplemental fuel. The natural-gas-fired alternative would release similar types of emissions, but in lesser quantities than the coal-fired alternative, and in much larger quantities than the nuclear alternative.

The largest environmental impact from this type of facility would result from the air emissions. The emissions resulting from burning natural gas only would be ~~195.2~~226.0 T. per year of SO_2, ~~7465~~8642 T. per year of NO_x, ~~379~~438.8 T. per year of particulate matter (PM), and ~~1723~~1994 T. per year of carbon monoxide (CO). A facility of this size would add ~~6,316,591~~7,312,568 T. per year of CO_2 to the environment. Assumptions and calculations for these emissions are provided in Table 9.2-5 and Table 9.2-4 respectively. The overall impacts are characterized as MODERATE.

9.2.3.2.4 Other Impacts

Land - ~~Use of the Lee Nuclear Site for a natural-gas-fired combined cycle plant would require no new lands.~~ A major combined cycle generation station can be located on less than 200 ac on the Lee Nuclear Site. A Make-Up Pond C would be required to provide supplemental water to the combined cycle generation station during periods of extended drought. Make-Up Pond C would be approximately 363 acres and would also include additional area for the main dam, stockpiles, laydown areas, temporary haul roads, and other ancillary features similar to what is required for the construction of Make-Up Pond C for the Lee Nuclear Station.

One obstacle to the consideration of combined cycle generation using only natural gas is the availability of the gas. Based on current technology, a facility of this size would require in excess of 100 billion cu. ft. per year of natural gas. If legislation is passed~~,~~ requiring the reduction of CO_2 levels, increased use of natural gas in the generation mix would be required in order to meet these standards, resulting in reduced availability of natural gas. There are four natural gas pipelines, all located in the same right-of-way, approximately 4 mi. northwest of the site. A large, new baseload combined cycle facility would require extending one or more of the existing gas pipelines to the site, which would disturb significant acreage between the right-of-way and the plant site. Additionally, the existing gas pipelines do not have adequate capacity to provide sufficient fuel for a natural gas-fired

combined cycle plant. Approximately 50 to 60 mi of pipeline would need to be upgraded and would involve temporary impacts to land. ~~This assumes that the current gas supply is adequate to fuel a new facility along with the current users. If these lines do not have adequate capacity to service the current users as well as the new site, a new pipeline would need to be run, which would have a larger impact than assumed here. The overall impacts are characterized as MODERATE.~~

NUREG-1437 estimated that approximately 3,600 ac. of land would be required for wells, collection stations, and pipelines to bring the natural gas to a 1,000-MWe NGCC facility. For a NGCC facility of 2480-MWe, the additional land would be 8,928 ac. Overall, the land-use impacts from a natural gas-fired combined cycle facility would be SMALL to MODERATE.

Ecology - Locating a new combined cycle facility at the Lee Nuclear Site would alter the ecology. On-site impacts would likely not be as significant as with coal-fired generation due to the smaller footprint requirement. A smaller Make-Up Pond C to support natural-gas-fired combined cycle facility operation would impact less vegetation, wetlands, and streams than Make-Up Pond C for the Lee Nuclear Station; however, impacts to the resources would still be noticeable and on the same scale. Impacts from a new intake (impingement and entrainment) and discharge (waste heat to a receiving water body) would be created. ~~However,~~ Ecological impacts created by new gas transmission needs could create significant off-site issues. Impacts would include wildlife habitat loss and reduced productivity, and could include habitat fragmentation and a local reduction in biological diversity. ~~Impacts from a new intake (impingement and entrainment) and discharge (waste heat to a receiving water body) would be created.~~ These ecological impacts would vary depending upon the corridor selected for the gas pipeline and the locations of the trunkline upgrades. However, the overall impacts are characterized as SMALL to MODERATE.

Human Health - A new combined cycle power plant introduces small risks to workers and the public. The generic environmental impact statement (GEIS) analysis noted that there could be human health impacts from the inhalation of toxins and particulates. Regulatory agencies, such as the EPA, have established regulatory requirements for power plant emissions and discharges to protect human health. A new combined cycle plant would comply with these regulatory requirements. The overall impacts are characterized as SMALL.

Socioeconomics - Construction of a major combined cycle plant would take approximately 2 – 3 years. Construction of a new combined cycle station of this size would employ a construction workforce of approximately 800, which would stimulate the economy of the region. The surrounding communities would experience demands on housing and public services. After construction, the workers would leave, and the operating plant would provide new jobs. However, long-term job opportunities would be less than for a coal-fired station and substantially less than those during operation of the Lee Nuclear Station.

Operational impacts could result in moderate socioeconomic benefits in the form of jobs, tax revenue, and plant expenditures. However, by comparison, these benefits will be less than those achieved through operation of the Lee Nuclear Station.

The size of the construction workforce for a combined cycle plant and plant-related spending during construction could be substantial. Operational impacts, once the combined cycle plant is constructed, would result in approximately 807 fewer jobs available to the regional economy (Lee Nuclear Station Units 1 and 2 would employ 957 workers compared to a projected 150 for the combined cycle plant). The overall impacts are characterized as ~~MODERATE~~ SMALL (Adverse) to MODERATE (Beneficial).

Aesthetics - The ~~five~~ four power plant units with their approximately ~~200-ft~~ 160-ft stacks could be visible at a distance of several miles. Combined cycle generation would introduce additional mechanical sources of noise that would be audible off-site. Sources contributing to total noise produced by plant operation are classified as continuous or intermittent. Continuous sources include the mechanical equipment (e.g., combustion turbine units and mechanical-draft cooling towers) associated with normal plant operations. Intermittent sources include the equipment related to ammonia handling and solid waste disposal. Noise levels associated with a combined cycle generation facility are expected to be similar to those of a nuclear facility as discussed in Subsection 5.8.1.5. The overall impacts are characterized as SMALL ~~to MODERATE~~.

Cultural Resources - The GEIS analysis concluded that impacts to cultural resources would be relatively small unless important site-specific resources were affected. Construction impacts would be similar to those for construction of two nuclear units, which have been discussed and evaluated for the Lee Nuclear Site in Subsections 2.5.3 and 4.1.3. The overall impacts are characterized as SMALL.

Environmental Justice - Environmental justice effects depend upon the nearby population distribution. Construction activities offer new employment possibilities, but have negative effects on the availability and cost of housing, which disproportionately affects low-income populations. The overall impacts are characterized as SMALL.

9.2.3.2.5 Conclusion

A natural gas-fired combined cycle facility would be a viable replacement for Lee Nuclear Station baseload generation. Land-use and ecology impacts for the natural gas-fired combined cycle facility would be less than the Lee Nuclear Station but would be a similar scale of impact. However, the air quality~~, land, ecology, socioeconomic, and aesthetic~~ impacts would be greater than the impacts from construction and operation of the Lee Nuclear Station. Socioeconomic effects would not be as beneficial as effects from the construction and operation of the Lee Nuclear Station; therefore, socioeconomic impacts would be greater with the natural gas-fired combined cycle alternative.

Duke Energy concludes that a natural gas-fired combined cycle facility is not an environmentally preferred alternative to the chosen resource, the Lee Nuclear Station.

Attachment 114S-02

Revisions to Environmental Report

Table 9.2-4

TABLE 9.2-4
AIR EMISSIONS FROM GAS-FIRED ALTERNATIVE

Parameter	Result
Annual Gas Consumption	~~2,404,470~~2,783,598 T. per year
Annual BTU Input	~~114,847,104~~132,955,776 MMBtu per year
SO_2	~~195.2~~226.0 T. SO_2 per year
NO_x	~~74658~~8642 T. NO_x per year
CO	~~17231~~1994 T. CO per year
PM	~~379~~438.8 T. PM per year
PM_{10}	~~109~~126.3 T. filterable PM_{10} per year
CO_2	~~6,316,591~~7,312,568 T. CO_2 per year

Notes:

Btu	British thermal unit
CO	Carbon monoxide
CO_2	Carbon dioxide
kWh	Kilowatt hour
lb.	Pound
MW	Megawatt
NO_x	Oxides of Nitrogen
PM	Particulate Matter
PM_{10}	Particulates having diameter less than 10 microns
SO_2	Sulfur dioxide
T.	Ton
yr.	Year

Attachment 114S-03

Revisions to Environmental Report
Table 9.2-5

TABLE 9.2-5
GAS-FIRED ALTERNATIVE CHARACTERISTICS
(Sheet 1 of 2)

Characteristic	Basis
Unit size = ~~482~~620 MW IS0 rating net Two ~~112~~160 MW-combustion turbines ~~138~~300 MW-heat recovery boiler	Standard size (Duke Energy experience)
Number of units = ~~5~~4	Approximate capacity to replace ~~2400~~2234 MWe net (twin AP1000 units)
Fuel type = natural gas	Assumed
Fuel heating value = 23,882 Btu/lb (HHV)	Typical for natural gas used in NC (Duke Energy experience)
SO_2 Emission Factor = 0.0034 lb/MMBtu	Used when sulfur content is not available
NOx control = selective catalytic reduction (SCR) with water injection	Best available for minimizing NOx emissions
Fuel NOx Emission Factor = 0.13 lb/MMBtu	SCR control in conjunction with water-steam injection (Reference 15, Table 3.1-1)
Fuel CO_2 Emission Factor = 110 lb/MMBtu	Based on 99.5% conversion of fuel carbon to CO_2 (Reference 15, Table 3.1-2a)
Fuel CO Emission Factor = 0.03 lb/MMBtu	SCR control in conjunction with water-steam injection (Reference 15, Table 3.1-1)
Heat rate = 6800 Btu/kWh	Typical for combined cycle gas-fired turbines (@ ISO)
Capacity factor = 0.~~8~~9	Typical for baseload units in Integrated Resource Planning (IRP) models

TABLE 9.2-5
GAS-FIRED ALTERNATIVE CHARACTERISTICS
(Sheet 2 of 2)

Notes	
Net	The difference between “net” and “gross” is electricity consumed on-site.
Btu	British thermal unit
ISO Rating	International Standards Organization rating at standard atmospheric conditions of 59°F 60% relative humidity and 14.696 lb. of atmospheric pressure per sq. in.
kWh	Kilowatt hour
MM	Million
MW	Megawatts
MWe	Megawatts electric
NOx	Nitrogen oxides
HHV	High Heating Value

Attachment 123S-01

Revisions to Environmental Report
Subsection 9.2.3.1

1. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.3.1, Paragraph 2, as follows:

For purposes of this analysis, Duke Energy defined the pulverized coal-fired alternative as consisting of four conventional boiler units, each with a net capacity of 530 MW for a combined capacity of 2120 MW. This coal-fired alternative, for purposes of this analysis, is located at the proposed project site. The coal-fired alternative would require supplemental make-up water during periods of extended drought in amounts similar to the Lee Nuclear Station and would therefore require a Make-Up Pond C similar in size. Table 9.2-1 presents the assumed basic operational characteristics of the coal-fired units.

2. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.3.1.3, Paragraphs 1 through 5, as follows:

Land - In NUREG-1437, the NRC staff estimated that approximately 1700 ac. are needed for a 1000-MW coal-fired plant. Duke Energy experience indicates that a 2120-MWe coal-fired plant requires approximately 2000 ac. This area includes land for the coal pile, a limestone pile, an ash and scrubber solids disposal area, and plant buildings and structures, but it does not include land for an associated coal mine, access road, and railroad spur. Construction of a 2120-MWe coal-fired plant would also require the construction of a Make-Up Pond C to provide supplemental make-up water during times of extended drought. A Make-Up Pond C for a 2120-MWe coal-fired plant would be similar in size to the Make-Up Pond C required for the Lee Nuclear Station and would have similar land impacts.

NUREG-1437 estimated that approximately 22,000 ac. of land are affected for mining the coal and disposing of the waste to support a 1000-MW coal-fired plant during its operational life. A replacement 2120-MWe coal-fired plant to substitute for the proposed project affects approximately 46,640 ac. of land.

Construction of the alternative permanently changes the land use at the site, and most likely involves an irretrievable but moderate loss of forest land and/or farmland. No significant effects to plant site soils are anticipated because of the use of erosion control practices during and following construction.

The effect of the coal-fired alternative on land use is best characterized as SMALL to MODERATE, similar to the proposed project.

Ecology - The coal-fired generation alternative introduces construction effects and new incremental operational effects. Even assuming siting at a previously disturbed area, the effects alter the ecology. Ecological effects to a plant site and utility easements include effects on ~~threatened or endangered species,~~ wildlife habitat loss, reduced wildlife reproduction, habitat fragmentation, and a local reduction in biological diversity. The construction of a Make-Up Pond C has ecological impacts similar to that of the Make-Up Pond C for the Lee Nuclear Station. Use of cooling makeup water from a nearby surface water body has adverse aquatic resource effects. If needed, maintenance of a transmission

line and a rail spur has ecological effects. There are effects to terrestrial ecology from cooling tower drift. Overall, the ecological effects are SMALL to MODERATE, similar to the proposed project.

3. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.3.1.3, Paragraph 23, as follows:

Cultural Resources - ~~Studies likely are needed to identify, evaluate, and address mitigation of the potential effects of new plant construction on historic and archaeological resources before construction begins at any site. The studies likely are needed for areas of potential disturbance at the proposed plant site and along associated corridors where new construction occurs (e.g., roads, rail lines, or other rights-of-way)~~. Cultural resource studies have been conducted at the proposed Lee Nuclear Site and Make-Up Pond C Site. Impacts from the construction of a coal-fired generation plant at the Lee Nuclear Site would be similar to those associated with the construction of the Lee Nuclear Station. Historic and archaeological resource effects can generally be effectively managed and as such are considered SMALL.

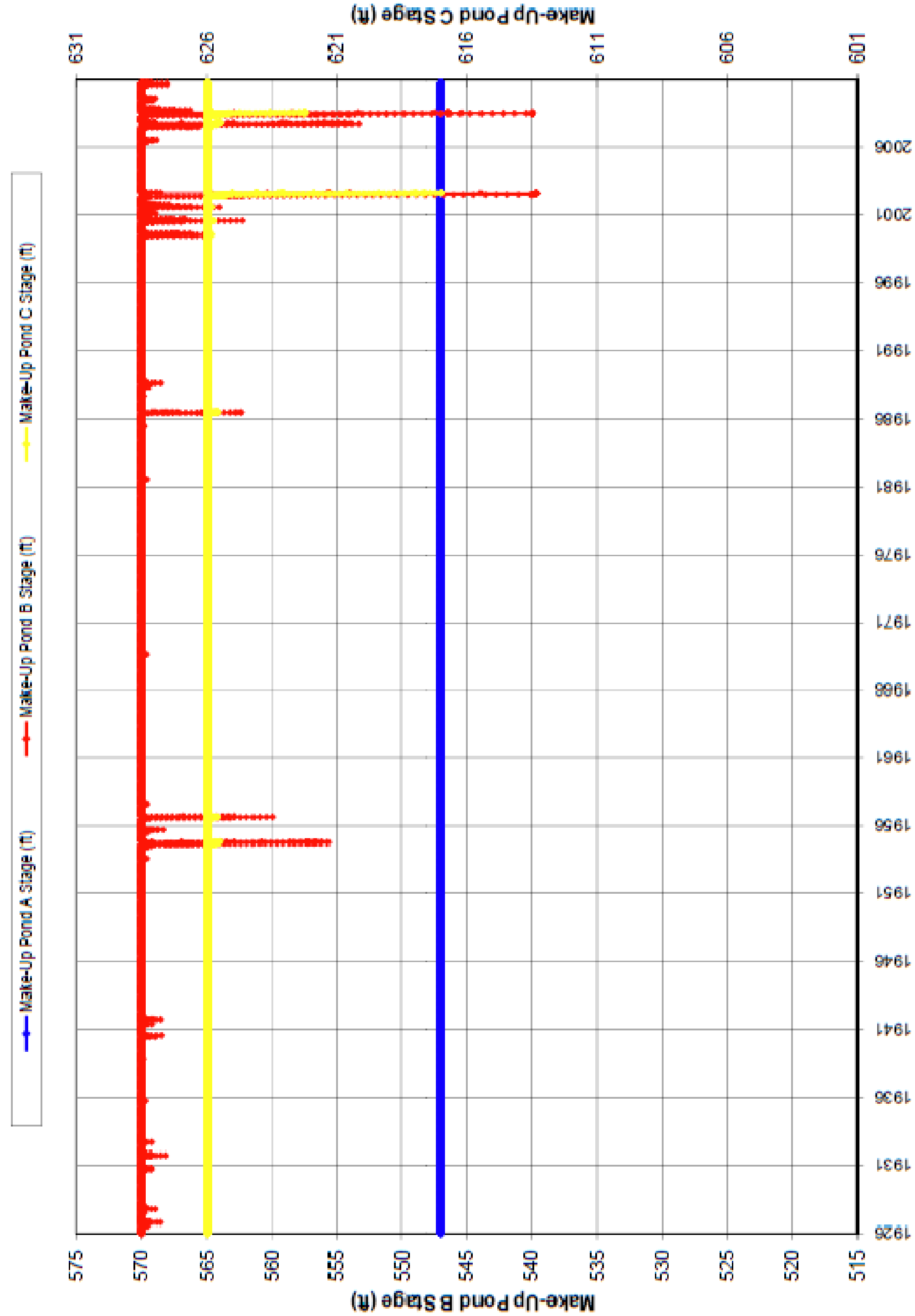
4. Revise COLA, Part 3, ER Chapter 9, Subsection 9.2.3.1.3, Paragraph 25, as follows:

Conclusion: Duke Energy identified and evaluated a coal-fired facility as an alternative to the Lee Nuclear Station and concludes that it is not an environmentally ~~superior~~ preferred alternative to the chosen resource, the Lee Nuclear Station.

Attachment 123S-02

Figure 1
2480 MW Combined Cycle Plant
Water Usage Impact on Water Surface Elevations
of Make-Up Ponds with Refill from the Broad River
(85-year record) with Future Water Demands

Figure 1. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make Up Ponds with Refill from the Broad River (85-year record) and Future Water Demands



Attachment 123S-03

Figure 2

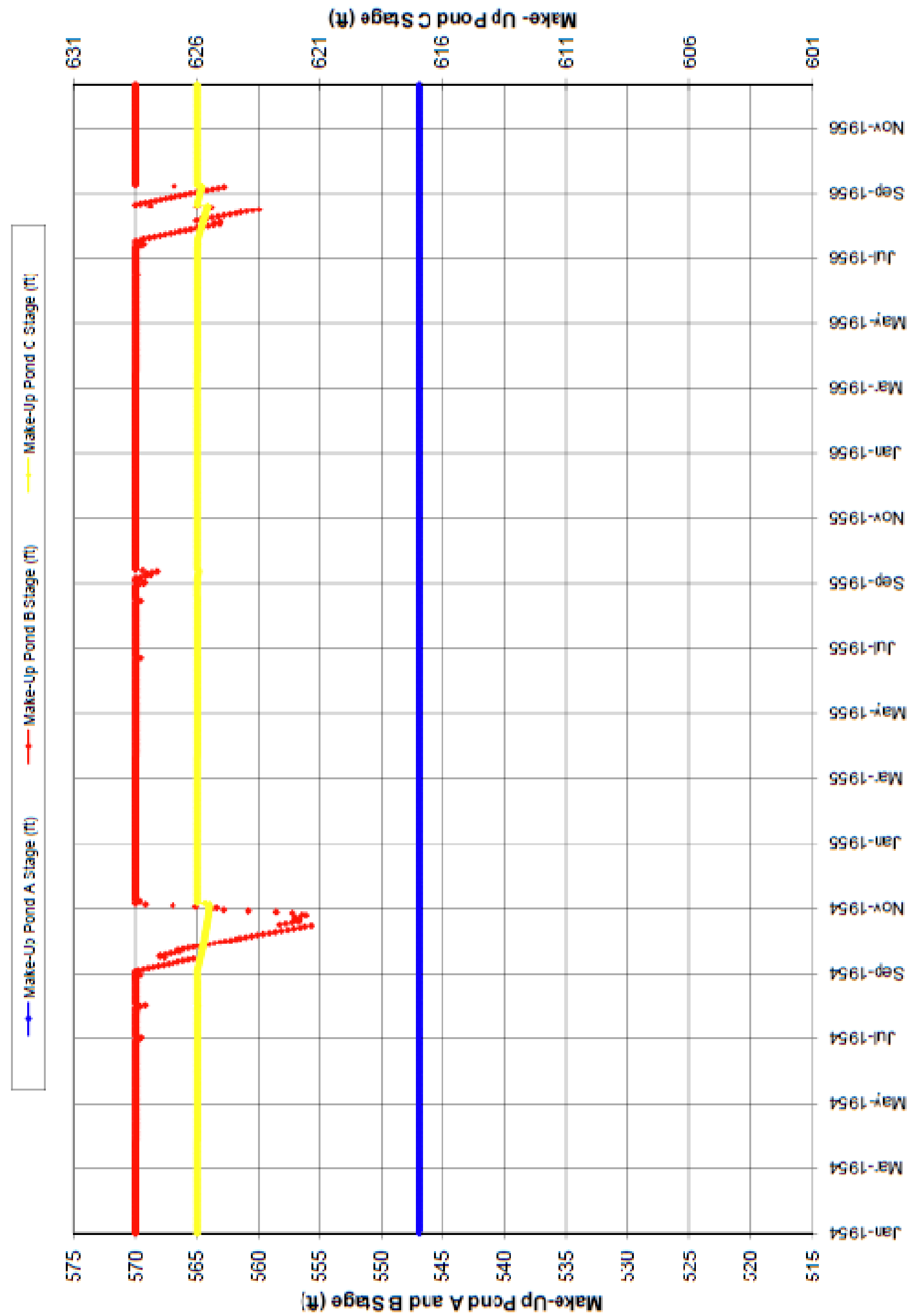
2480 MW Combined Cycle Plant

Water Usage on Water Surface Elevations

of Make-Up Ponds with Refill from the Broad River

(1954 – 1956 Drought) with Future Water Demands

Figure 2. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make Up Ponds with Refill from the Broad River (1954 - 1956 drought) and Future Water Demands



Attachment 123S-04

Figure 3

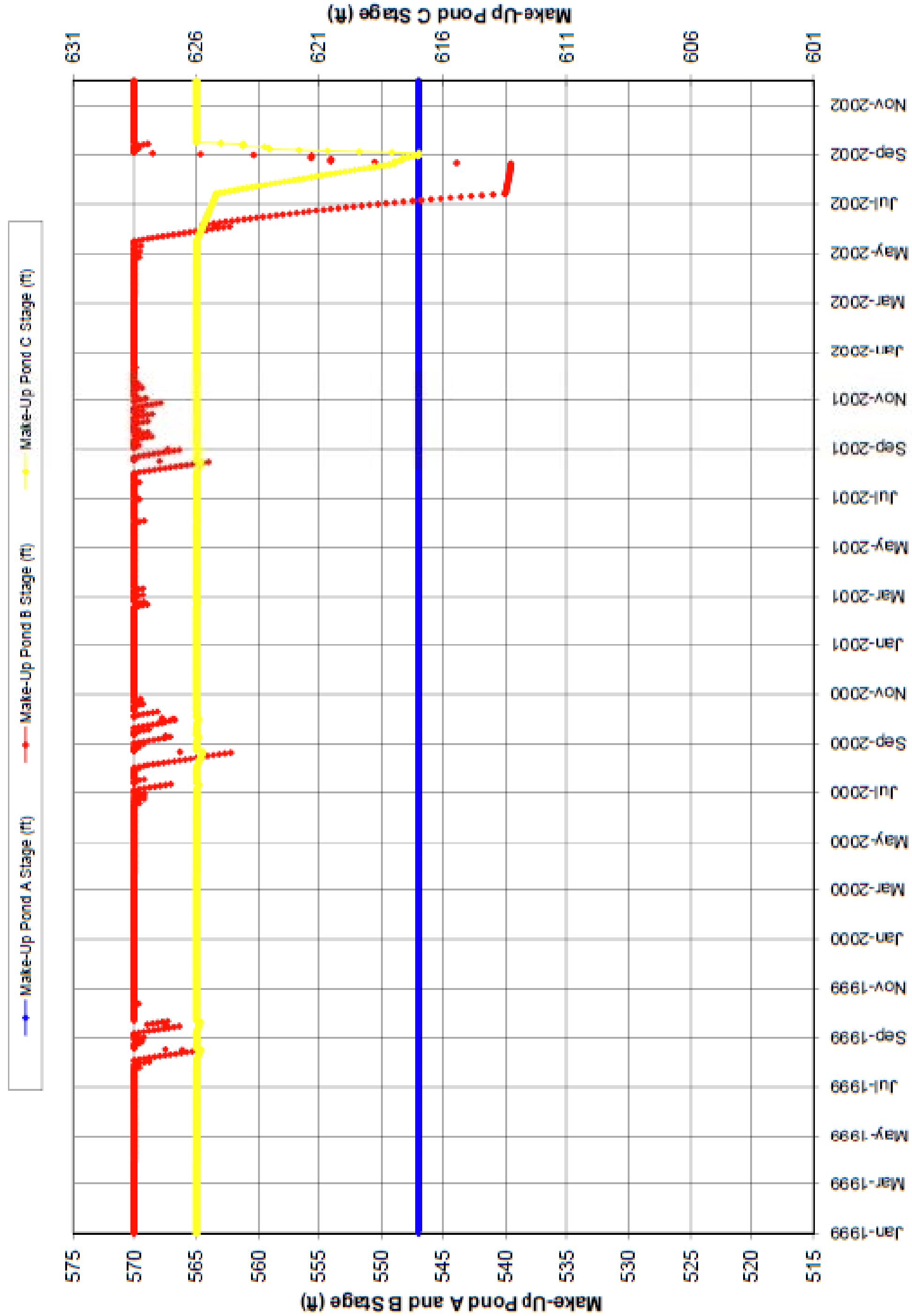
2480 MW Combined Cycle Plant

Water Usage Impact on Water Surface Elevations

of Make-Up Ponds with Refill from the Broad River

(1999 – 2002 Drought) with Future Water Demands

Figure 3. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make Up Ponds with Refill from the Broad River (1999 - 2002 drought) and Future Water Demands



Attachment 123S-05

Figure 4

2480 MW Combined Cycle Plant

Water Usage Impact on Water Surface Elevations

of Make-Up Ponds with Refill from the Broad River

(2007 – 2009 Drought) with Future Water Demands

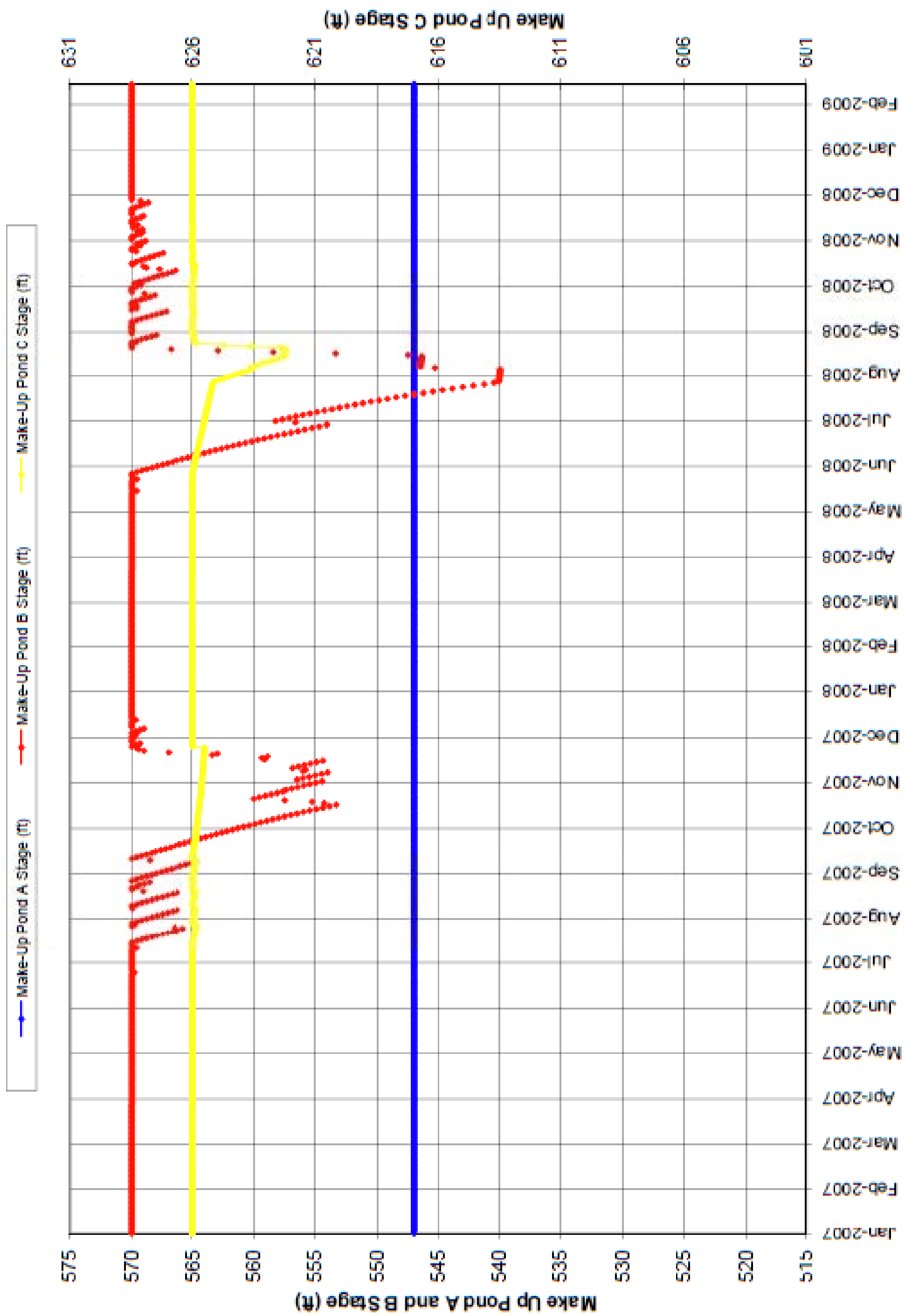


Figure 4. 2480 MW Combined Cycle Plant Water Usage Impact on Water Surface Elevations of Make Up Ponds with Refill from the Broad River (2007 - 2009) and Future Water Demands

Attachment 123S-06

Table 2
Environmental Impacts Considering
a Natural Gas Combined Cycle Plant

Table 2. Environmental Impacts Considering a Natural Gas Combined Cycle Plant

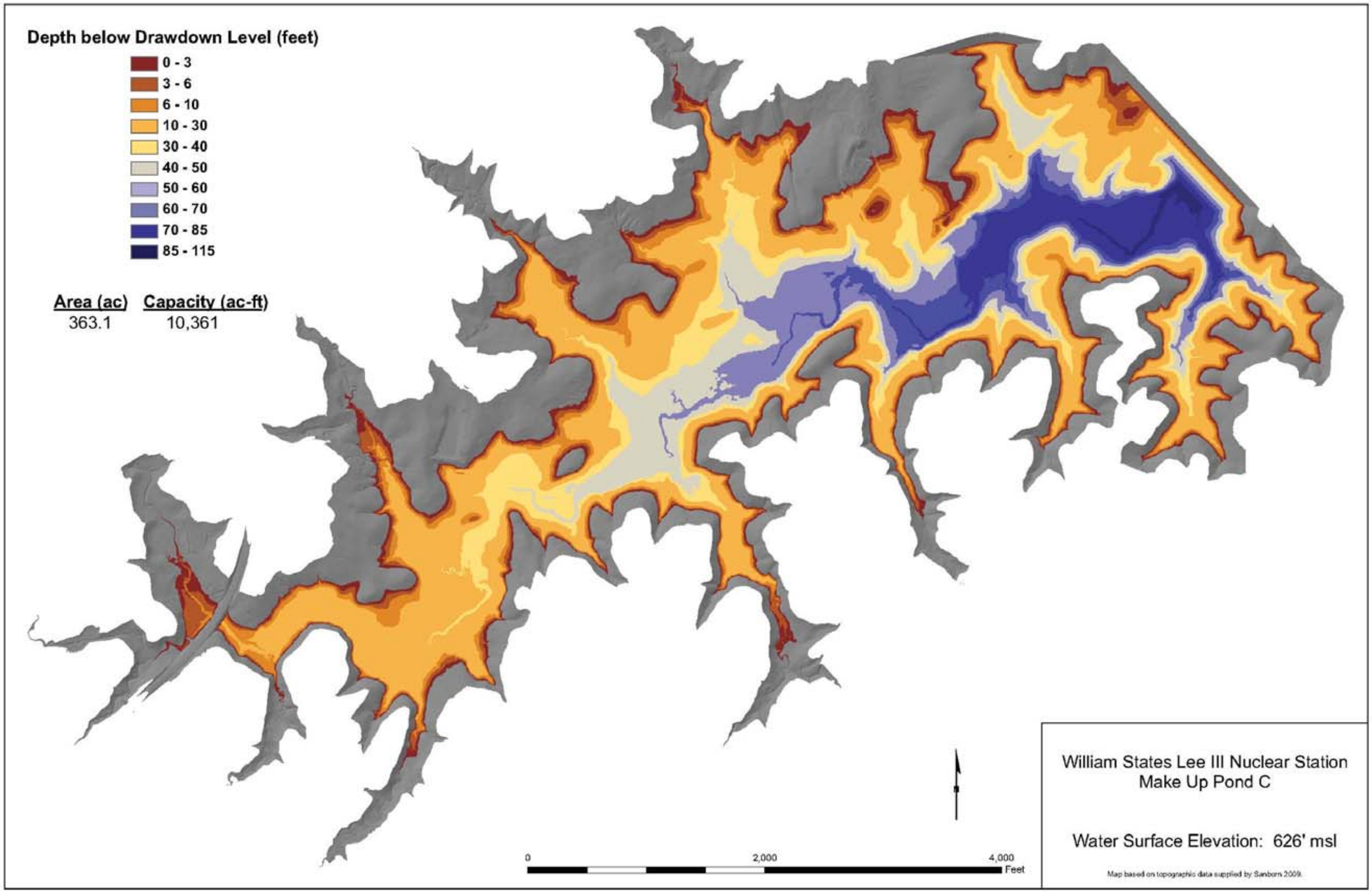
	Land Use (ac)	**Cover Type**										
		MH	**MHP**	**PMH**	**NJW**	**OFM**	**USC**	**AW**	**OW**	**OPMH**	**P**	**NAW**
Natural Gas Combined Cycle w/Make-Up Pond C (Full Pond Elevation 626 ft msl)												
Lee Nuclear Site	134.41	15.35	14.57	7.70	0.03	79.53	7.93	0.00	3.15	5.83	0.24	0.08
Make-Up Pond C Impact	812.83	280.48	79.98	18.41	0	222.68	14.50	0.00	16.00	0.26	180.52	0
Total	**947.24**	**295.83**	**94.55**	**26.11**	**0.03**	**302.21**	**22.43**	**0.00**	**19.15**	**6.09**	**180.76**	**0.08**
Natural Gas Combined Cycle w/Expanded Make-Up Pond B												
Lee Nuclear Site	134.41	15.35	14.57	7.70	0.03	79.53	7.93	0.00	3.15	5.83	0.24	0.08
Make-Up Pond B Impact	149.82	5.97	20.00	11.35	0.00	17.77	6.95	0.00	70.04	17.73	0.01	0.00
Spoils at Make-Up Pond C Site	264.47	66.64	13.85	0.00	0.00	151.78	0.00	0.00	14.52	0.00	17.68	0.00
Total	**548.7**	**87.96**	**48.42**	**19.05**	**0.03**	**249.08**	**14.88**	**0.00**	**87.71**	**23.56**	**17.93**	**0.08**

	Wetlands (ac)	Streams (ft)	Open Water (ac)
Natural Gas Combined Cycle w/Make-Up Pond C (Full Pond Elevation 626 ft msl)			
Lee Nuclear Site	0.03	254	2.88
Make-Up Pond C Impact	2.63	51,142	13.86
Total	**2.66**	**51,396**	**16.74**
Natural Gas Combined Cycle w/Expanded Make-Up Pond B			
Lee Nuclear Site	0.03	254	2.88
Make-Up Pond B Impact	0.00	0	70.04
Spoils at Make-Up Pond C Site	1.00	7406	11.13
Total	**1.03**	**7,660**	**84.05**

Attachment 123S-07

Figure 5
Make-Up Pond C Full Pond Elevation 626 Ft. MSL
Footprint and Water Depths

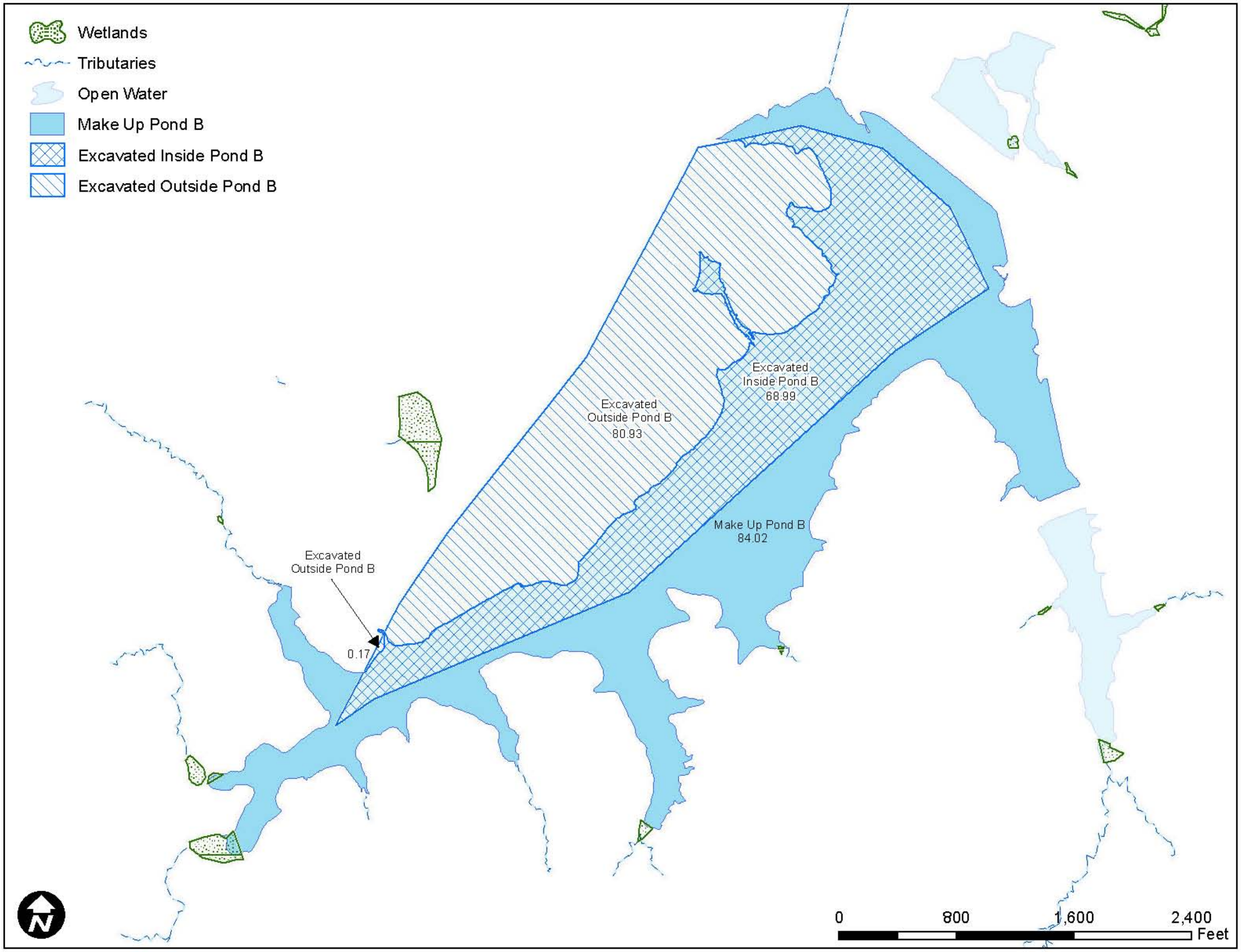
Figure 5. Make-Up Pond C Full Pond Elevation 626 Ft. MSL – Footprint and Water Depths



Attachment 123S-08

Figure 6. Make-Up Pond B Excavation

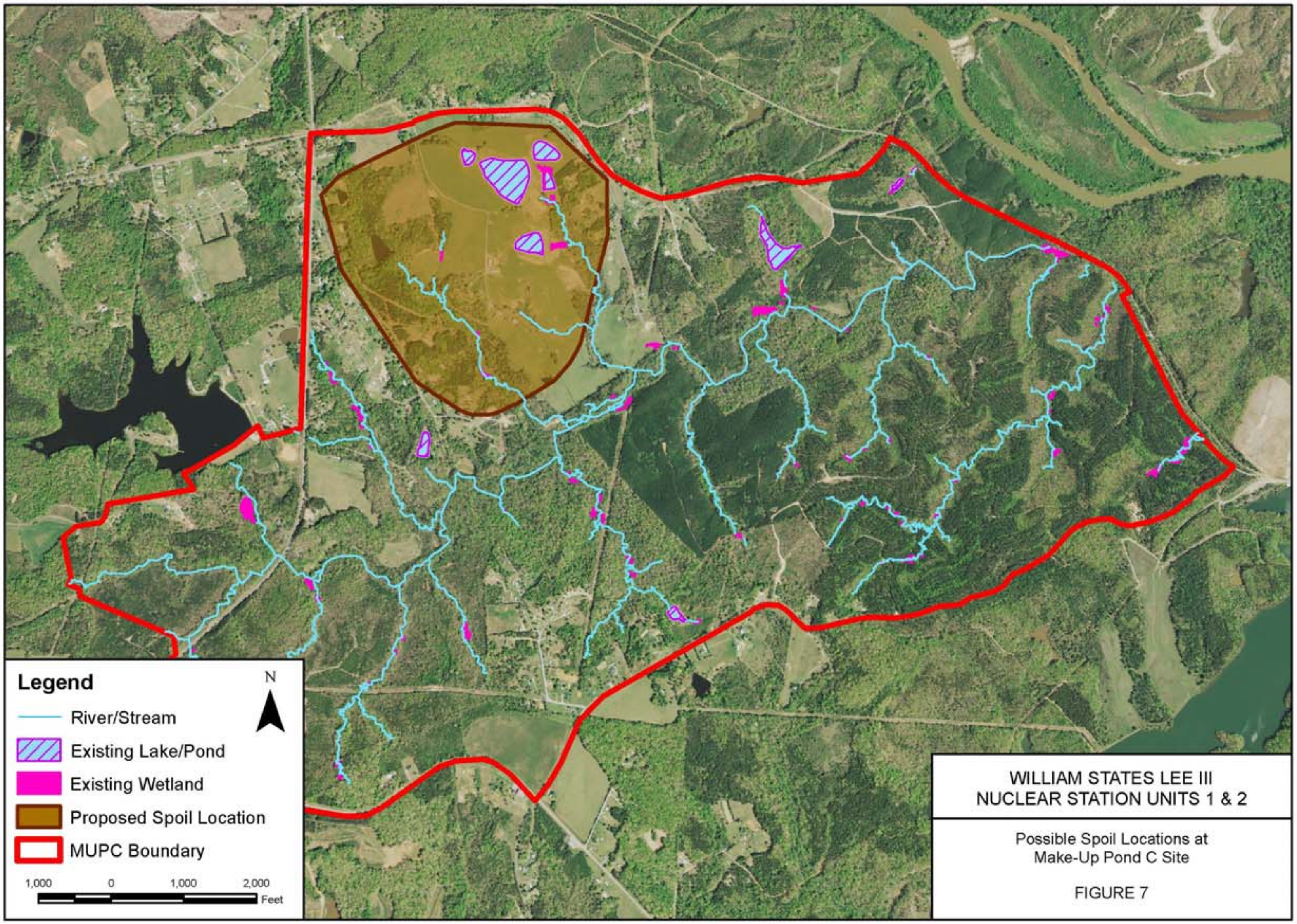
Figure 6. Make-Up Pond B Excavation



Attachment 123S-09

Figure 7
Possible Spoil Locations
at Make-Up Pond C Site.

Figure 7. Possible Spoil Locations at Make-Up Pond C Site



Attachment 123S-10

Revisions to Environmental Report
Table 9.2-3

Table 9.2-3
Comparison of the Environmental Impacts of the Coal-Fired and Natural Gas Alternatives to the Lee Nuclear Station

	Environmental Impacts		
Attribute	Lee Nuclear Station	Coal-Fired Alternative	Natural Gas Generation
Air Quality	SMALL	MODERATE	MODERATE
Waste Management	SMALL	MODERATE	SMALL
Land	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Ecology	SMALL to MODERATE	SMALL to MODERATE	SMALL to MODERATE
Water Use & Quality	SMALL	SMALL	SMALL
Human Health	SMALL	SMALL	SMALL
Socioeconomics	SMALL (Adverse) to LARGE (Beneficial	SMALL (Adverse) to LARGE (Beneficial)	SMALL (Adverse) to MODERATE (Beneficial)
Aesthetics	SMALL	SMALL	SMALL ~~to MODERATE~~
Cultural Resources	SMALL	SMALL	SMALL
Environmental Justice	SMALL	SMALL	SMALL

Appendix H

Potentially Applicable Alternatives Evaluation

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§ 316(b) COMPLIANCE DEMONSTRATION
FOR WILLIAM S. LEE III NUCLEAR STATION

APPENDIX H

SCREENING ANALYSIS TO ELIMINATE TRACK I COMPLIANCE OPTIONS FROM DETAILED ANALYSIS

Prepared by:

AKRF, Inc.
7250 Parkway Drive
Hanover, MD 21076

February 11, 2011

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Table of Contents

List of Acronyms, Defined Terms, and Abbreviations

ACC	air cooled condensers
AP1000	Westinghouse Standardized Advanced Passive pressurized water reactor
cfs	cubic feet per second
Duke Energy	Duke Energy Carolinas, LLC
EPA	United States Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
ft	feet
Initial Temperature Difference	the difference between the temperature of the ambient air and the saturation temperature of the steam to be condensed within the condenser tube bundles
Lee Nuclear Station	William S. Lee III Nuclear Station
MGD	million gallons per day
NRC	United States Nuclear Regulatory Commission
Proportional Flow Limitation	40 CFR § 125.84(b)(3)(i)
SCDHEC	South Carolina Department of Health and Environmental Control
WWTP	wastewater treatment plant

1.0 INTRODUCTION

Duke Energy Carolinas, LLC (Duke Energy) conducted a thorough process to identify, screen, and then evaluate compliance options at William S. Lee III Nuclear Station (Lee Nuclear Station) that could potentially meet the requirement of 40 CFR § 125.84(b)(3)(i) (Proportional Flow Limitation), as adopted by the South Carolina Department of Health and Environmental Control (SCDHEC). Six criteria were applied in the screening analysis to determine if the compliance option warranted further investigation. These screening criteria were:

- feasibility of the application at the proposed site for Lee Nuclear Station, considering Duke Energy's experience with the technology and its having been demonstrated at the appropriate scale;
- ability to meet the requirements of § 125.84(b)(3)(i);
- ability to provide sufficient quantity of make-up water for station operations during extended drought conditions when not using the river intake;
- ability to meet the load requirements forecasted by Duke Energy;
- ability to obtain required permits and/or licenses;
- ability to meet other federally mandated regulatory requirements; and
- other environmental impacts.

Based on these criteria eleven potential compliance options were eliminated from further consideration:

- use alternative reactor design;
- use indirect dry towers;
- use air cooled condensers;
- increase the capacity of existing drought contingency pond;
- raise height of Ninety-Nine Islands Dam;
- relocate the primary intake structure;
- release additional water from upstream reservoirs;
- impound Kings Creek;
- use groundwater;
- use reclaimed water; and
- use municipal water.

This Appendix presents the results of the screening analysis that eliminated these potential compliance options from the detailed analysis presented in Section 3.2.4 of the § 316(b) Compliance Demonstration.

2.0 COMPLIANCE OPTIONS ELIMINATED FROM DETAILED ANALYSIS

2.1 USE ALTERNATIVE REACTOR DESIGN

This compliance option assumes that Lee Nuclear Station would be built using a design other than the Westinghouse Standardized Advanced Passive pressurized water reactor (AP1000). There is no material difference in consumptive water use between the different reactor designs. This option was eliminated from detailed evaluation and deemed infeasible based on its inability to achieve compliance with § 125.84(b)(3)(i).

2.2 USE INDIRECT DRY TOWERS

Duke Energy considered the use of indirect dry towers at Lee Nuclear Station. With the indirect dry tower alternative, the wet tower in the AP1000 certified design would be replaced with a large water to air heat exchanger (Duke Energy 2009a).

The United States Environmental Protection Agency (EPA) (2001) rejected dry cooling as best technology available for a national requirement:

> …because the technology of dry cooling carries costs that are sufficient to pose a barrier to entry to the marketplace for some projected new facilities. Dry cooling technology also has some detrimental effect on electricity production by reducing energy efficiency of steam turbines and is not technically feasible for all manufacturing applications. Finally, dry cooling technology may pose unfair competitive disadvantages by region and climate. Further, the two-track option selected is extremely effective at reducing impingement and entrainment, and while the dry cooling option is slightly more effective at reducing impingement and entrainment, it does so at a cost that is more than three times the cost of wet cooling. Therefore, EPA does not find it to represent the ‘‘best technology available’’ for minimizing adverse environmental impact.

This technology has not been demonstrated at a nuclear plant or at a large fossil plant in the United States. The indirect dry cooling towers required at Lee Nuclear Station would be substantially larger than any other installation in the world (Appendix G). Indirect dry cooling would have a negative impact on turbine reliability. Moreover, there are serious operational concerns related to its use in a baseload plant in the southeastern United States, due to climatological conditions. Historic temperature data indicate that dry cooling towers could not operate reliably between June and September (Appendix G). This compliance option was deemed infeasible and was eliminated from further analysis.

2.3 USE AIR COOLED CONDENSERS

Duke Energy considered the use of air cooled condensers (ACC) as an alternative cooling system. There are no nuclear power plants that are currently using ACC systems in the United States. The governing design characteristic of an ACC used in a dry cooling system is the difference between the temperature of the ambient air and the saturation temperature of the steam to be condensed within the condenser tube bundles (Initial Temperature Difference). Because this saturation temperature is directly related to the backpressure of the steam condensing within the tubes, the Initial Temperature Difference directly impacts the backpressure on the steam turbine (Appendix I).

During testimony on the Early Site Permit for the Vogtle Nuclear Station, James W. Cuchens testified on the operation of ACC systems for nuclear power plants and the AP1000 design in particular (Appendix I)[1]. Cuchens' testimony concerned the operation and reliability of an ACC cooling system at the Vogtle Nuclear Station. Cuchens concluded that climatic conditions at the Vogtle Nuclear Station significantly affect reliability of generation during summer months. The Lee Nuclear Station has similar climatic conditions as the Vogtle Nuclear Station and would have similar obstacles to implementing an ACC system.

Additionally, incorporation of ACC technology at the Lee Nuclear Station would require large-scale changes to the AP1000 certified design reviewed by United States Nuclear Regulatory Commission (NRC) during the 10 CFR 52 Design Certification process. The ACC system would have to be significantly larger than a comparable wet system to maintain the same unit performance. Cuchens presented a theoretical ACC design for the AP1000 with an ACC occupying an area about 300 feet (ft) wide by 1,700 ft long. If applied at the Lee Nuclear Site, such a design would result in clearing and grading impacts far greater than the current design, assuming the site could even accommodate the equipment layout. Cuchens' entire testimony on the feasibility of an ACC cooling system with an AP1000 design at a site with similar climatic conditions to the Lee Nuclear Site is provided as Appendix I. Because ACC technology cannot be utilized at Lee Nuclear Station, it was eliminated as a compliance option for further evaluation.

2.4 INCREASE THE CAPACITY OF EXISTING DROUGHT CONTINGENCY POND

This compliance option was deemed infeasible and was eliminated from detailed analysis, as it would not provide sufficient make-up water during extended drought conditions.

1 Cuchens (2009) provided an assessment of the feasibility of deploying ACC technology at Vogtle 3 & 4 project, a nuclear station under construction Burke County, Georgia. Both the Vogtle project and Lee Nuclear Station will be deploying two Westinghouse Standardized AP1000 certified design units. Therefore, the two projects have identical generating capacities and cooling requirements. Based on the identical station designs and cooling requirements as well as similar site temperature conditions, the ACC design proposed for Vogtle is considered to be applicable for Lee Nuclear Station.

2.5 RAISE HEIGHT OF NINETY-NINE ISLANDS DAM

This compliance option would involve increasing the storage capacity of the Ninety-Nine Islands Reservoir by raising the height of the Ninety-Nine Islands Dam. While this compliance option might be capable of supplying the requisite cooling water, significant concerns exist with respect to: potential conditions of a new Federal Energy Regulatory Commission (FERC) license; the reliability of supply in the FERC impoundment; significant impacts to wetlands; and the timeliness of such a project. Raising the height of the dam would not likely increase the retention time in the Ninety-Nine Islands Reservoir beyond seven days; therefore, water withdrawals would still be subject to the same mean annual flow requirements of § 125.84(b)(3)(i). The mean annual flow of the Broad River would not change because of the modification to the Ninety-Nine Islands Dam, and it is doubtful that this compliance option would allow the facility to meet the requirements of § 125.84(b)(3)(i). Therefore, this compliance option was deemed infeasible and was eliminated from detailed analysis.

2.6 RELOCATE THE PRIMARY INTAKE STRUCTURE

The alternative location would not allow Duke Energy to meet instream flow restrictions and would not meet the requirements of § 125.84(b)(3)(i). This compliance option was deemed infeasible and was eliminated from detailed analysis.

2.7 RELEASE ADDITIONAL WATER FROM UPSTREAM RESERVOIRS

This compliance option would involve releasing water from one or more of six upstream reservoirs to provide adequate water resources for Lee Nuclear Station: Lake Summit and Lake Adger on the Green River; Lake Lure, Gaston Shoals, and Cherokee Falls on the Broad River; and a proposed water supply reservoir to be constructed by the Cleveland County Sanitary District on the First Broad River. This compliance option poses multiple problems. A number of these reservoirs do not have excess water that could be released downstream. Other reservoirs are at a distance that would pose significant legal and logistical difficulties, rendering the water supply unreliable. Moreover, Duke Energy does not control the release of water from these reservoirs and, thus, cannot guarantee sufficient make-up water for use at the Lee Nuclear Station, even if enough capacity were available (Duke Energy 2009b). Therefore, this compliance option was eliminated from detailed evaluation and deemed infeasible.

2.8 IMPOUND KINGS CREEK

This compliance option would involve impounding Kings Creek, northeast of Lee Nuclear Station, to meet supplemental water storage requirements. Although this compliance option was determined

to be capable of supplying sufficient water supplies; the environmental consequences of such an impoundment to streams, wetlands, land use, transportation corridors, and cultural resources would exceed those that would result from impounding London Creek (Duke Energy 2009b). It is also uncertain as to whether the refill of this impoundment could be accomplished without requiring an alternative requirement to § 125.84(b)(3)(i). Therefore, this compliance option was eliminated from detailed evaluation.

2.9 USE GROUNDWATER

This compliance option would involve the use of groundwater as an alternative water source for normal station operation at Lee Nuclear Station. Groundwater resources would not be sufficient to meet Lee Nuclear Station's cooling water needs. Lee Nuclear Station would need to withdraw groundwater from approximately 84 square miles (53,760 acres) to provide adequate make-up water for the circulating water system (Duke Energy 2009b). This compliance option was deemed infeasible and was eliminated from detailed analysis.

2.10 USE RECLAIMED WATER

This compliance option would include wet cooling towers, highly protective intake screen technologies on all intake structures, and use of Ponds A and B, and the proposed Pond C. This compliance option also would include the use of reclaimed (or gray) water.

Treated wastewater would be transported from the Clary wastewater treatment plant (WWTP) and the Broad River WWTP. A summary of this study can be found in Appendix J.

Reclaimed water resources would not be sufficient to meet the cooling water needs of Lee Nuclear Station. The Clary WWTP has a permitted maximum capacity of 7.7 cubic feet per second (cfs) [5.0 million gallons per day (MGD)] and a current utilization of 4.6 cfs (3.0 MGD). The Broad River WWTP has a permitted maximum capacity of 6.2 cfs (4.0 MGD) and a current utilization of 2.5 cfs (1.6 MGD) (Duke Energy 2009a). The combined maximum capacities of 13.9 cfs (9.0 MGD) (Duke Energy 2009a) and the combined utilization rates of 7.1 cfs (4.6 MGD) from the Clary and Broad River WWTPs are insufficient to meet the Lee Nuclear Station average consumptive water requirement of 55 cfs (35.3 MGD) (Duke Energy 2009b). Therefore, this compliance option was deemed infeasible and was eliminated from detailed analysis.

2.11 USE MUNICIPAL WATER

This compliance option would involve the use of municipal water to supplement water requirements during periods of drought. Of the total surface water use in Cherokee County (410,584 million gallons), the primary water users are for hydroelectric facilities (407,518 million

gallons) and water supply (2,562 million gallons).[2] Pursuant to SC R Title 58, Chapter 5, Article 7, all water utility companies have an obligation to provide reliable service and adequate water supply to their customers. Municipal water sources potentially available to Lee Nuclear Station use water from the Broad River – the same source of water that Duke Energy is proposing to use. By using this same water from a municipal supply, Duke Energy would incur significant capital costs (e.g., piping), operating costs (e.g., unnecessary levels of treatment), and would circumvent the intent of § 125.84(b)(3)(i), i.e., to minimize entrainment of aquatic organisms. Because there would be no assurances that sufficient water would be available, no benefit to the environment, and increased capital and operating costs, this compliance option was eliminated from further analysis.

[2] Solely based on water users that withdraw three million gallons or greater in any month.

3.0 REFERENCES

Cuchens, J.W. 2009. Feasibility of Air-Cooled Condenser Cooling System for the Standardized AP1000 Nuclear Plant. Corrected on March 11, 2009, originally filed on January 9, 2009. (Appendix I)

Dolan, B.J. 2010. Bryan Dolan to the U.S. Nuclear Regulatory Commission (Response to Request for Additional Information). Letter WLG2010.10-09. October 29, 2010. (Appendix G)

Duke Energy. 2009a. William States Lee III Nuclear Station COL Application Part 3 Applicant's Environmental Report-Combined License State (Environmental Report) Rev. 1. March 2009.

Duke Energy. 2009b. Supplement to Rev. 1 of the William States Lee III Nuclear Station COL Application Part 3, Applicant's Environmental Report, Construction and Operation of Make-Up Pond C. September 2009.

Summit Engineering Group Inc. 2010. Gray Water Study for the Lee Nuclear Site. March 2010. (Appendix J)

U.S. Environmental Protection Agency (EPA). 2001. National Pollutant Discharge Elimination System: Cooling Water Intake Structures for New Facilities; Final Rule. [40 CFR Parts 9, 122, 123, 124, and 125] December 18, 2001.

Part VII
Appendix I

Testimony of James W. Cuchens
on Behalf of
Southern Nuclear Operating Company

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket No. 52-011-ESP
Southern Nuclear Operating Company	)	ASLBP No. 07-850-01-ESP-BD01
(Early Site Permit for Vogtle ESP Site)	)	January 9, 2009

TESTIMONY OF JAMES W. CUCHENS ON BEHALF OF SOUTHERN NUCLEAR OPERATING COMPANY CONCERNING ENVIRONMENTAL CONTENTION 1.3

Q1: Please state your name, occupation and business address.

A1: My name is James W. Cuchens. I hold the position of Principal Engineer for Southern Company Generation Engineering and Construction Services (SCG Engineering) in Birmingham, Alabama. SCG Engineering is a division of Southern Company Services, which is a sister company of Southern Nuclear Operating Company (SNC) both of which are subsidiaries of The Southern Company. My business address is: Inverness Office Park, Birmingham, Alabama 35201.

Q2: Please describe your educational and professional background.

A2: I earned a B.S. degree in Mechanical Engineering from Mississippi State University in 1973 and hold professional engineering licenses in Alabama (PE # 13752), Florida (PE # 37700), Georgia (PE # 16164), and Mississippi (PE # 09905).

I have worked as an engineer for The Southern Company for 35 years. My experience encompasses all phases of power plant design and construction: conceptual design studies,

equipment design specifications, and equipment bid evaluations. I have designed the thermal cycle equipment, boiler and draft system equipment, and plant cooling system equipment for various types of units, including nuclear, fossil, and co-generation. As relevant to this proceeding, in the area of cooling, I have been involved in the development of equipment technical specifications, bid evaluations, and applied research of systems equipment technologies. I have developed expertise in the design of various types of cooling cycles, including closed loop, once-through, and/or cooling ponds, serving nuclear units, fossil units, and cogeneration units.

My job requires operating knowledge of the optimization of the cooling system equipment (towers, pumps, and condensers) for new and/or existing units, taking into consideration performance, capital cost, and operation and maintenance. I have developed computer programs for selection of cooling cycle equipment design as well as the analysis of equipment and/or plant performance. I have extensive experience with modeling cooling system/cycles and performance analysis for simulation of various cooling system(s), including mechanical and draft, and wet and dry. I have performed feasibility studies for modifying and/or upgrading existing towers for enhancing tower performance and reducing operations and maintenance costs.

I contribute my expertise to various professional engineering organizations including the ASME (formerly, American Society of Mechanical Engineers) and the Cooling Technology Institute ("CTI"). With the ASME, I served on PTC 23, Cooling Tower Test Code Committee, and PTC 30, Air Cooled Condenser Test Code Committee. With CTI, I sat as a member of the Codes and Standards Committee. Besides my committee work for CTI, I had the honor of serving as the organization's President and Chairman of the Board (2000), Vice President

(1999), and a member of the Board of Directors (1995-1997 and 1999-2001). For the past four years, I have served as the Education Program Chairman of CTI. My Curriculum Vitae is attached hereto (*See* Exhibit SNC000023).

Q3: Please state the purpose of your testimony.

A3: My testimony focuses in detail on the feasibility of dry cooling technology for the Vogtle 3 and 4 nuclear units. In two respects, I address the specific topics on which the Joint Intervenors raised factual disputes. First, I sponsor "Feasibility of Air-Cooled Condenser Cooling System for the Standardized AP1000 Nuclear Plant" (the "Revised Report") (Exhibit SNC000024, attached hereto). The Revised Report revises and expands on the report dated June 25, 2007 (the "Initial Report") I attached as Exhibit 1 to my affidavit in support of SNC's Motion for Summary Disposition of contention EC 1.3 (the dry cooling issue) submitted to the Commission on October 17, 2007. Both documents study the feasibility of incorporating a dry cooling system into the design for an AP1000 Nuclear Plant in South Georgia, the location of the proposed Vogtle units. My colleague, Chris Lazenby, helped me research and draft the Revised Report and his Curriculum Vitae is attached (*See* Exhibit SNC000025). Second, I respond to specific assertions in the Declaration of Mr. Bill Powers ("Powers Declaration") which supported the Intervenors' Answer Opposing to SNC's Motion for Summary Disposition.

Q4: Please explain how the closed-cycle wet cooling system of the AP1000 Nuclear Plant and a dry cooling system operate.

A4: In the standard design of the AP1000 Nuclear Plant, steam is passed across a steam turbine and the turbine turns a generator, creating electricity. The steam leaves the turbine and goes to a steam surface condenser, a large heat exchanger filled with tubes that have cold water flowing through them. The cold water in the tubes absorbs the heat from the steam, causing the steam to condense back into liquid form; the condensed liquid is then pumped back

to the steam generator and the process begins again. The water circulating through the condenser tubes is then pumped out to a wet cooling tower where it is cooled by discharging its heat to the surrounding air largely by evaporation. Once cool, the water is collected in a basin below the tower and pumped back through the condenser tubes. Both circuits continue in a continuous process (hence the name – "closed loop cooling system").

In contrast to a closed-cycle wet cooling system, which relies on the cooling property of water, a dry cooling system is based on an air-cooled condenser (ACC). In such a system, the steam leaving the turbine is piped through large ducts outside of the turbine building to an ACC where it is cooled by air flowing over large metal-finned tubes. The heat from the cooling water is rejected directly to the air and atmosphere. As the steam loses its heat, it condenses to water and is drained to a large tank from which it is pumped back to the nuclear steam supply system. (*See* Revised Report, Exhibit SNC000024, pp. 3, 10).

Q5: What do you conclude in your Revised Report regarding the feasibility of dry cooling technology for the Vogtle 3 and 4 units?

A5: In the Revised Report I conclude, in greater detail than in the Initial Report, that dry cooling is not feasible for use in the current standard AP1000 design at Vogtle 3 and 4. We originally intended to conceptualize a dry ACC cooling system to match the performance of the AP1000 wet cooling system. However, we quickly realized that our efforts were futile. Simply designing the ACC for the same backpressure (exhaust pressure) as the steam surface condenser of the wet cooling system quickly translated to other design and performance challenges such as: 1) adding miles of large steam ducts to get the steam from the turbine to the ACC; 2) eliminating air-in leakage in miles of steam ducts in order to avoid further degradation of backpressure/performance; and 3) designing an air-removal system (vacuum pumps/jets, etc.)

that would be capable of evacuating the huge steam ducts. The extreme difficulty in resolving these significant design issues makes use of dry cooling, for all practical purposes, impossible. (*See* Revised Report, Exhibit SNC000024, pp. 22-23).

Q6: What is backpressure?

A6: During the cooling process described above, when steam is condensed back to liquid form, it requires a significantly less amount of space and/or volume. When this occurs, it creates a vacuum which is often referred to as backpressure inside a steam condenser and turbine exhaust. Typically, the lower the backpressure (or vacuum), the better turbine performance will be because the lower the pressure, the less restriction is being placed on the turbine exhaust flow. It is similar to an automobile's exhaust system. If you obstruct the exhaust system by placing a tennis ball in the exhaust pipe, the engine's performance will be adversely affected. If that tennis ball is removed, the vehicle's performance will improve. (*See* Exhibit SNC000026, p. 7).

Q7: As part of your analysis regarding the feasibility of dry cooling technology for the Vogtle 3 and 4 units, what specific issues do you discuss in your testimony?

A7: In order to explain why dry cooling technology is not feasible for the Vogtle 3 and 4 units, I will address feasibility as it relates to the four disputes of material fact set forth in the Atomic Safety and Licensing Board's ruling on SNC's Motion for Summary Disposition. These four disputes of material fact are: 1) the types of turbines that can be used with an AP1000 Nuclear Plant; 2) the adequacy of dry cooling system design for use in facilities like the Vogtle 3 and 4 units; 3) the impact of the climate in the vicinity of the Vogtle 3 and 4 units on the efficacy of a wet and dry system cooling; and 4) the potential financial, environmental and performance impacts on the facility design, construction and operation of using a dry rather than

wet cooling system. In this testimony, I discuss each of these matters, except for the environmental impacts of installing dry cooling, which will be addressed by Tom Moorer.

Q8: Do you discuss any other issues in your testimony?

A8: Yes. The Intervenors' expert, Mr. Powers, denied that dry cooling impeded the standard design for the NRC-approved AP1000 Nuclear Plant. (Powers Declaration ¶ 10.) I also discuss how dry cooling at the Vogtle 3 and 4 units would be inconsistent with the standard design for the AP1000 Nuclear Plant.

Q9: Please describe the type of turbine that is specified for an AP1000 Nuclear Plant.

A9: For optimum plant efficiency, the turbine-generator design for the AP1000 Nuclear Plant, as specified in the Design Control Document (DCD), Rev. 17, Table 10.1-1 (attached hereto, Exhibit SNC000027), currently pending before the NRC, requires a Toshiba tandem-compound six-flow turbine with a 52-inch last stage blade (LSB). This turbine-generator package consists of a high pressure (HP) element and three low pressure (LP) elements. This means that the turbine exhausts its steam in three distinct sections (the triple exhaust) with each section being physically split so that two distinct steam flows per section are pushed through simultaneously (thus, six flows). For the standard AP1000 Nuclear Plant design as specified in the DCD, the three exhaust sections operate at different design backpressures ranging from 2.37" to 3.57" HgA, giving an average backpressure for all three sections of 2.9" HgA at the design inlet cold water temperature of 91°F. To avoid structural damage caused by operating at a backpressure in excess of what the turbine can withstand, the standard turbine has an alarm point of 5.0" HgA (five inches of mercury) backpressure. This means that, if at any

point the backpressure in the turbine rises above 5.0" HgA, the unit heat load must be decreased in order to continue operation.

During normal operations, the AP1000 standard turbine generator experiences backpressure in the range of ~ 1.0" to a maximum of less than 5.0" HgA. The higher the backpressure on the turbine, the less electricity the generator is able to produce, while the lower the backpressure is on the turbine, the more electricity the generator is able to produce (down to choke flow backpressure at ~ 1.0" HgA). Backpressure in excess of 5" HgA exceeds the functional operational limit of the turbine (*See* Revised Report, Exhibit SNC000024, p. 9).

Q10: Could a dry cooling system be used with the AP1000 standard turbine generator?

A10: No, the current limits of technology would likely prevent that. As detailed on p. 11 of the Revised Report, current "state-of-the-art" dry cooling units or ACC's for the utility industry are designed with an Initial Temperature Difference (ITD) of around 40°F, although there have been a few such condensers built in the United States with an ITD of 35°F. ITD refers to the constant difference between the temperature of the outside air and the temperature of the steam condensing within the tube bundles. No manufacturer of ACC's has successfully designed or built an ACC with a lower ITD than 35°F ITD.

For an ACC designed with a certain ITD, the higher the outside ambient temperature, the higher the steam saturation temperature, and therefore the higher the backpressures of the turbine will be. For example, if an ACC was designed for a 35°F ITD, then at an ambient temperature of 75°F the saturation temperature of the steam condensing inside of it would be 110°F (75° + 35° ITD), which would correspond to a backpressure of 2.6" HgA (the saturation pressure of steam at 110°F). If the ambient temperature around the same ACC rose to 100°F, then the saturation

temperature of the steam would rise to 135°F (100°F + 35°F ITD) and the unit backpressure would rise to 5.16" HgA. At the design ambient air temperature of 95°F, the lowest turbine backpressure potentially achievable with an ACC based on the current technological limit of a 35°F ITD would be around 4.5" HgA, which is only .5" HgA below the alarm point for the turbine incorporated into the AP1000 design. Additionally, with an ACC, operation at multiple exhaust pressures would no longer be viable. Since 4.5" HgA is the lowest achievable backpressure and any rise above this would put the turbine near or above its alarm point, an AP1000 unit as described in DCD Rev. 17 would not be able operate at full rated power any time the inlet air temperature to the ACC was greater than 95°F.

Q11: Is a triple-exhaust turbine required in the AP1000 Nuclear Plant?

A11: Yes. The AP1000 thermal cycle produces large volumes of exhaust steam and this makes it physically impossible to send exhaust through a single-exhaust or, in most cases, a double-exhaust turbine. Physical limits of the materials and construction of turbine shafts, blades, and casing dictate the maximum amount of steam that can safely pass through a given flow area within a turbine and the maximum safe operating speed of the turbine shaft. Importantly, large, multi-exhaust turbine-generators similar to the Toshiba turbine incorporated in the AP1000 design are standard in the nuclear industry. *See* DCD, Section 10.2.4. (attached as Exhibit SNC000028).[1] Thus, it is accurate to say that an AP1000 unit, regardless of its cooling system design, would have to use at least a triple-exhaust turbine in order to physically be able to pass the steam flow specified in the AP1000 thermal cycle.

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[1] *See also* Exhibit SNC000029, p. 13 (G.E. Steam Turbine Product Brochure (an example of a GE "standard" nuclear steam turbine and note that it contains a six-flow LP turbine.) (available at: http://www.gepower.com/prod_serv/ products/steam_turbines/en/ downloads/steam_brochure.pdf).

Q12: Can an AP1000 Nuclear Plant operate with a uniform pressure on all sections?

A12: While not recommended, the turbine could physically operate with all three exhaust sections seeing the same backpressure, even though such operation would drastically deviate from the current thermal cycle design and, more important, change the heat balance performance (performance guarantee) for an AP1000 Nuclear Plant located on the Vogtle site. Operating the turbine as a single-pressure turbine rather than a multi-pressure turbine would have a detrimental impact on turbine/cycle efficiency. In comparison to operating a triple pressure turbine, operating a single pressure turbine restricts the exhaust sufficiently to reduce turbine performance. A simple analogy would be to stick a tennis ball in one of the exhausts of an automobile with a dual exhaust system. While the automobile will still run, it would not be as efficient nor would it be good for the engine since the exhaust pressure on half of the engine will be restricted due to the tennis ball.

Q13: Mr. Powers claims (Power's Declaration, ¶ 13) that the AP1000 Nuclear Plant could use less expensive, higher-backpressure turbines, rated to 8" HgA, to accommodate dry cooling. In fact, he recounts a conversation with a General Electric official who stated that a high-pressure GE D11 system can work with dry cooling. How do you respond?

A13: The current AP1000 standard plant design as specified in DCD Rev. 17 **does not** employ a high backpressure turbine which would be necessary to accommodate an 8" HgA backpressure as suggested by Mr. Powers. I am not aware of any turbine manufacturer that offers a triple-exhaust high-backpressure turbine capable of handling the steam flows that would be associated with the current AP1000 steam cycle if the reactor used dry cooling. As such,

while I would not say that a high backpressure turbine and/or an air-cooled system could never theoretically be used with any kind of AP1000 plant design, I would say that it cannot be used with the **current** AP1000 standard plant design, as proposed for the Vogtle site and specified in DCD Rev. 17.

Moreover, in making the assertion that a high-backpressure turbine could be used in conjunction with the AP1000 units at the Vogtle site, the Intervenors and Mr. Powers appear to extrapolate from experience with significantly smaller generating units. (Powers Declaration ¶ 23). Their underlying assumption appears to be that since those smaller units can use high backpressure turbines, then it is true for every power plant in operation. Even if we were to accept the assertion from the General Electric official cited by Mr. Powers at face value, that teaches us nothing about the AP1000 Nuclear Plant. (See Powers Declaration ¶ 13 n.1) The specific turbine Mr. Powers references is a GE single-exhaust, dual-flow turbine designed for "Medium Fossil Applications"[2] and is not comparable to the significantly larger and more complex turbine specified in the DCD for an AP1000 Nuclear Plant located on the Vogtle site. What Mr. Powers asserts is akin to suggesting that the four cylinder engine in your personal automobile is capable of producing the horsepower necessary to compete in a NASCAR race because both your car and a race car are four-wheeled vehicles driven by internal combustion engines. There is a point at which such generalizations become overbroad and that is the case here.

[2] *See* Exhibit SNC000030 (available at: http://www.gepower.com/ prod_serv/products /steam_turbines/en/fossil =/d_series.htm).

Q14: Mr. Powers said that you ignore nuclear plants in the U.S. and abroad that incorporate dry cooling (Powers Declaration ¶¶ 7 and 9). How do you respond?

A14: Mr. Powers does not identify a nuclear power plant that utilizes dry cooling. He suggests that the Palo Verde Nuclear Generating Station uses dry cooling based on a "plant expansion proposed in the late 1970s", but this suggestion is incorrect. A simple search on the Internet, reveals that the Palo Verde reactor actually uses wet cooling. (*See* Exhibit SNC000031, attached hereto (www.pnm.com/systems/pv.htm)) Though located in the desert, the plant uses treated municipal waste water and stores it in a man-made reservoir.

Speaking in a broader context, we have visited and studied numerous large dry cooling installations both in the U.S. and abroad, (including Majuba, Matimba, and Kendal in South Africa)[3] in order to capture their experiences, lessons learned and best practices from design and operational perspectives. As such, our opinions are based on solid experience with applied technology rather than cherry-picking, as suggested by Mr. Powers.

As part of our research regarding the use of dry cooling in Southern Company generating facilities, we have investigated numerous dry cooling technologies in pursuit of water conservation and have spent considerable efforts on optimizing dry cooling systems for potential use on future combined cycle gas plants, where dry cooling proves to be an economically viable technology, in part because of the relatively smaller size of the turbines as compared with the AP1000 turbine. I doubt that anyone else has gone through as extensive an effort in pursuit of applied dry cooling technology as we have at Southern Company. Having gone through these

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[3] *See* Exhibit SNC000032, Overview of Kendal Power Station (available at: http://www.eskom.co.za/live/content.php?Item_ID=170&Revision=en/0); Overview of Majuba Power Station (available at http://www.eskom.co.za/live/content.php?Item_ID=181&Revision=en/2); Overview of Matimba Power Station (available at: http://www.eskom.co.za/live/content.php?Item_ID=183&Revision=en/0).

efforts, we are confident in our assertion that dry cooling is not feasible at the Vogtle 3 and 4 units.

Q15: The Intervenors' Answer to the Motion for Summary Disposition (¶ 12) asserts that you did not address the Midlothian coal plant, which uses dry cooling and Intervenors allege is nearly the capacity of either the Vogtle 3 or Vogtle 4 AP1000 units. Is the Midlothian coal plant relevant to assessing the feasibility of dry cooling for the Vogtle site?

A15: No. While the total capacity of the Midlothian plant is 1,650 megawatts, slightly higher than that of Vogtle 3 or Vogtle 4, the 1,650 actually arises from six separate units of 275 megawatts each.[4] Therefore, no relevant comparison can be made between a Midlothian unit and an AP1000 Nuclear Plant at the Vogtle site (*i.e.*, comparing six small high backpressure turbines to a single large standard backpressure turbine is like comparing apples to oranges). The same is true for the Matimba plant in South Africa that Mr. Powers mentions at ¶ 23 of his declaration.[5] To be relevant, the comparison would have to entail dry cooled units of equal size with similar turbine cycles rather than a group of small units to a single large unit. However, since such large dry cooled units don't exist, Mr. Powers' comparison inappropriately attempts to make it appear as though they are technically sound and viable.

Q16: Even if it were possible to construct and install a dry cooling system, is it feasible to use dry cooling at the Vogtle site given the climate of South Georgia location?

A16: No. As I stated earlier, operating an AP1000 Nuclear Plant as currently specified in the DCD with a "state-of-the-art" air-cooled system would likely result in backpressure in

[4] *See* Exhibit SNC000033, Description of the Midlothian Power Plant, Energy Information Administration Existing Generating Units in the United States by State, Company and Plant, 2006 (p. 188) (available at: http://www.eia.doe.gov/cneaf/electricity/page/capacity/existingunits2006.xls).

[5] Exhibit SNC000032, Overview of Matimba Power Station.

excess of the steam turbine alarm point any time the temperature was at or above the design ambient air temperature of 95°F, which can occur quite a bit in South Georgia. In addition, the 20°-30°F differential in daily temperatures on hot days would harm operation of the plant. (*See* Revised Report, pp. 11-12).

Q17: Mr. Powers contends that the difference in air temperature over the course of a day does not affect the capability of dry cooling systems and that you failed to demonstrate that is does. (Powers Declaration ¶ 14). **Does the difference in air temperature affect dry cooling systems?**

A17: Yes. This opinion is not mine only, but it is shared by industry experts. For example, in a paper presented at the 2002 National Energy Technology Laboratory (NETL) Electric Utilities and Water: Emerging Issues and R&D Needs Conference, John M. Burns, the Chairman of the recent ASME PTC 30.1 committee that wrote an acceptance test code for ACCs, and Wayne Micheletti, an recognized industry consultant in the area of power plant cooling and environmental issues, stated the following:

> For dry cooling systems, sensible heat transfer is the only form of heat rejection, so performance depends upon the ambient air dry-bulb temperature instead of the wet-bulb temperature. Because ambient dry-bulb temperatures are usually higher and tend to *experience more dramatic daily and seasonal fluctuations* than ambient wet-bulb temperatures, *designing and operating dry cooling systems to obtain the consistent and continuous performance historically provided by wet cooling systems is possibly the greatest obstacle to the increased use of dry cooling in power plants.*[6]

Q18: How does the daily fluctuation in temperature affect dry cooling systems?

A18: First, we would need to assume that a "state-of-the-art" ACC could be constructed for an AP1000 Nuclear Plant on the Vogtle site and it could actually maintain a backpressure of

[6] Exhibit SNC000034, "Emerging Issues and Needs in Power Plant Cooling Systems" by Wayne C. Micheletti and John M. Burns, P.E., presented at the 2002 National Energy Technology Laboratory (NETL) Electric Utilities and Water: Emerging Issues and R&D Needs Conference, at p. 5 (emphasis added) (available at http://204.154.137.14/publications/proceedings/02/EUW/Micheletti_JMB.PDF).

4.5" HgA at an ambient temperature of 95°F. On a summer afternoon in South Georgia when the ambient temperature (*e.g.*, 98°F) was already exceeding the design temperature, a breeze could blow the hot air discharge from the top of the ACC back down into the inlet of the ACC, instantaneously raising the inlet temperature by another 5°F. This, in turn, would increase the ITD and the backpressure. The breeze will have caused the unit to operate well above its turbine alarm set point and have placed it, with only another 3°F rise in temperature, in danger of tripping off. The operators, as they must, would begin decreasing the thermal power of the reactor in order to get below the alarm set point. This results in a decrease in the amount of power produced by the unit precisely when it is most needed by the customers dependent on Georgia Power. Then, assume a sudden thunderstorm moved in and cooled the air by 15°F. In that case, the operators would try to increase production from the plant back towards the unit's rated output, and so on as climate conditions changed.

In short, an AP1000 Nuclear Plant operating with an ACC would be in a mode where the operators were constantly "chasing" the weather. This is a very real situation that could, and would, occur due to the sensitivity of a dry-cooled system to changes in the ambient dry bulb temperatures. In addition, due to exposure to winds from all directions, the vast size of the ACC, which the current standard AP1000 Nuclear Plant would entail, enhances the detrimental impact of temperature and/or wind fluctuations. Lastly, though ACC performance can change suddenly from meteorological influences, it does not respond rapidly to sudden changes in thermal loading. Thus, it would be virtually impossible to control and/or modulate a large ACC system (with approximately 300 fans) to react to fluctuating weather influences without impacting unit performance.

By contrast, these climate conditions would pose a less significant risk on a wet cooling system because it relies on wet-bulb temperature, meaning that, in addition to the ambient air temperature, the operation of a wet cooling tower is dependent upon the amount of moisture in the air. In contrast to the temperature, the moisture in the air remains more stable. The only way wet cooling would cause the same fluctuations in electric generation as an ACC is if both the temperature and moisture in the air would change quickly and dramatically. A wet cooling tower would also be significantly smaller and thus we would be able to place it in a more favorable location on the plant site in order to minimize hot plume recirculation effects of sudden winds (or, as a result of the height of a natural draft cooling tower, render them almost entirely moot). (*See* Revised Report, pp. 12, 15).

Q19: Please summarize your conclusions about the impact of the climate at the Vogtle site on the desirability of a possible dry cooling system.

A19: In South Georgia, extreme maximum temperatures recorded in the vicinity of the Vogtle site have ranged from 105°F to 112°F at Louisville IE station. According to climatic data referenced in the Vogtle Environmental Report at section 2.7.4.1.1, the station record high temperature for the Midville Experiment Station (*i.e.*, 105°F) has been reached on four separate occasions. Individual station extreme maximum temperature records were set at multiple locations on the same or adjacent dates. The similarity of the respective extremes suggests that the statistics are reasonably representative of the temperature extremes that might be expected

load. This creates a practically insurmountable limitation on the technical feasibility of an ACC system in conjunction with the AP1000 steam turbine at the proposed site. Conversely, even if an ACC could be designed and constructed that would deliver backpressures within the AP1000's specification (2.9" HgA), the ITD necessary to deliver such pressures would need to be approximately 20°F, or approximately 50 percent of the minimum ITD achievable with current ACC technology.

Q20: Mr. Powers stated that you exaggerate the extreme climate in South Georgia. He said that "during much of the year" the area experiences maximum temperatures below 70°F and no difference between dry and wet cooling will appear (Powers Declaration ¶ 20). How do you respond to Mr. Powers?

A20: Mr. Powers' assertions mischaracterize the issue. First, with regard to the ambient air design point of 95°F, using a 1 percent temperature value is standard industry practice when designing a cooling system for an electric generating plant. While it is true that these design values are typically only exceeded in 1 percent of the hours during a year (87 hours), there is no way to know if temperatures will be higher than that value for a much greater amount of time. As shown in a study by Michael Kjelgaard in calendar year 2003, the ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) found that 1 percent of summer design dry bulb and/or wet bulb temperatures were exceeded in literally hundreds of hours in a dozen major cities[7]. It may be that an AP1000 Nuclear Plant located on the Vogtle site would not frequently experience temperatures in excess of 95°F, but that does not help much during a summer such as that of 2007 when temperatures exceeded 100°F across the Southeast for days at a time. Moreover, the days when the temperature is the highest tend to be

[7] *See* Exhibit SNC000035, "June 2003: a year in review: ASHRAE design conditions vs. 2002 - weather report," Engineered Systems, August 2003, FindArticles.com, 24 Jul. 2008 (available at: http://findarticles.com/p/articles/mi_m0BPR/is_8_20/ai_107123411/pg_2).

the days of heaviest electricity demand. Reliance on dry cooling for large baseload capacity such as a two unit nuclear power plant would create significant reliability issues for Georgia Power and its customers.

Second, with regard to average temperatures and unit operation, Mr. Powers' assertion that during much of the year the performance of a dry-cooled unit and a wet-cooled unit would be virtually the same is misleading (Powers Declaration ¶ 20). To begin with, the reference cited by Mr. Powers, states that: "Dry cooling saves a lot of water but there is a price to pay for it...*the heat rate may be impacted on all but the coldest days*" (Powers Declaration at Attachment D, p. 9 (emphasis added) (Exhibit SNC000036, attached hereto). A chart in that same document clearly shows that, at dry bulb temperatures down to 60°F, a typical air-cooled system produces a higher turbine backpressure than a typical wet-cooled system. Even accepting that the "typical" values shown on that chart are applicable for an AP1000 Nuclear Plant and that the difference in backpressure produced by the two systems decreases as the ambient air temperature decreases to the point that below 60°F the turbine backpressure could be considered virtually the same, at 70°F there is still approximately a 0.5" HgA difference in turbine backpressure between a wet-cooled unit and a dry-cooled unit. On each AP1000 Nuclear Plant on the Vogtle site, this would equate to around 15 MW[8] of lost generation and that difference is quite significant. Based on historical data, the average temperature in Augusta, Georgia exceeds 60°F over 58 percent of the hours in a year.[9] Based on this, it is correct to say that an AP1000 Nuclear Plant located on the Vogtle site would face significant performance degradation for the majority of every year it is in operation by implementing an air-cooled system as compared to a wet cooling system.

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[8] All references in my testimony to "MW" or "megawatts" are MWe.

[9] *See* Exhibit SNC000037, (Ref. TMY-2 data set constructed by the National Renewable Energy Laboratory (NREL) in Golden, CO, as listed in BinMaker PLUS software published by InterEnergy Software Inc., ©1999).

Q21: Do you have an opinion regarding the potential financial, environmental and performance impacts on the design, construction and operation of using dry, rather than wet, cooling?

A21: I will discuss the financial and operational questions. I understand that Tom Moorer will testify on the environmental impacts of installing dry cooling units on the Vogtle site.

Q22: What did you conclude are the financial effects of dry cooling?

A22: As I testified earlier, I am not aware of a triple pressure, 1117 MW turbine available in the marketplace that would operate at the high backpressures produced by a state-of-the-art ACC system. Conversely, as my Revised Report indicates on p. 14, constructing a dry cooling system at the Vogtle site that could replicate the performance of a wet cooling system specified in the DCD is impossible with the current turbine cycle configuration. Current limits of technology do not allow for construction of an ACC that could condense that amount of steam to that low of a backpressure on that warm of a day. However, using ratios of numbers generated from manufacturer curves for much smaller ACCs, I estimated that if such a unit could be designed and built, it would necessitate construction of approximately 324 cooling modules linked with large steam ducts. The estimated cost of construction of this ACC (excluding cost of large steam ducts, condensate tanks/pumps, foundations, and associated vacuum systems) would be approximately $445 million for each of the Vogtle 3 and 4 units, for a total of a minimum $890 million for the entire plant. None of these costs include any additional engineering or construction costs associated with required design changes to the turbine island and the significant losses of electrical output due to the inordinately large number of fans employed with an ACC of this size. In a nutshell, the incremental cost for an ACC for the current standard

AP1000 Nuclear Plant design including unit performance penalty and associated equipment is more than the cost of a single 500 MW combined cycle generating unit.

The ACC design and cost was estimated based on a design backpressure which would presumably still allow use of the steam turbine in the current standard AP1000 Nuclear Plant design. This in itself is a stretch, since the steam duct piping, ambient temperatures, and wind effects may make such a design impossible or the cooling system useless. As such, any ACC design chosen will not provide equitable performance (heat rate or net MW) in comparison with that of the steam surface/wet tower cooling system. I will elaborate on that later.

Q23: Mr. Powers indicated that you admitted that dry cooling would require 230 units in each plant, not the 334 you testified to in the summary disposition phase of this case (Power's Declaration ¶ 14). He also said that the cost in each of the proposed plants would come to $200 million, for a total of $400 million, not the $361 million for each plant, or the total of $722 million you had claimed. Please respond to his assertions.

A23: I did not mention anything about a 230 module ACC in my Initial Report that could operate successfully in conjunction with an AP1000 Nuclear Plant at the Vogtle site or the cost associated with such a unit. Moreover, I cannot find any factual basis or calculations supporting these figures within any of the supplied documentation. I think that the 230 module ACC that Mr. Powers attributes to me is actually his guess as to how large an ACC designed

Nuclear Plant proposed for the Vogtle site. In theory, the unit would suffer no output degradation with this ACC since it was operating at the same backpressure as with the wet system. However, the size of this unit would increase the consumptive power demand on the unit by anywhere from 27-33 MW over that of a wet cooling system (*See* Revised Report, p. 20).

Q25: Mr. Powers said that the actual operating loss would come to 1.5 percent, or 15-20 MW's, not the much larger volume you contend (Powers Declaration ¶ 15). How do you explain this difference?

A25: Mr. Powers did not provide any support for his measurement of the loss in efficiency from using ACC. However, I infer that the performance penalties Mr. Powers claims are based upon a paper Mr. Powers authored studying the heat rate impacts on "a 515 MW pulverized coal-fired boiler equipped with air-cooled condenser (ACC) at a north central U.S. site location" (*See* Powers Declaration, Attachment C, p.1). In this paper, Mr. Powers estimated that the average annual heat rate penalty for such a unit operating with an ACC designed with a 35°F ITD would be about 1.5 percent when compared to operation with a wet cooling tower system. The Intervenors, in Section I.13 of their opposition to summary disposition, equate this loss in efficiency to a loss of "15-20 MW at peak conditions" for an AP1000 Nuclear Plant operating with an ACC designed with a 35°F ITD at the Vogtle site.

It seems to me that Mr. Powers is using a 515 MW coal plant as an exact model for the much larger AP1000 Nuclear Plant. Such a comparison has no scientific validity.

Q26: Could you elaborate on why the comparison of a 515 MW coal plant to the 1,193 MW AP1000 Nuclear Plant is invalid?

A26: Yes. As has been repeatedly said and demonstrated, comparisons between a 515 MW coal-fired unit, which, given its capacity, would not use a multiple exhaust turbine, and a much larger, triple-turbine 1,193 MW nuclear unit are not at all germane.

The fact that the coal unit Mr. Powers studied was located in Wisconsin adds another layer of incompatibility to the study. The annual temperature distribution for Madison, Wisconsin listed in his study as representative of the plant site is quite different from that of the Vogtle site (Powers Declaration, Attachment C, p. 4). Madison, Wisconsin also has a much colder climate than South Georgia.[10]

Additionally, Mr. Powers' conclusion about the coal unit is based on an assumption that it was going to have an "average annual load (equal to) 2/3 of rated load." (*See* Powers Declaration at Attachment C, p. 5.) An AP1000 Nuclear Plant built on the Vogtle site would be a base-load unit, meaning that it would operate at its rated unit load for the entire year.

I note as well that Mr. Powers misunderstands the concept of loss of efficiency. He asserted in ¶ 15 of the Powers Declaration, "The *estimated annual average efficiency penalty* of using dry cooling at Plant Vogtle is approximately 1.5 percent using a 35°F ITD ACC" (emphasis added). What the 1.5 percent penalty in Attachment C actually refers to is an increase in plant net heat rate, or the amount of heat (in Btu's) necessary to generate one kilowatt-hour of electricity. While heat rate is a common way of expressing thermal cycle effectiveness of a power plant, strictly speaking the thermal efficiency of a power cycle is the constant 3,412 Btu/kWh divided by the plant heat rate. Semantics aside, a point of importance is that a 1.5

[10] *See* Exhibit SNC000038, National Climatic Data Center, Normal Daily Maximum Temperature, Deg F (available at: http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/maxtemp.html).

percent increase in heat rate would typically only equate to around a 0.5 percent drop in thermal cycle efficiency. I do not say that the loss of efficiency at the AP1000 Nuclear Plants in Augusta, Georgia would amount to only 0.5 percent. Rather, this shows that Mr. Powers' calculation of loss of efficiency lacks merit.

Q27: What effect would the use of a dry cooling system with the Vogtle 3 and 4 units have on Georgia Power's customers?

A27: Assuming the turbine technology existed to support it, using dry cooling for the current AP1000 standard plant design would force the citizens of Georgia to pay considerably more money for less electricity and lower reliability. I estimate the capital cost increase alone for an air-cooled system at $890 million and, even according to Mr. Powers, would be at least around $200 million per unit, for a total of $400 million (Powers Declaration ¶ 14), as compared to a wet cooling system. An ACC would also cost significantly more to maintain and operate over the life of the plant than a wet system. As others have noted,

> Both direct and indirect dry cooling systems...are larger and mechanically more complex than corresponding wet cooling systems. . . .[D]ry and hybrid cooling systems will have more fans, meaning more electrical motors, gearboxes and drive shafts. As such, labor requirements for a large ACC can be substantial. At one site with a 60-cell ACC...the maintenance staff was increased by two people for such activities as cleaning fan blades and heat exchanger tube fins, monitoring lube-oil systems, and leak-checking the vacuum system.[11]

In addition to any dedicated maintenance personnel required to maintain a 200 module ACC, let alone a 324 module system, the cost of maintaining such a large number of fans, gearboxes, and motors over the life of the plant would be substantially greater than those for a comparable wet system.

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[11] *See* Micheletti and Burns, at p. 5 (Exhibit SNC000034).

The worst of it is that all of this additional money would buy significantly *less* power than a plant cooled by a wet cooling system could produce for the majority of the year. On hot days, when the temperature can reach 105°F or more, as I testified earlier, this penalty would be even greater because the plant operators would have to lower the thermal output of the reactor in order to avoid exceeding the steam turbine alarm limit. In a worst case scenario, sudden transient conditions could cause the plant to shut down because the turbine backpressure exceeded the trip point and the entire unit output of close 1,200 MW would be unavailable. If this coincided with a system peak, then residents of the area could suffer power outages. At a minimum, Georgia Power would have to buy expensive replacement power from the spot market.

As the very reference that Mr. Powers provided as Attachment D to his Declaration states,

> Since a wet tower has a lower capital cost and has a better performance in hot weather, it will be the best choice if sufficient water is available at reasonable cost...Dry cooling saves a lot of water but there is a price to pay for it; the capital cost is significantly greater and there may be plant limitations on the hottest days (*See* Powers Declaration, Attachment D, p. 9)(Exhibit SNC000036).

It would not be reasonable to ask the citizens of Georgia to pay substantial amounts of money up front to build air-cooled units that would produce less electricity and be less reliable than wet-cooled units, especially when those units would be located near the banks of a major river.

In addition to cost and performance implications discussed above, the demand for reliable clean power supply is of utmost concern. An ACC for the current standard AP1000 design with a standard backpressure turbine requires a huge land/footprint area due to the large number of

fans/modules. As stated previously, such a large ACC will be impacted by fluctuating meteorological conditions which can jeopardize unit reliability. (*See* Revised Report, pp. 22-23).

Q28: Mr. Powers states that you gave no reason "why the dry cooled system must match the performance of the standard wet tower system at peak hot day conditions" (Powers Declaration ¶ 14). Please explain your comparison.

A28: The purpose of my testimony is to compare the feasibility of dry cooling to closed cycle wet cooling. I thought it intuitively obvious that I was trying to make an "apples-to-apples" comparison between wet and dry cooling, which to me implies that the comparison should focus, if possible, on a dry cooling system that performs its cooling function as effectively and efficiently as a closed cycle wet cooling system.

To allay any confusion, my Revised Report also compares a smaller ACC configuration that Mr. Powers and the Intervenors posit would work with an AP1000 Nuclear Plant located on the Vogtle site – a position that I do not share. When differences in unit output and consumptive power demand are taken into account, this option does not compare favorably. Using such an ACC would result in a loss of around 55 MW out of the generator at design conditions and would require an additional 9-15 MW of consumptive power versus the current wet system, making the total reduction in unit net output at design conditions at 64-70 MW (approximately 130 MW total for Vogtle 3 and 4). (*See* Revised Report, pp. 22-23).

Q29: Mr. Powers states that nuclear power plants do not serve peak load on hot days and, therefore, the NRC should not be concerned about the loss of output on hot days (Powers Declaration ¶ 21). How do you respond?

A29: Mr. Powers' assertion is a non-sequitor. Suppliers of electricity must balance generation with load. Specific generation sources do not normally serve specific loads, and that

is particularly true of nuclear power plants. As I testified earlier, a nuclear unit, as a base-load plant, operates as much as possible during both peak and non-peak periods. It is nonsense to suggest that nuclear units do not serve peak load on hot days, because on those days *all* generation is serving *all* load. If the nuclear unit were not there, then it would be necessary to bring the smaller, higher cost, units on-line sooner in order to cover the load. Then, it would be necessary to have additional generation capacity, either through additional generation or costly purchases from the spot market, to cover the peak load that would normally be covered by those smaller units. On very hot days, we need to utilize each of our generators to satisfy our customers' demand. As such, the nuclear generation is in the mix of "total load demand" which include peak loads. However, if generation provided from a nuclear unit is not reliable (*i.e.*, due to potential meteorological influences on an ACC), then it may not be considered viable for meeting either base or peaking load demands.

Q30: Mr. Powers says that the increased thermal efficiency of an LM6000 gas-fired unit and the infrequent need to use those units (he claims these units cost $13 million each) would result in almost no impact in the overall cost of electricity (Powers Declaration ¶ 21). Is this as inexpensive an option as Mr. Powers suggests?

A30: No. While it is true that purchasing and building additional gas-fired capacity to offset losses may be an option, Mr. Powers' cost numbers of such generating capacity are a few years old and thus understated. Using a more recent version of the *Gas Turbine World 2007-08 GTW Handbook* that he uses as the basis for the $13 million dollar figure,[12] a more current cost for a 50 MW LM6000 gas turbine is $17.8 million. This increase in cost for the unit, however, is small when compared to the permitting, engineering, real estate, gas pipeline, transmission,

[12] Mr. Powers is using the 2006 version of this annual publication (Powers Declaration ¶ 21 n.2), while I am getting my information from the 2007-2008 version, which is attached (Exhibit SNC000039).

construction, and potential variability in fuel costs associated with putting even a simple-cycle gas turbine generating unit into operation.

A more pertinent point, however, is that, even if one accepts his figures, Mr. Powers is guilty again of comparing "apples-to-oranges." The appropriate comparison in this situation is not the cost of gas-fired generating capacity compared to that of a larger ACC. Instead, Mr. Powers and the Intervenors might offer justification for why it makes sense to spend what they say is an additional $400 million dollars (plus costs for permitting, real estate, etc. as mentioned above) for a smaller ACC and gas turbine to send the same amount of electricity to the grid as a wet-cooled AP1000 Nuclear Plant would at no additional cost.

Q31: Please describe the design changes to the AP1000 Nuclear Plant that would be necessitated by a dry cooling system.

A31: These changes are described in greater detail in my Revised Report, pp. 13-14. In general, if an ACC were to be designed for an AP1000 Nuclear Plant, the current turbine building layout would have to be reworked. In place of the current steam surface condenser, three large ducts would have to be constructed beneath the turbine. Admittedly, I erred in my Initial Report when I suggested that 16'-20' steam ducts would be sufficient to transport the steam from the turbine to the ACC unit. I was basing this on operating experience with smaller, combined-cycle gas generating units and did not account in my analysis for the fact that the exhaust steam flows of those units (typically around 1,300,000 lbs/hr) are small when compared with those of an AP1000 Nuclear Plant (over 8,300,000 lbs/hr total, or around 2,750,000 lbs/hr per duct). After discussing relative steam flows and duct sizes with an ACC manufacturer, it is estimated that the ducts would actually need to be much larger, probably at least 30' in diameter.

Even if they were to fit, an issue which I cannot speak to, these ducts would then have to be run through the walls of the turbine building and outside to a spot a substantial distance away prior to routing the ducts to individual sections of the ACC up to 2000 feet away. This would necessitate changes to the wall of the turbine building and potentially the turbine pedestal. It could also cause layout changes to other equipment in order to provide a path for the steam ducts.

In addition, as shown on Westinghouse preliminary drawings APP-2000-P2-901, -903, and 905, there are six feedwater heaters currently located in the neck of the steam surface condenser on the current AP1000 standard design. Contrary to a condenser, which would have adequate internal bracing and structure to support the heaters, an open duct would not contain the structure necessary to support this equipment. Changing to an air-cooled system would require either an independent support system be constructed within the steam ducts or relocation of all six heaters and their associated piping to a different location within the turbine building (more building space and cost).

Finally, the sheer size of even a "smaller" ACC may dictate a change in the entire plant layout. Trying to fit a dry cooling system that occupies almost ten acres may necessitate moving buildings and/or other equipment external to the turbine building. Indeed, the entire plant site layout may have to be rearranged.

These are all primarily layout issues, but there is a much more significant design issue as well. The DCD Rev. 17 reports in Section 10.2.2.1 that the turbine-generator foundation forms "an integral part of the turbine building structural system...[t]he lateral bracing under the turbine-generator deck also serves to brace the building frame." Modifying the turbine pedestal in any way, whether to accommodate steam ducts or the theoretical "high backpressure" turbine

that Mr. Powers purports would work on an AP1000 plant design (Powers Declaration ¶ 13, would impact the structural framework of the entire turbine building and may require literal redesign of the entire building itself.

Ultimately, Mr. Powers fails to realize that a nuclear power unit is composed of numerous sub-systems including the turbine cycle, steam cycle, cooling cycle, condensate and feed-water cycle, which are all designed to optimize performance (heat rate and generation) based on the unit's thermal cycle. All of these systems would face redesign if an ACC were to be used with the AP1000 or if the steam turbine were changed to accommodate an ACC. Redesigning a power plant with the main purpose of accommodating the cooling cycle (either wet or dry) is analogous to designing an automobile engine to primarily accommodate the radiator.

Q32: Mr. Powers claims that the changes to the plant design "are simply design engineering adjustments necessary to accommodate the air-cooled system" (Powers Declaration ¶ 11). Is he correct that the only changes needed to incorporate a dry cooling system are simple design engineering adjustments?

A32: No. Mr. Powers underestimates the extent of the changes that would be needed. I don't think the changes I just described amount to "simple adjustments." It is true that right now all of these issues are only on paper and thus easier to remedy than after construction begins. However, the impacts to the plant layout will necessitate a substantial amount of engineering on the front end, especially since preliminary drawings of the plant layout have already been issued. Relocating the feed-water heaters and rerouting the associated feed-water piping, steam piping, and condensate drain piping will be a significant change to the existing standard plant design which will require substantial costs and redesign efforts, to say nothing of what it would take to

redesign the entire turbine building structural support system. This would also incur additional engineering and equipment/material costs to Southern Companies that, while small compared to the cost of the plant, will still be an unnecessary expenditure.

Further, costs would be incurred due to the potential operational and safety analyses that changing to an ACC might necessitate. As noted in Section 10.1.2 of DCD Rev. 17, the current Toshiba turbine design and orientation minimize the probability of missile generation and directs potential missiles away from safety-related equipment and structures. Changing the steam turbine to accommodate an ACC would require a re-working of this analysis. It would also cause a similar effort on Chapter 11 of the DCD, as removing the condensing mechanism from the turbine building and placing it in the open air where a tube leak would vent straight to the atmosphere would most certainly impact the analysis of primary-to-secondary system leakage.

In conclusion, it would appear that Mr. Powers has a rather narrow perspective if he considers these design alterations as simple changes.

Q33: Mr. Powers says that dry cooling does not require steam condensers and that removing them will make room for dry cooling at the Vogtle site (Powers Declaration ¶ 16). Is his assertion correct?

A33: Removing the steam condensers *might* create enough room for the steam ducts necessary to carry the steam to an ACC; but Mr. Powers provided no backup data. Moreover, I cannot say that conclusively based on the information I have seen. Additionally, the feed-water heaters currently located in the neck of the condenser would have to be put somewhere else. These heaters are 5-6 foot diameter cylindrical heaters on the order of 45-55 feet long each. Six would take up 170-330 feet.

As stated previously, plant and/or equipment design changes associated with eliminating the steam surface condenser will require significant changes to the existing standard plant design which will require substantial costs and redesign efforts.

Q34: Mr. Powers contends that you admitted in your Initial Report that a dry cooling system would entail a simpler design (Powers Declaration ¶ 17). Did you make that admission?

A34: No. I was speaking specifically of the thermodynamic process involving an air-cooled system as being simpler than a wet-cooled system due to its lack of an intermediate heat transfer step. I never suggested that mechanical operation of an air-cooled condenser with an AP1000 Nuclear Plant would be simpler than unit operation with a wet tower system. In fact, I detailed multiple operational complexities that would ensue from using dry cooling, as I testify herein. I reiterate from the quote I read before:

> Both direct and indirect dry cooling systems…are larger and mechanically more complex than corresponding wet cooling systems...[D]ry and hybrid cooling systems will have more fans, meaning more electrical motors, gearboxes and drive shafts. As such, labor requirements for a large ACC can be substantial.[13]

While the thermodynamic process may be simpler for an ACC system, it would be erroneous to conclude that it would enable a simpler cooling system. Mr. Powers again suggests interchangeability of wet/dry systems with almost total disregard for basic power plant thermal cycle fundamentals and turbine technology.

Even if operation with an ACC were simpler, in a power plant as in real life, there are often times when simpler is not better.

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[13] *See* Micheletti and Burns, at p. 5.

Q35: Mr. Powers claims that the cooling system does not form part of the standard design, but serves only as a point of departure (Powers Declaration ¶¶ 10, 12). Why does replacing the closed-cycle wet cooling system, in fact, alter the standard design?

A35: I testified earlier that using dry cooling would require a different turbine and even Mr. Powers admits that the steam turbine does form part of the standard design. Mr. Powers, in fact, says explicitly that "the standard design accommodates any cooling system, wet or dry, as long as the cooling system maintains the steam turbine backpressure *within the design limitations of the steam turbine established by Westinghouse Nuclear in its standard AP1000 design*" (Powers Declaration ¶ 12 (emphasis added)).

Mr. Powers' Declaration contradicts the AP1000 DCD, since the AP1000's standard design as specified in DCD Rev. 17 currently employs a specific turbine with specific physical characteristics, a specific orientation, and a specific support structure that is integral to that of the entire turbine building. Yet, as we previously discussed here, he suggested use of an ACC with a design backpressure of 8.0" HgA for the new Vogtle units.

Q36: Mr. Powers says that every plant requires modifications from the standard design to suit differences at each site and that he considers dry cooling one such typical modification. Is this a "typical" modification? (Powers Declaration ¶¶ 9, 11)

A36: No. As I have discussed at great length and as detailed in my Revised Report, the modifications to the standard design would not stop there (*See* Revised Report, pp. 16-17, 20-22). Changing the cooling system on an AP1000 Nuclear Plant as specified in DCD Rev. 17 would result in 1) mandating a change in the steam turbine to a design that does not exist or 2) spending exorbitant money both in up front costs and in higher maintenance costs over the life of the plant and potentially changing the entire plant layout only to suffer lower unit output the

majority of the year, higher consumptive power demands the entire year, at a minimum, less unit reliability and, at worst, outright shutdowns during times of critical power demand. I would not consider either set of circumstances "typical."

Q37: Are true, accurate and correct copies of each of the exhibits heretofore referenced in your testimony attached to this pre-filed written testimony, and do they accurately portray the facts they purport to portray?

A37: Yes.

Q38: Are Exhibits SNC000033, SNC000034, SNC000035, SNC000036, and SNC000039 scholarly or learned journals, articles or treatises commonly relied upon in your profession?

A38: Yes.

Q39: Does this conclude your testimony?

A39: Yes.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	Docket No. 52-011-ESP
	)	
Southern Nuclear Operating Company	)	ASLBP No. 07-850-01-ESP-BD01
	)	
(Early Site Permit for Vogtle ESP Site)	)	January 9, 2009

AFFIDAVIT OF JAMES W. CUCHENS IN SUPPORT OF SOUTHERN NUCLEAR'S PRE-FILED TESTIMONY ON ENVIRONMENTAL CONTENTION 1.3

I, James W. Cuchens, do hereby state as follows:

1. I am employed by Southern Company Generation as a Principal Engineer. A statement of my professional qualifications is attached to the SNC pre-filed testimony to be submitted on January 9, 2009, in response to hearing issues identified by the Board.

2. I have read the foregoing prepared testimony regarding environmental matters at the Plant Vogtle Site.

3. I attest to the accuracy of those statements, support them as my own, and endorse their introduction into the record of this proceeding. I declare under penalty of perjury that those statements, and my statements in this affidavit, are true and correct to the best of my knowledge, information and belief.

James W. Cuchens
James W. Cuchens

Subscribed and sworn to before me
this 9th day of January, 2009.

[signature]
Notary Public

MY COMMISSION EXPIRES 10/11/2012

Part VII
Appendix J

Gray Water Study for Lee Nuclear Site

Introduction

Duke Energy investigated the use of gray water from the Gaffney Board of Public Works wastewater treatment plants (WWTPs) as an alternate source of water for Lee Nuclear Station during periods of low flow in the Broad River. There are two WWTPs located in the city of Gaffney in Cherokee County, South Carolina within the Lee Nuclear Station area. The Clary WWTP is located on the west side of Gaffney and the Broad River WWTP is located on the east side of Gaffney.

The term "gray water" refers to the treated effluent from the wastewater treatment plants. Typically, "gray water" refers to septic tank effluent or primary clarifier effluent in which the solids have been removed but the "gray water" still has high BOD and other characteristics. The treated effluent from the plants will be much cleaner and will have much better water quality than typical "gray water" (Summit Engineering Group Inc. 2010).

Gray Water Study

A study of the feasibility of piping wastewater effluent from both of the Gaffney Board of Public Works WWTPs to the proposed Duke Energy Pond C located near the Lee Nuclear Station site was performed. This study included the following:

- Conceptual routing of pipelines from both the Clary WWTP and the Broad River WWTP to Pond C
- Proposed locations of pump stations
- Preliminary sizing of pump stations (based on conceptual routings of pipelines)
- Preliminary sizing of pipelines from WWTPs to Pond C (based on conceptual routings of pipelines and maximum design flow for WWTPs)
- Proposed location for outlet structures at Pond C
- Estimated cost for construction of the pipelines, pump stations and outlet structures
- Estimated timeline for detailed engineering, permitting and construction.

Piping wastewater effluent from the Clary WWTP to Pond C includes a new gray water force main, new gray water pump station and an outlet structure at Pond C. The new gray water force main will be 24 inches in diameter and will be approximately 54,500 feet (10 +/- miles) long. The routing of the pipeline will be a mixture of private easements and highway right-of-way and includes two major gas line crossings, one railroad crossing and approximately eleven creek/stream crossings. All of these crossings will present additional permitting requirements (Summit Engineering Group Inc. 2010).

Piping wastewater effluent from the Broad River WWTP to Pond C includes a new gray water force main, new gray water pump station and an outlet structure at Pond C. The new gray water force main will be 18 inches in diameter and will be approximately 12,300 feet (2.33 +/- miles) long. The routing of the pipeline will be a mixture of private easements and highway right-of-way and includes one railroad crossing and approximately two creek/stream crossings. All of these crossings will present additional permitting requirements (Summit Engineering Group Inc. 2010).

The conceptual routings of the new gray water force mains from both the Clary WWTP and the Broad River WWTP to Pond C are shown on Figure 1. Costs were estimated to be in the range of $17.5 million to $22 million for both force mains, pump stations and outlet structures at Pond C; however, these costs do not include costs associated with the acquisition of the private easements that will be needed. An overall schedule duration of 24 months was estimated to complete a project of this scope of work (engineering. permitting and construction); however, the time required to acquire the required private easements was not included in this duration (Summit Engineering Group Inc. 2010).

Gray Water Alternative

The Clary WWTP has a permitted maximum capacity of 7.7 cfs (5.0 MGD) and current utilization of 4.6 cfs (3.0 MGD). The Broad River WWTP has a permitted maximum capacity of 6.2 cfs (4.0 MGD) and a current utilization of 2.5 cfs (1.6 MGD) (Duke Energy 2009). The combined maximum capacities of 13.9 cfs (9.0 MGD) and the combined utilization rates of 7.1 cfs (4.6 MGD) from the Clary and Broad River WWTPs are insufficient to meet the Lee Nuclear Station average consumptive water requirement of 55 cfs (35.3 MGD). Consequently, this alternative was deemed not feasible and was eliminated from further analysis.

References

Duke Energy, 2009, William States Lee III Nuclear Station COL Application, Part 3 Environmental Report, Revision 1, March 2009.

Summit Engineering Group Inc, 2010, Gray Water Study for the Lee Nuclear Site, March 2010.

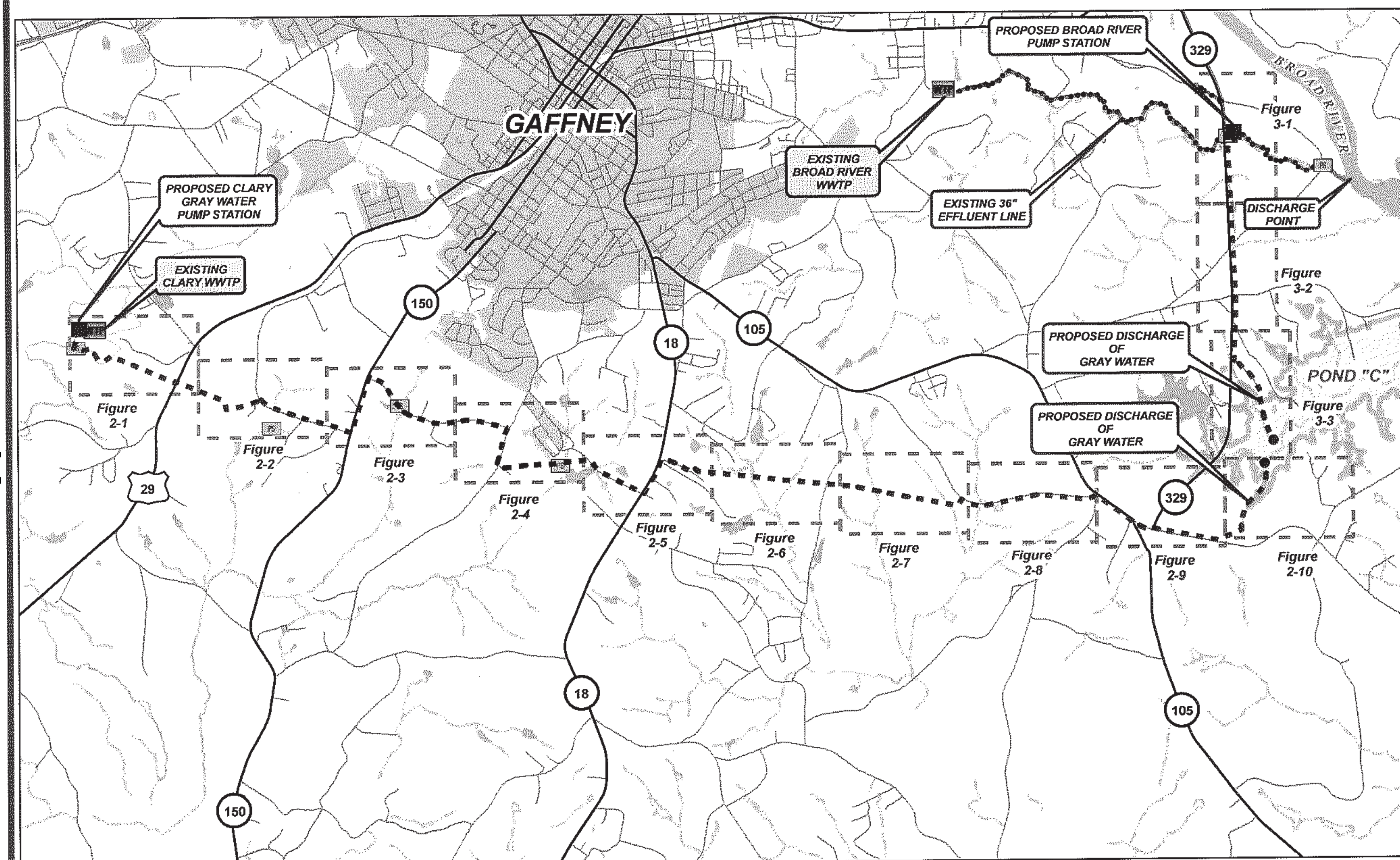

Figure 1

DUKE ENERGY GRAY WATER STUDY

OVERALL MAP

Duke Energy Confidential – Business Proprietary

Part VII
Appendix K

Broad River Downstream of the Ninety-Nine Islands Dam

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§ 316(b) COMPLIANCE DEMONSTRATION
FOR WILLIAM S. LEE III NUCLEAR STATION

APPENDIX K

BROAD RIVER DOWNSTREAM OF THE NINETY-NINE ISLANDS DAM

Prepared by:

AKRF, Inc.
7250 Parkway Drive
Hanover, MD 21076

July 21, 2011

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List of Acronyms, Defined Terms, and Abbreviations

cfs	cubic feet per second
Duke Energy	Duke Energy Carolinas, LLC
Duke Power	Duke Power Company
ESA	Endangered Species Act
ft	feet
Lee Nuclear Station	William S. Lee III Nuclear Station
MGD	million gallons per day
mi	miles
Proportional Flow Limitation	40 CFR § 125.84(b)(3)(i)
RRCC	Robust Redhorse Conservation Committee
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
sq mi	square miles
USGS	United States Geological Survey

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1.0 INTRODUCTION AND BACKGROUND

Duke Energy Carolinas, LLC (Duke Energy) is submitting a § 316(b) Compliance Demonstration for William S. Lee III Nuclear Station (Lee Nuclear Station). In this demonstration, Duke Energy is requesting that the South Carolina Department of Health and Environmental Control (SCDHEC) grant an alternative limit to the requirements of 40 CFR § 125.84(b)(3)(i), referred to as the Proportional Flow Limitation. As discussed in Section 3.2 of Duke Energy's § 316(b) Compliance Demonstration, the Alternative Requirement Duke Energy is seeking is necessary to protect local water resources, and in particular the Broad River below the Ninety-Nine Islands Dam, by restricting consumptive withdrawals during low flow conditions. This Appendix describes the lower Broad River and its resources that will be protected if SCDHEC grants Duke Energy's request for an Alternative Requirement.

2.0 HYDROLOGY

Approximately 950 square miles (sq mi) of the Upper Broad River Basin Watershed lie downstream of the Lee Nuclear Site. The Broad River bedform downstream of Ninety-Nine Islands Dam consists of a long, continuous shallow riffle, which gives way to alternating pools and riffles farther downstream. Downstream of the Irene Bridge, the Broad River bedform is dominated by large pools, with diminishing riffles (Duke Energy 2009).

A United States Geological Survey (USGS) stream gauging station located just below Ninety-Nine Islands Dam continuously monitors stream flow to the Broad River (USGS Gauging Station 02153551 below Ninety-Nine Islands Reservoir, South Carolina) (Figure K-1) (USGS 2011). The mean annual flow between 2001 and 2010[1] was 1,947 cubic feet per second (cfs) [1,258.4 million gallons per day (MGD)]. The annual mean flow ranged from 834 cfs (539.0 MGD) in 2008 to 4,255 (2,750.1 MGD) cfs in 2003. Daily mean flow ranged from 42 cfs (27.1 MGD) on August 23, 2008 to 60,000 cfs (38,779.2 MGD) on September 9, 2004.

[1] The data from October 20, 2010 through December 31, 2010 is still considered provisional by USGS.

3.0 AQUATIC COMMUNITY

The Broad River aquatic community downriver of the Ninety-Nine Islands Reservoir is typical of a warmwater Piedmont river. The sections of the river above and below the Ninety-Nine Islands Reservoir are similar lotic ecosystems, while the Ninety-Nine Islands Reservoir more closely resembles a lentic ecosystem. The downstream river has more habitat diversity than the reservoir. These habitats include, but are not limited to, the river channel, riffles, rocks, detrital vegetation, and overhanging vegetation. Boat electrofishing collections in the Broad River downstream of the Ninety-Nine Islands Reservoir in 2001-2002 were numerically dominated by redbreast sunfish (*Lepomis auritus*), sandbar shiner (*Notropis scepticus*), and silver redhorse (*Moxostoma collapsum*), while backpack electrofishing at the same time was dominated by whitefin shiner (*Cyprinella nivea*), sandbar shiner, thicklip chub (*Hybopsis labrosa*), and spottail shiner (*Notropis hudsonius*) (Bettinger et al. 2003). Electrofishing collections in 2006 in the river downstream of the Ninety-Nine Islands Reservoir were numerically dominated by snail bullhead (*Ameiurus brunneus*), spottail shiner, whitefin shiner, and northern hogsucker (*Hypentelium nigricans*) (Duke Energy 2009). Insects (e.g., midges, caddisflies, and mayflies) are quite abundant and represent the largest group of macroinvertebrates in this section of the Broad River. More limited populations of other benthos (e.g., mussels) and phytoplankton are also present.

3.1 FISHES

The Broad River downstream of the Ninety-Nine Islands Dam contains an abundance of fish species. There are fewer backwater areas than in the river upstream from the Ninety-Nine Islands Dam. The most common species in the slower moving, deeper sections of the downstream Broad River are sunfish, suckers, catfish/bullheads, and bass (*Micropterus sp*), as well as smaller species such as shiners. In the shallower riffles, runs, and shoreline areas; smaller fish, such as shiners, chubs, and darters are the dominant species. Fantail darters (*Etheostoma flabellare*), a South Carolina fish of special concern, are likely present below the Ninety-Nine Islands Dam (Bettinger et al. 2003). A number of studies were conducted, dating back to the 1970s, which examined fish populations in the vicinity of Lee Nuclear Station. Results of these studies are discussed in detail in Appendix A.

3.2 BENTHOS

The benthic community in the river downstream of the Ninety-Nine Islands Reservoir is similar to that of the Broad River above the reservoir. Both the river upstream and downstream of the reservoir have higher benthic biodiversity than the reservoir itself because of the diversity of habitats located within those areas. The dominant benthos are insects that include midges (Diptera), caddisflies (Trichoptera), mayflies (Ephemeroptera), and dragonflies and damselflies

(Odonata). At least three species of mussels are present below the reservoir. Mussel population and diversity are greater below the reservoir than in or above it. A number of studies were conducted, dating back to the 1970s, which examined macroinvertebrate populations in the vicinity of Lee Nuclear Station. Results of these studies are discussed in detail in Appendix A.

3.3 PHYTOPLANKTON

Phytoplankton are autotrophic, planktonic organisms. The phytoplankton composition and abundance downstream of the Ninety-Nine Islands Reservoir are similar to those found upstream. Phytoplankton in the Broad River are primarily comprised of diatoms and blue-green algae (cyanobacteria). Because photosynthesis is essential for their existence, turbid rivers such as the Broad River can only sustain phytoplankton at the surface or in shallow water. This limits the significance of their role within the aquatic community (Duke Power 1975).

3.4 PROTECTED SPECIES

No federally-listed threatened or endangered species under the Endangered Species Act (ESA), ESA candidate species, or species of concern for Cherokee County were collected by the South Carolina Department of Natural Resources (SCDNR) in surveys performed in 2001 and 2002 downstream of Ninety-Nine Islands Reservoir in the Broad River (Bettinger et al. 2003). However, a few fantail darters, a South Carolina fish of special concern, were collected in the same area in SCDNR backpack electrofishing surveys. Bettinger et al. (2003) recognize that this species is abundant throughout its range outside of South Carolina; however, only one population has been identified at one location in the Broad River. Based on the rarity of this fish in SCDNR's collections, fantail darter have been included on the South Carolina Heritage Trust List of fishes of special concern.

The Cherokee Nuclear Station Environmental Report (Duke Power 1975) discussed collection of seven robust redhorse at the confluence of the Broad River and King's Creek immediately downstream of the Ninety-Nine Islands Reservoir. Further evaluation and identification by taxonomic experts revealed that the report was a result of misidentification due to incomplete understanding of the taxonomy of the species (Duke Energy 2009).

Although the robust redhorse had been under consideration in the early 1990s for listing under the ESA, voluntary efforts to conserve this species were already underway. Therefore, the species was not listed under the ESA. The Robust Redhorse Conservation Committee (RRCC) was formally established in 1995 under a Memorandum of Understanding between State and Federal resource agencies, private industry, and the conservation community to work proactively to aid the robust redhorse population in its recovery across its historic range. A plan entitled Conservation Strategy for the Robust Redhorse (Nichols 2003), providing overall guidance to ensure the continued

survival of the species, was adopted by the RRCC in 1998 and updated by Nichols in 2003. During the fall of 2004, SCDNR stocked 18,920 robust redhorse fingerlings (5-6 inches) in the Broad River below the Neal Shoals and Parr Shoals Reservoirs (Self and Bettinger 2011). In 2007, the RRCC Habitat Technical Working Group published the Habitat Restoration Management Plan for the Robust Redhorse (RRCC Habitat Technical Working Group 2007). This guidance prioritizes restoration sites and facilitates suitable habitat restoration activities for specific individual river basins.

4.0 WETLANDS/OTHER PROTECTED LANDS

Wetlands within 3,000 feet (ft) from the edges of the Broad River in the 20-mile (mi) reach downstream from the Ninety-Nine Islands Dam were identified using the United States Fish and Wildlife Service's National Wetland Inventory map and mapped streams information from SCDNR (Table K-1) (USFWS 2009). A total of 499 wetlands covering approximately 1,619 acres were found within this 20 mi reach.

5.0 OTHER DOWNSTREAM USERS OF THE BROAD RIVER

The Broad River downstream of the Lee Nuclear Site supports a number of uses, including potable water supply, industrial water supply, impoundments, and various recreational uses. Three permitted surface water intakes, two of which are for public water supply, are located downstream of the Lee Nuclear Site (Figure K-2 and Table K-2) (Duke Energy 2009). However, these intakes are also located downstream of the Pacolet River's confluence with the Broad River; therefore, they are not totally dependent upon releases from the Ninety-Nine Islands Reservoir. The closest intake is for the City of Union, South Carolina, which withdraws water from the Broad River 21 mi downstream from the proposed Lee Nuclear Site and has a maximum withdrawal rate of approximately 37 cfs (23.8 MGD). The intake for Carlisle Cone Mills is located approximately 30 mi downstream and has a withdrawal capacity of approximately 13 cfs (8.1 MGD) (Duke Energy 2009). The V.C. Summer Nuclear Station is approximately 52 mi downstream from the proposed Lee Nuclear Station and withdraws approximately 5 cfs (3.1 MGD) from the Broad River; however, its main cooling water intake structure is located on the Monticello Reservoir.

The Broad River downstream of the Ninety-Nine Islands Dam is also used for various recreational activities. The current recreational uses of the Broad River include: fishing, boating, rafting, tubing, swimming, nature study, photography, and bird watching. Hunting and trapping are also common outdoor activities along the river. The entire length of the corridor from the Ninety-Nine Islands Hydroelectric Station to the confluence with the Pacolet River is considered navigable waters. The South Carolina Rivers Assessment, prepared by the South Carolina Water Resources Commission in 1988, reports the Broad River as locally significant in the "Backcountry Boating" and the "Flatwater Boating" categories. It also rated the Broad River as a significant resource in the "Recreational Fishing," "Historic and Cultural," "Inland Fisheries," "Undeveloped," "Water Supply," "Wildlife Habitat," "Timber Management," "Utilities," and "Industrial" categories. There are two public access points within the 15 mi downstream of the Ninety-Nine Islands Dam: the Ninety-Nine Islands Boat Landing, and the Cherokee Landing (Broad Scenic River Advisory Council 2003).

6.0 REFERENCES

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Tables

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Table K-1.

Wetlands within 20 Miles Downstream of the Ninety-Nine Islands Dam and the Proposed Lee Nuclear Station

Miles Downstream from the Ninety-Nine Islands Dam	Number of Wetlands	Size (Acres)
0.00-1.00	32	72.022
1.01-2.00	17	66.453
2.01-3.00	10	55.080
3.01-4.00	20	64.274
4.01-5.00	19	45.896
5.01-6.00	11	36.506
6.01-7.00	33	89.354
7.01-8.00	18	37.286
8.01-9.00	31	81.400
9.01-10.00	22	87.978
10.01-11.00	12	45.302
11.01-12.00	11	34.297
12.01-13.00	21	72.411
13.01-14.00	49	118.750
14.01-15.00	47	131.780
15.01-16.00	25	134.560
16.01-17.00	18	106.800
17.01-18.00	28	101.470
18.01-19.00	39	115.160
19.01-20.00	36	122.020
Total	499	1618.799

Source: USFWS 2009

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Table K-2 (Sheet 1 of 2)
Area Surface Water Intakes in the Upper Broad River Watershed

Facility	County, State	Distance		Source	Withdrawal Capacity		Consumptive Use[a]		Use Type
		mi.[b]	Direction		Mgd	cfs	Mgd	cfs	
Gaffney BPW	Cherokee, SC	8	Upstream	Lake Whelchel	12	18.6	NIA	NIA	Public Supply
Gaffney BPW	Cherokee, SC	9	Upstream	Broad River	(c)	(c)	NIA	NIA	Public Supply
CNA Holdings, Inc. – Ticona-Shelby	Cleveland, NC	12	Upstream	Buffalo Creek	1.15	1.78	0.290	0.45	Industrial
Shelby	Cleveland, NC	13	Upstream	Broad River	10 [d]	15.5	0	0	Public Supply
Northbrook Carolina Hydro, LLC – Stice Shoals Plant	Cleveland, NC	14	Upstream	First Broad River	(e)	(e)	(e)	(e)	Instream Hydro
Martin Marietta Materials, Inc	Cleveland, NC	16	Upstream	Storm Water Quarry	0.23	0.36	0	0	Industrial
Kings Mountain	Cleveland, NC	17	Upstream	Moss Lake	37.6	58.3	1.611	2.50	Public Supply
Cleveland County Country Club	Cleveland, NC	18	Upstream	Lake/Pond	1.15	1.79	0.047	0.07	Golf Course
Shelby	Cleveland, NC	19	Upstream	First Broad River	18	28	2.424	4	Public Supply
Duke Energy Corp. – Cliffside Steam Station	Cleveland, NC	19	Upstream	Broad River	288	446	75	116	Industrial
Duke Energy Corp. – Cliffside Steam Station (planned)[f]	Cleveland, NC	19	Upstream	Broad River	32	50	20.645	32	Industrial
Cleveland-Caroknit	Cleveland, NC	25	Upstream	First Broad River	1	1.55	0.017	0.03	Industrial
Mako Marine International (formerly ITG/Burlington Industries – J.C. Cowan Plant)	Rutherford, NC	26	Upstream	Second Broad River	3	4.65	0.07	0.11	Industrial
Cleveland County Sanitary District	Cleveland, NC	27	Upstream	First Broad River	6	9.63	3.364	5.21	Public Supply
Cleveland County Sanitary District (planned)	Cleveland, NC	27	Upstream	Knob Creek	6	9.3	3.445	5.3	Public Supply
Forest City	Rutherford, NC	31	Upstream	Second Broad River	12	18.60	1.483	2.30	Public Supply

Source: Duke Energy 2009.

Table K-2 (Sheet 2 of 2)
Area Surface Water Intakes in the Upper Broad River Watershed

Facility	County, State	Distance mi.[b]	Distance Direction	Source	Withdrawal Capacity Mgd	Withdrawal Capacity cfs	Consumptive Use[a] Mgd	Consumptive Use[a] cfs	Use Type
Broad River Water Authority (formerly Rutherfordton-Spindale)	Rutherford, NC	33	Upstream	Broad River	13	20.15	4.733	7.34	Public Supply
Northbrook Carolina Hydro, LLC – Turner Shoals Plant	Polk, NC	43	Upstream	Green River	(e)	(e)	(e)	(e)	Instream Hydro
Duke Energy Corp. – Tuxedo Hydro	Henderson, NC	52	Upstream	Lake Summit	(e)	(e)	(e)	(e)	Instream Hydro
Kenmure Country Club	Henderson, NC	54	Upstream	King Creek	0.82	1.26	0.97	1.50	Golf Course
V.C. Summer Nuclear Station	Fairfield, SC	52	Downstream	Lake Monticello	3.1	4.81	NIA	NIA	Industrial
V.C. Summer Nuclear Station (Planned)	Fairfield, SC	52	Downstream	Lake Monticello	NIA	NIA	NIA	NIA	Industrial
Carlisle Cone Mills	Union, SC	30	Downstream	Broad River	8.1	12.56	NIA	NIA	Public Supply
City of Union	Union, SC	21	Downstream	Broad River	23.8	36.89	NIA	NIA	Public Supply

a) Consumptive use based on reported withdrawals and returns from 1999 registration and 2002 LWSP reports.

b) Distance provided is a linear distance and not river miles.

c) The Gaffney BPW (Board of Public Works) system is authorized 18 Mgd and uses Lake Whelchel for storage.

d) The Shelby Broad River intake is used as a temporary emergency supply intake.

e) Instream hydro facilities maximum use rate not reported. Instream water use indicates water is returned directly to source. Additional hydro facilities are present within watershed, but no withdrawal permits exist.

f) Additional Cliffside Steam Plant use rate is based on anticipated expansion of 1 unit. “Planned” figures include the consumption of the existing Cliffside Unit 5 (15 cfs) and the planned expansion Unit (17 cfs).

See Figure K-2 NIA - No Information Available

Source: Duke Energy 2009.

Figures

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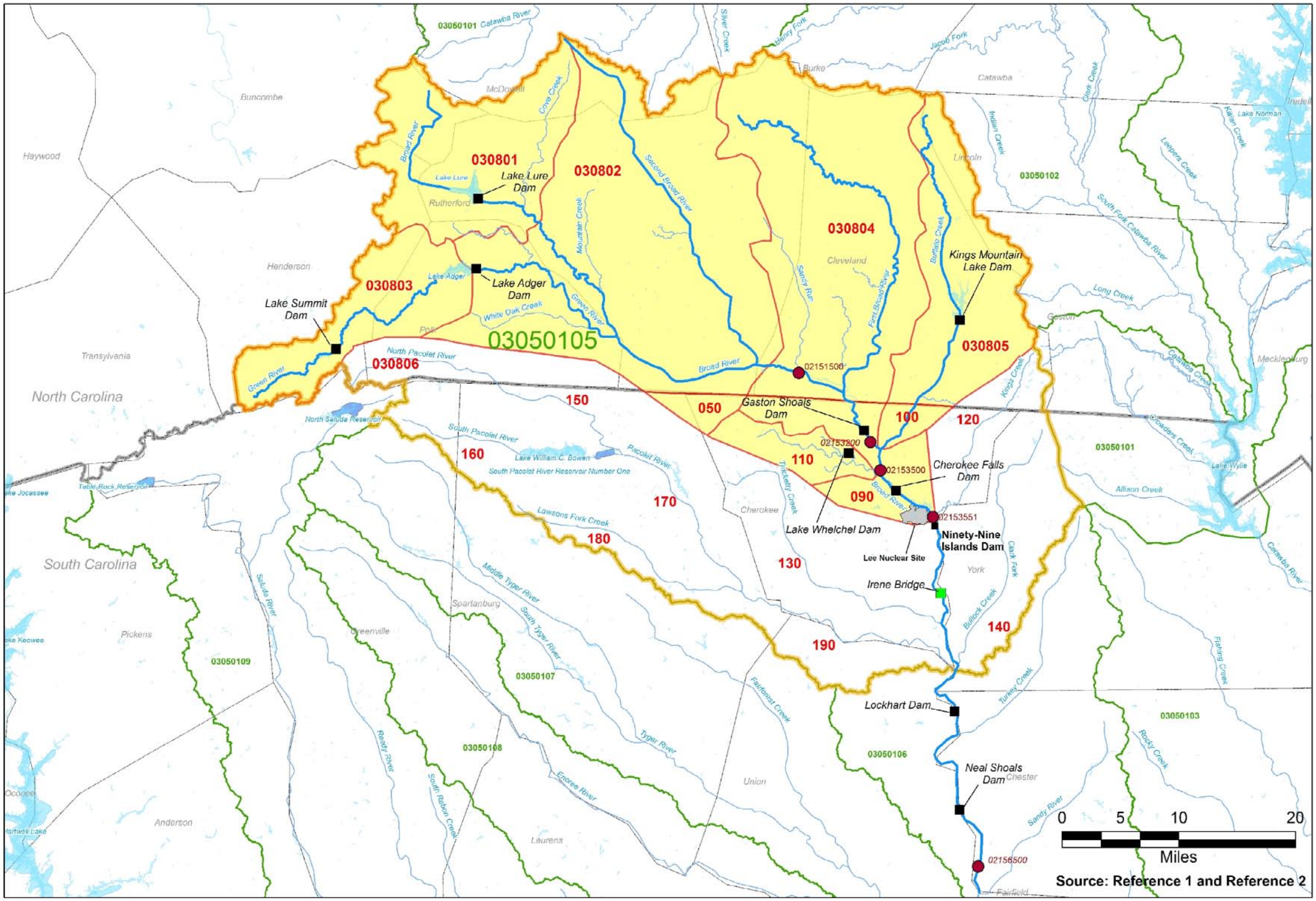

Legend

Gauging Stations	Other Rivers	Counties
Dam	Upper Broad River Basin	Santee Subbasins
Bridge	Lee Nuclear Site	Lake
Broad River (and major tributaries above Ninety-Nine Islands Dam)	Affected Subbasins	Reservoir

See Table 2.3-1 and Table 2.3-2

Hydrologic Unit 03050105

(Duke Energy 2009)

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Upper Broad River
Basin and Subbasins

FIGURE K-1

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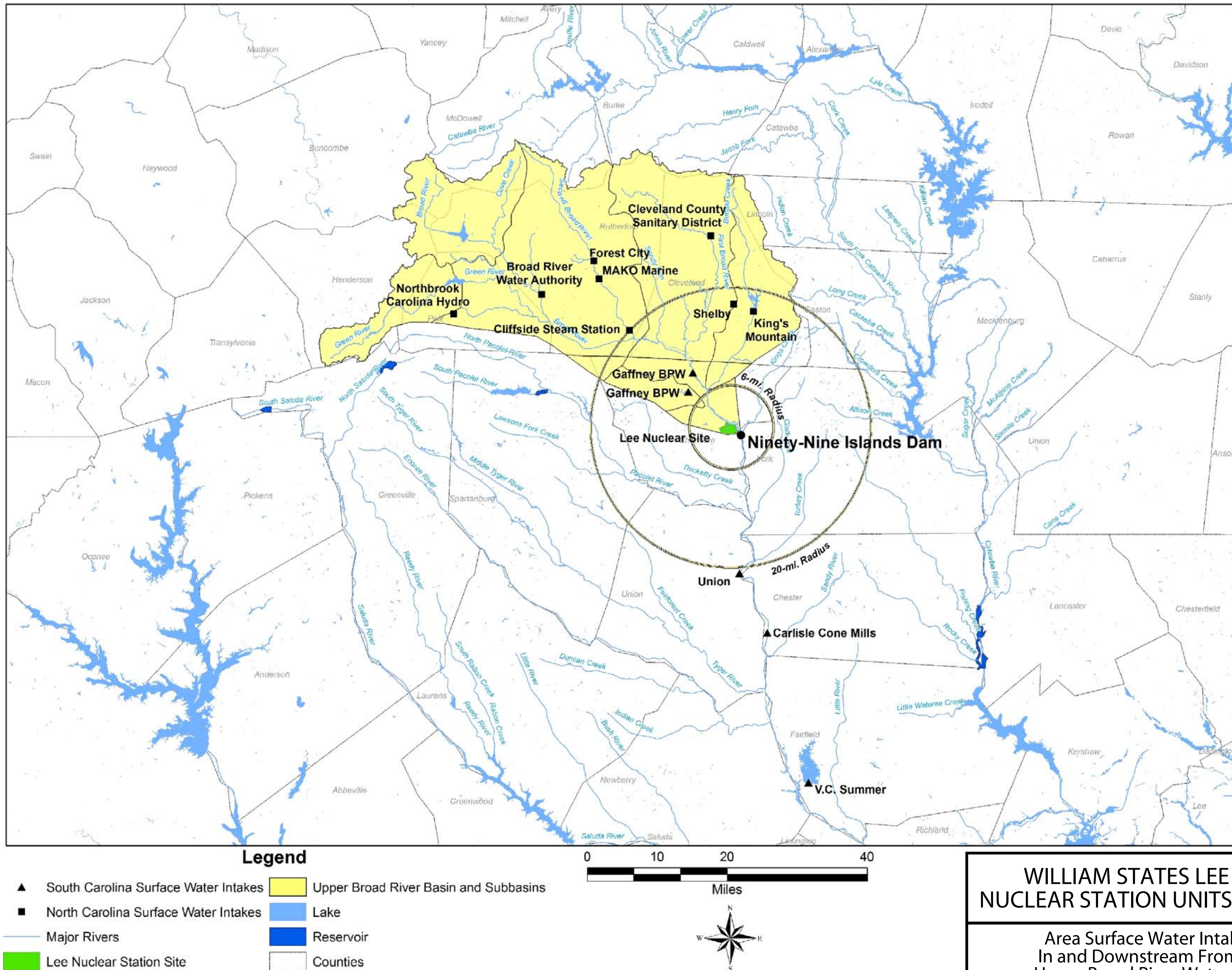

(Duke Energy 2009)

WILLIAM STATES LEE III
NUCLEAR STATION UNITS 1 & 2

Area Surface Water Intakes In and Downstream From the Upper Broad River Watershed

FIGURE K-2

§ 316(b) COMPLIANCE DEMONSTRATION
FOR
WILLIAM S. LEE III NUCLEAR STATION

APPENDIX L

ENTRAINMENT ASSESSMENT

Prepared by:

AKRF, Inc.
and
Duke Energy Carolinas, LLC

July 20, 2011

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List of Acronyms, Defined Terms and Abbreviations

cfs	cubic feet per second
CPUE	catch per unit effort
Duke Energy	Duke Energy Carolinas, LLC
EPA	United States Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
Lee Nuclear Station	William S. Lee III Nuclear Station
Phase I Rule	§316(b) Rule for New Facilities
WMP	Water Management Plan

1.0 INTRODUCTION AND BACKGROUND

The purpose of this assessment was to compare levels of entrainment that would be likely to occur at Duke Energy Carolinas, LLC's (Duke Energy) proposed William S. Lee III Nuclear Station (Lee Nuclear Station) under two water withdrawal scenarios:

- the United States Environmental Protection Agency (EPA) Track I Scenario: Constant daily water withdrawal rate, year-round, equal to 5% of the ten-year average annual flow of the Broad River in the vicinity of Lee Nuclear Station [i.e., 98 cubic feet per second (cfs)], as allowed by EPA's §316(b) Rule for New Facilities (Phase I Rule) Track I compliance path; and
- Duke Energy's Water Management Plan (WMP): Maximum daily water withdrawal rate March through June equal to 98 cfs[1]; maximum daily water withdrawal rate July through February equal to 304 cfs[2]; and no withdrawals that would cause the Broad River flow to drop below 543 cfs.[3]

The assessment was conducted using reported daily Broad River flows from 2001 through 2010 (HDR/DTA 2011).

Likely levels of entrainment were estimated by considering the proportion of the Broad River flow past Lee Nuclear Station that would be withdrawn during the period of entrainment vulnerability for fish inhabiting the Broad River in the vicinity of Lee Nuclear Station. The assessment was intended to compare levels of entrainment that would be likely under Duke Energy's WMP to the likely levels of entrainment that would be allowed under EPA's interpretation of §125.84(b)(3)(i) of the Phase I Rule. Accordingly, the assessment focused only on entrainable organisms moving past the Lee Nuclear Station site, and estimates of river-wide population abundance were not required.

The approach for identifying the period of entrainment vulnerability for fish in the Broad River, in the vicinity of Lee Nuclear Station, utilized empirical data from the Broad River and the Ninety-Nine Islands Reservoir, and life history information from the scientific literature. Empirical data on fish larvae were used to characterize the temporal patterns of abundance of the larvae of fish species that inhabit the Broad River in the vicinity of the Lee Nuclear Station

[1] 5% of the ten-year average annual flow of the Broad River in the vicinity of Lee Nuclear Station, as allowed by EPA's Phase I Rule.

[2] Includes 23 cfs intake screen wash water and 6 cfs refill pump screen wash water that is returned to the river.

[3] Federal Energy Regulatory Commission (FERC) minimum flow requirement of 483 cfs plus 60 cfs contingency for future upstream water use.

site. Empirical data on older fish were used to characterize the relative abundance of the fish species that utilize the Broad River for spawning. Life history information from the scientific literature was used to confirm the empirical observations on temporal patterns of larval abundance by considering documented spawning seasons, fecundity rates (i.e., eggs per female fish), life stage durations and natural mortality rates for the fish species that were collected in the empirical studies.

A key source of empirical data on fish larvae was a study conducted in the Broad River and Ninety-Nine Islands Reservoir in 1976 (Cloutman and Edwards 1977). Larvae were collected with ichthyoplankton nets in weekly or biweekly sampling that was conducted from late April through September. The relative abundance of older ages of fish in the Broad River adjacent to the Lee Nuclear Station site was characterized in a four-season study conducted in the Broad River and Ninety-Nine Islands Reservoir in 2006 (Duke Energy 2009). Fish were collected by electrofishing in February, April, July and October. Life history information in the scientific literature was found through a detailed literature search which identified many citations.

2.0 METHODS

2.1 PROPORTION OF LARVAE ENTRAINED

The number of larvae of species, *k*, that would pass the Lee Nuclear Station site on each day, *t*, is proportionate to density ($D_{k,t}$) and river flow (F_t):

$$PASS_{k,t} = b_1 \times D_{k,t} \times F_t \quad (1)$$

where b_1 is a proportionality constant.

The number of larvae of species, *k*, that would be entrained on each day, *t*, is proportionate to density and station withdrawal rate (G_t):

$$ENT_{k,t} = b_1 \times D_{k,t} \times G_t \quad (2)$$

The proportion of all larvae that pass by the Lee Nuclear Station site annually that would be entrained is equal to the ratio of the annual number entrained and the annual number passing the site:

$$P_k = \frac{\sum_t ENT_{k,t}}{\sum_t PASS_{k,t}} = \frac{\sum_t D_{k,t} G_t}{\sum_t D_{k,t} F_t} \quad (3)$$

The proportionality constant (b_1) cancels in the ratio.

The density of larvae in the river can be expressed in terms of the number of larvae passing the site and the flow rate past the site:

$$D_{k,t} = \frac{N_{k,t}}{F_t} \quad (4)$$

Therefore, the annual proportion of larvae entrained is a weighted average of the daily proportion of river flow that is withdrawn:

$$P_k = \frac{\sum_t D_{k,t} G_t}{\sum_t D_{k,t} F_t} = \sum_t \left(\frac{N_{k,t}}{\sum_t N_{k,t}} \right) \frac{G_t}{F_t} = \sum_t W_{1,k,t} \frac{G_t}{F_t} \quad (5)$$

where the daily weighting factor ($W_{1,k,t}$) is the fraction of total larval-days for species, *k*, that occurs on day, *t*. The daily weighting factor contains no information on the magnitude of larval abundance, only the temporal pattern.

Over multiple species, the overall proportion of larvae entrained is a weighted average of the species-specific proportions entrained:

$$P = \frac{\sum_k \sum_t D_{k,t} G_t}{\sum_k \sum_t D_{k,t} F_t} = \sum_k \sum_t \left(\frac{N_{k,t}}{\sum_k \sum_t N_{k,t}} \right) \frac{G_t}{F_t}$$

$$= \sum_k \left(\frac{\sum_t N_{k,t}}{\sum_k \sum_t N_{k,t}} \right) P_k = \sum_k W_{2,k} P_k \quad (6)$$

where the species-specific weighting factor ($W_{2,k}$) is the fraction of all larval-days (over all species) attributable to each species, *k*.

In addition to conducting the assessment using the species-specific weighting factors, a sensitivity analysis was conducted using an unweighted average of the species-specific proportions entrained.

2.2 TEMPORAL PATTERN OF LARVAL ABUNDANCE

The weighting factors representing relative abundance were computed from the results of a simulation of daily abundances of each species, *k*, based on spawning periods and life history parameter estimates for eggs and larvae. The number of larvae present on day *t* was computed as the sum of daily cohort-specific abundances:

$$N_{k,t} = \sum_c N_{k,c,t} = \sum_c \left(e^{-M_{E,k} d_{E,k}} \right) \left(e^{-M_{L,k}(t-(d_{E,k}+c))} \right) E_{k,c} \quad (7)$$

for days, $t=(S_{start,k} + d_{E,k})$ to $(S_{end,k} + (d_{E,k}+d_{L,k}))$,
and daily cohorts, $c=S_{start,k}$ to $S_{end,k}$

where,

$E_{k,c}$ is the number of eggs in daily cohort, *c*.
$d_{E,k}$ is the duration of the egg lifestage (in days) for species, *k*,
$d_{L,k}$ is the duration of the larval lifestage (in days) for species, *k*,
$M_{E,k}$ is the daily mortality rate for eggs of species, *k*,

$M_{L,k}$ is the daily mortality rate for larvae of species, *k*,
$S_{start,k}$ is the first day of the spawning season for species, *k*, and
$S_{end,k}$ is the last day of the spawning season for species, *k*.

The number of eggs in daily cohort, *c*, was assumed to be proportional to the product of the adult abundance (A_k), the eggs per female (EPF_k), and the fraction ($f_{c,k}$) of the total annual spawn that occurs on day, *c*:

$$E_{k,c} = b_2 \times EPF_k \times A_k \times f_{c,k} \qquad (8)$$

and the adult abundance was assumed to be proportional to catch per unit effort (CPUE) from field sampling:

$$A_k = b_3 \times CPUE_k \qquad (9)$$

Estimates for the proportionality constants (b_2 and b_3) were not needed because they cancel in the ratios of the weighting factors.

For each species, the temporal pattern of spawning was modeled as a triangular distribution between the first and last date of spawning:

$$f_{t,k} = \begin{cases} \dfrac{t - S_{start,k}}{\left(\dfrac{S_{end,k} - S_{start,k}}{2}\right)^2} & \text{for} \quad S_{start,k} \le t \le S_{mid,k} \\ \dfrac{S_{end,k} - t}{\left(\dfrac{S_{end,k} - S_{start,k}}{2}\right)^2} & \text{for} \quad S_{mid,k} \le t \le S_{end,k} \end{cases} \qquad (10)$$

Absent detailed information on year- and species-specific temporal spawning patterns, a triangular distribution was selected because it can be defined based solely on start and end dates, and it represents a general pattern with a peak in the middle of the range.

2.3 COMPARISONS OF LIKELY LEVELS OF ENTRAINMENT

To compare the magnitude of likely entrainment under Duke Energy's WMP to the likely entrainment allowed by the EPA Phase I Rule, the ratio of:

- the overall proportion of larvae entrained (P) for Duke Energy's WMP, to
- the overall proportion of larvae entrained as allowed by the EPA Phase I Rule

was computed for each scenario:

$$CR_{WMP} = \frac{P_{WMP}}{P_{EPA}} \qquad (11)$$

3.0 INPUT DATA AND INFORMATION

The assessment included all 22 species collected during the 2006 field sampling (Duke Energy 2007) conducted in the mainstem of the Broad River in the vicinity of Lee Nuclear Station (Table L-1). Life history parameter estimates required for the assessment were obtained from the literature. Estimates of natural mortality rates for eggs and larvae (Table L-2) were taken from EPA Phase III Regional Benefits Assessment (EPA 2006). Ranges of estimates of the number of eggs per female fish (Table L-3) were taken from several literature sources (Attachment L.1) and from EPA Phase II Case Studies (EPA 2002). For each species, the upper bound of the range may have represented an extreme value. Therefore, species-specific estimates of the number of eggs per female fish were computed as the geometric mean of the upper and lower bounds of the range. Ranges for the durations of egg and larval life stages (Table L-5) were summarized from a variety of sources (Attachment L.2). Generally, the ranges for life stage duration were narrow, and, therefore the midpoint of the reported range for each species was used for the assessment. Qualitative descriptions of spawning seasons (Table L-4) were summarized from several literature sources (Attachment L.1). As described in Section 4.0, data on the temporal patterns of larval abundance in the Broad River were used to refine the species-specific descriptions of spawning seasons. The data on temporal patterns of larval abundance (Table L-6) were from a 1976 ichthyoplankton study conducted in the mainstem and adjacent backwaters of the Broad River in the vicinity of Lee Nuclear Station (Cloutman and Edwards 1977). Estimates of CPUE for the 22 target species in the vicinity of Lee Nuclear Station (Table L-7) were based on electrofishing conducted in the mainstem of the Broad River in 2006 (Duke Energy 2009). A schedule of daily water withdrawal rates for Duke Energy's WMP was provided by HDR/DTA (Figure L-1).

4.0 RESULTS

4.1 SPECIES-SPECIFIC PATTERNS OF LARVAL ABUNDANCE

Species-specific temporal patterns of larval abundance that were computed using equations (7), (8) and (10) were compared to the observed patterns of larval abundance from the 1976 ichthyoplankton study. If discrepancies were observed for a species, the start and end dates for the spawning season for that species were refined, while keeping them within the seasonal description from the literature, to achieve a higher degree of agreement. The resulting start and end dates for the spawning seasons are listed in Table L-8. The species-specific temporal patterns from the simulation along with the empirical data from the 1976 ichthyoplankton study are presented in Figures L-2 through L-10 for the taxonomic groups reported by the ichthyoplankton study.

Estimates of species-specific weighting factors ($W_{2,k}$) based on relative abundance from equation (8) are shown in Figure L-11. Due to the high CPUE of bluegill in the 2006 field sampling, bluegill had the highest weighting factor of all species. As noted above, a sensitivity analysis was conducted in which every species was given an equal weighting factor. The sensitivity analysis was conducted to examine the influence of such a high weighting factor for one species on the results of analysis.

4.2 TEMPORAL PATTERNS OF LARVAL ABUNDANCE AND TIMING OF WATER WITHDRAWALS

It can be seen from equation (5) that the level of entrainment is determined by the interaction between the daily proportion of water withdrawn (i.e., the ratio of G/F) and the daily relative abundance of larvae in the vicinity of the intake. Figure L-12 depicts that interaction for Duke Energy's WMP and the EPA water withdrawal scenario. Note that the overall temporal pattern of larval abundance in this figure closely resembles the pattern for sunfish (Figure L-5), due to the high CPUE of bluegill. Temporal patterns of larvae from the sensitivity analysis are depicted in Figure L-13. In this figure the period of larval presence extends further into the earlier parts of the year due to the equal inclusion of all species, many of which spawn much earlier in the year than sunfish.

4.3 COMPARISONS OF LEVELS OF ENTRAINMENT

Comparison ratios from equation (11) were computed separately for each year, 2001 through 2010, and each scenario (EPA and WMP). For every year and scenario, the projected entrainment under Duke Energy's WMP was lower than the projected entrainment that would be allowed by the EPA Phase I Rule (Table L-9). Averaged over the ten years, the likely level of entrainment for Duke Energy's WMP was 55.5% of the entrainment allowed by the Phase I Rule.

Results from the sensitivity analysis were similar – for every year and scenario the projected entrainment under Duke Energy's WMP was lower than the projected entrainment that would be allowed by the EPA Phase I Rule (Table L-10). In comparison to the entrainment allowed by the Rule, the likely entrainment under Duke Energy's WMP averaged 67.6%.

5.0 CONCLUSION AND DISCUSSION

For all years (2001-2010), the likely entrainment under Duke Energy's WMP is lower than the entrainment that would be allowed under the EPA Track I scenario (Figures 14 and 15). In years with low river flow, e.g., 2002 and 2008, the likely entrainment under Duke Energy's WMP is substantially lower. This is because the daily proportion of river flow withdrawn is lower for the WMP during periods when larvae are present and would be vulnerable to entrainment. During periods of the year when entrainable life stages are not present, higher flows would not lead to higher entrainment. The water withdrawal schedules for Duke Energy's WMP are specifically intended to minimize withdrawals during periods of high entrainment vulnerability and make up for those periods of low withdrawals by withdrawing additional volumes during periods of low entrainment vulnerability and high river flows.

Differences in the results from the main analysis and the sensitivity analysis reflect the facts that:

- the daily proportions of the Broad River flows withdrawn late in the summer under Duke Energy's WMP were much lower than the daily proportions that could be withdrawn under the Track I scenario (Figure L-13);
- the daily proportions of the Broad River flows withdrawn in the spring under Duke Energy's WMP were similar to the daily proportions that could be withdrawn under the Track I scenario (Figure L-13); and
- in comparison to the main analysis, the sensitivity analysis assumed a lower relative abundance of larvae would be present during late summer, and a higher relative abundance of larvae would be present in the spring, (compare Figures L-12 and L-13).

Therefore, the sensitivity analysis gave greater weight to the period of the year when withdrawals for Duke Energy's WMP were similar to withdrawals allowed under the Phase I Rule, and it gave less weight to the period of the year when withdrawals for the WMP were lower than the withdrawals allowed under the Phase I Rule.

6.0 REFERENCES

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United States Environmental Protection Agency (EPA). 2006. Regional Benefits Analysis for the Final Section 316(b) Phase III Existing Facilities Rule. Office of Water. EPA-821-R-04-007. June 2006.

Tables

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Table L-1. List of species included in the assessment based on results from seasonal sampling of the mainstem Broad River in the vicinity of Lee Nuclear Station in 2006 (Duke Energy 2009).

Family	Species (Scientific Name)	Species (Common Name)
Catostomidae	*Carpiodes cyprinus*	Quillback
Catostomidae	*Moxostoma collapsum*	Notchlip redhorse
Catostomidae	*Scartomyzon spp.*	Brassy jumprock
Centrarchidae	*Lepomis auritus*	Redbreast Sunfish
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed
Centrarchidae	*Lepomis gulosus*	Warmouth
Centrarchidae	*Lepomis macrochirus*	Bluegill
Centrarchidae	*Lepomis microlophus*	Redear sunfish
Centrarchidae	*Micropterus dolomieu*	Smallmouth bass
Centrarchidae	*Micropterus salmoides*	Largemouth bass
Centrarchidae	*Pomoxis nigromaculatus*	Black crappie
Clupeidae	*Dorosoma cepedianum*	Gizzard shad
Cyprinidae	*Cyprinella nivea*	Whitefin shiner
Cyprinidae	*Cyprinus carpio*	Common carp
Cyprinidae	*Notropis hudsonius*	Spottail shiner
Cyprinidae	*Notropis scepticus*	Sandbar shiner
Ictaluridae	*Ameiurus brunneus*	Snail bullhead
Ictaluridae	*Ameiurus catus*	White catfish
Ictaluridae	*Ameiurus platycephalus*	Flat bullhead
Ictaluridae	*Ictalurus punctatus*	Channel catfish
Percidae	*Etheostoma flabellare*	Fantail darter
Percidae	*Etheostoma olmstedi*	Tessellated darter

Table L-2. Estimates of age-0 natural mortality rates for egg and larval life stages (EPA 2006).

Species	Egg	Larvae
Quillback	2.30	2.30
Notchlip redhorse	2.30	2.30
Brassy jumprock	2.30	2.30
Redbreast sunfish	1.71	0.69
Pumpkinseed	1.71	0.69
Warmouth	1.71	0.69
Bluegill	1.73	0.58
Redear sunfish	1.71	0.69
Smallmouth bass	1.90	2.70
Largemouth bass	1.90	2.70
Black crappie	1.80	0.50
Gizzard shad	1.90	6.33
Whitefin shiner	1.90	4.61
Common carp	1.90	4.61
Spottail shiner	1.90	4.61
Sandbar shiner	1.90	4.61
Snail bullhead	1.90	4.61
White catfish	1.90	4.61
Flat bullhead	1.90	4.61
Channel catfish	1.90	4.61
Fantail darter	1.90	4.61
Tessellated darter	1.90	4.61

Table L-3. Ranges for annual number of eggs per mature female (see Attachment L.1).

Species	Eggs per Mature Female	
	Lower Bound	Upper Bound
Quillback	15,235	63,779
Notchlip redhorse*	20,000	50,000
Brassy jumprock*	20,000	50,000
Redbreast sunfish	963	8,250
Pumpkinseed	1,800	14,100
Warmouth	798	34,257
Bluegill	80,000	80,000
Redear sunfish	15,001	30,144
Smallmouth bass	3,601	27,716
Largemouth bass	17,501	21,751
Black crappie	6,100	109,000
Gizzard shad	22,400	543,910
Whitefin shiner**	870	8,700
Common carp	100,000	500,000
Spottail shiner	1,300	2,600
Sandbar shiner**	870	8,700
Snail bullhead***	207	1,742
White catfish	1,000	3,500
Flat bullhead	207	1,742
Channel catfish	2,000	7,000
Fantail darter	170	170
Tessellated darter	97	1,435

* White sucker as surrogate (EPA 2002).

** Emerald shiner as surrogate (EPA 2002).

*** Flat bullhead as surrogate

Table L-4. Spawning seasons for various species (see Attachment L.1).

Species	Spawning Season
Quillback	mid-April through May
Notchlip Redhorse	March to early May
Brassy Jumprock	April
Redbreast Sunfish	May through July
Pumpkinseed	April through August
Warmouth	April through August
Bluegill	May through August
Redear Sunfish	Late Spring to early Summer
Smallmouth Bass	April and early May
Largemouth Bass	March to May
Black Crappie	Late February to early May
Gizzard Shad	Spring
Whitefin Shiner	June to August
Common Carp	Spring
Spottail Shiner	April and May
Sandbar Shiner	
Snail Bullhead	May to early June
White Catfish	Late Spring to early Summer.
Flat Bullhead	June and July
Channel Catfish	Late Spring to early Summer.
Fantail Darter	April and May
Tessellated Darter	Late March through June

Table L-5. Ranges of egg and larval life stage durations in days from the literature (see Attachment L.2)

Species	Eggs		Larvae	
	Lower Bound	Upper Bound	Lower Bound	Upper Bound
Quillback*	4	11	.	.
Notchlip redhorse*	4	11	.	.
Brassy jumprock*	4	11	.	.
Redbreast sunfish	.	.	.	.
Pumpkinseed	3	3	22	22
Warmouth	1	2	5	5
Bluegill	2	5	30	30
Redear sunfish	.	.	.	.
Smallmouth bass	4	16	12	19
Largemouth bass	2	4	19	19
Black crappie	2	5	.	.
Gizzard shad	2	4	21	21
Whitefin shiner	.	.	.	.
Common carp	2	6	13	13
Spottail shiner	.	.	.	.
Sandbar shiner	.	.	.	.
Snail bullhead	.	.	.	.
White catfish	6	7	.	.
Flat bullhead	.	.	.	.
Channel catfish	3	10	7	16
Fantail darter	14	35	.	.
Tessellated darter	21	21	.	.

* White sucker as surrogate.

Table L-6. Average larval densities (#/1000m^3) from backwater and mainstem sampling stations in the vicinity of Lee Nuclear Station in 1976 (Cloutman and Edwards 1977).

Date	Suckers	Sunfish	Dorosoma spp	Minnows	Catfish	Piedmont Darter	Common Carp	Large-mouth Bass	Crappie
Apr 22	30	0	430	3	0	2	10	0	16
May 5	3	0	901	6	0	2	0	0	7
May 13	5	0	1218	17	0	0	0	0	0
May 24	1	0	1452	0	0	0	0	0	0
Jun 1	0	37	1426	1	1	0	0	0	0
Jun 7	0	20	715	2	0	0	0	0	0
Jun 14	1	89	411	8	0	0	0	2	0
Jun 21	0	124	1482	8	0	0	0	0	0
Jun 30	1	0	2303	3	3	0	0	0	0
Jul 7	0	123	534	2	30	0	0	0	0
Jul 15	0	17	1101	0	0	0	0	0	0
Jul 19	0	1294	503	7	41	0	0	0	0
Jul 26	0	671	212	7	2	0	0	0	0
Aug 2	0	96	85	168	6	0	0	0	0
Aug 16	0	4	58	70	0	0	0	0	0
Aug 24	0	0	41	1	0	0	0	0	0
Sep 7	0	0	19	0	0	0	0	0	0

Table L-7. Number of fish collected from the two mainstem stations (460 and 463) on the Broad River during the seasonal (February, April, July, and October) electrofishing study conducted in 2006 (Duke Energy 2009). Numbers of Catostomidae (i.e., quillback, notchlip redhorse and brassy jumprock) are based on fish collected at mainstem station 464 in April 2006 (Barwick et al. 2006).

Species	Number of Fish Collected
Quillback	49
Notchlip redhorse	33
Brassy jumprock	40
Redbreast sunfish	26
Pumpkinseed	1
Warmouth	4
Bluegill	344
Redear sunfish	17
Smallmouth bass	3
Largemouth bass	31
Black crappie	1
Gizzard shad	13
Whitefin shiner	18
Common carp	7
Spottail shiner	3
Sandbar shiner	1
Snail bullhead	1
White catfish	2
Flat bullhead	2
Channel catfish	8
Fantail darter	1
Tessellated darter	1

Table L-8. Spawning season dates used in the assessment.

Species	Season	Start Date	End Date
Quillback	mid-April through May	15-Apr	31-May
Notchlip redhorse	March to early May	1-Mar	7-May
Brassy jumprock	April	1-Apr	30-Apr
Redbreast sunfish	May through July	1-May	31-Jul
Pumpkinseed	April through August	1-Apr	31-Aug
Warmouth	April through August	1-Apr	31-Aug
Bluegill*	May through August	31-May	16-Aug
Redear sunfish	Late Spring to early Summer	28-May	13-Jul
Smallmouth bass	April and early May	1-Apr	15-May
Largemouth bass*	March to May	31-Mar	31-May
Black crappie	Late February to early May	21-Feb	7-May
Gizzard shad*	Spring	20-Apr	20-Jun
Whitefin shiner*	June to August	30-Jun	31-Aug
Common carp*	Spring	21-Mar	6-May
Spottail shiner	April and May	1-Apr	31-May
Sandbar shiner**	April and May	1-Apr	31-May
Snail bullhead*	May to early June	23-May	29-Jun
White catfish*	Late Spring to early Summer.	19-Jun	4-Aug
Flat bullhead*	June and July	23-Jun	22-Aug
Channel catfish*	Late Spring to early Summer.	19-Jun	4-Aug
Fantail darter	April and May	1-Apr	31-May
Tessellated darter	Late March through June	21-Mar	30-Jun

* Dates adjusted based on 1976 field sampling.
** Spottail shiner used as surrogate.

Table L-9. Projected entrainment (abundance weighted average across species) under Duke Energy's WMP as percentage of projected entrainment that would be allowed under the EPA Phase I Rule.

Year	WMP Entrainment as % of EPA-Allowed Entrainment
2001	80.0%
2002	26.1%
2003	93.1%
2004	93.2%
2005	92.9%
2006	84.3%
2007	59.0%
2008	30.3%
2009	85.8%
2010	92.4%
Average	55.5%

Table L-10. Projected entrainment (simple average across species) under Duke Energy's WMP as percentage of projected entrainment that would be allowed under the EPA Phase I Rule.

Year	WMP Entrainment as % of EPA-Allowed Entrainment
2001	86.1%
2002	41.2%
2003	91.3%
2004	91.2%
2005	91.1%
2006	86.4%
2007	74.7%
2008	42.7%
2009	88.2%
2010	91.7%
Average	67.6%

Figures

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Figure L-1. Average (2001-2010) daily water withdrawal rates for Duke Energy's WMP and the EPA Phase I Rule. (Note that Broad River flows were below 98 cfs on some dates which would have prevented the amount allowed under the EPA Track I scenario to be withdrawn.)

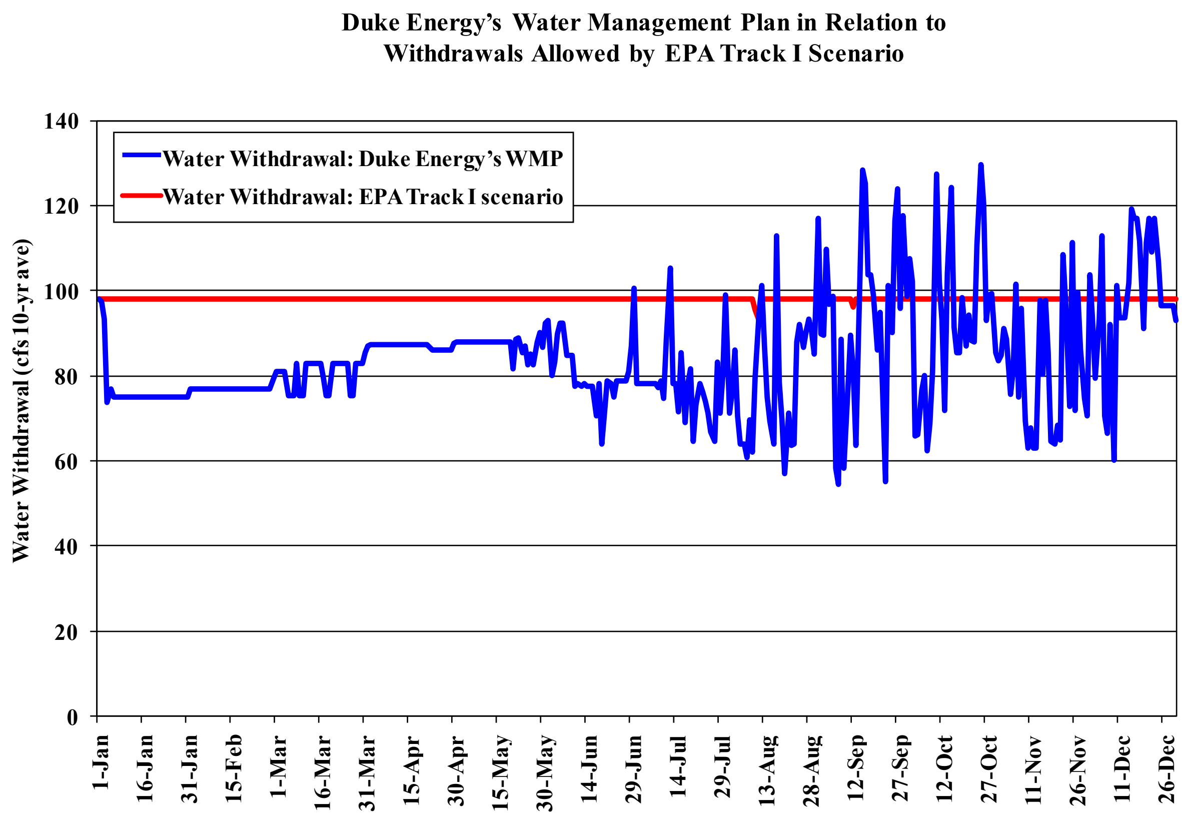


Figure L-2. Simulated and empirical temporal patterns of larval abundance for suckers (all species combined) in the Broad River in the vicinity of Lee Nuclear Station.

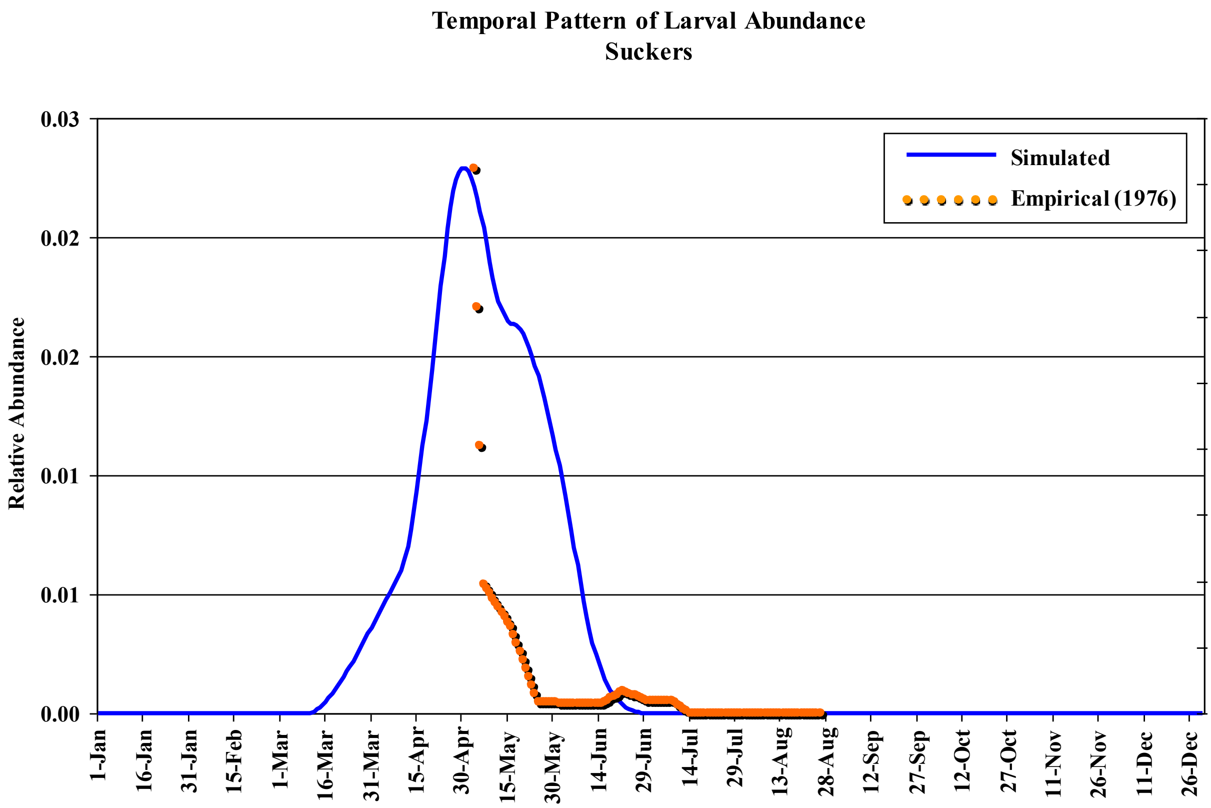


Figure L-3. Simulated and empirical temporal patterns of larval abundance for crappie in the Broad River in the vicinity of Lee Nuclear Station.

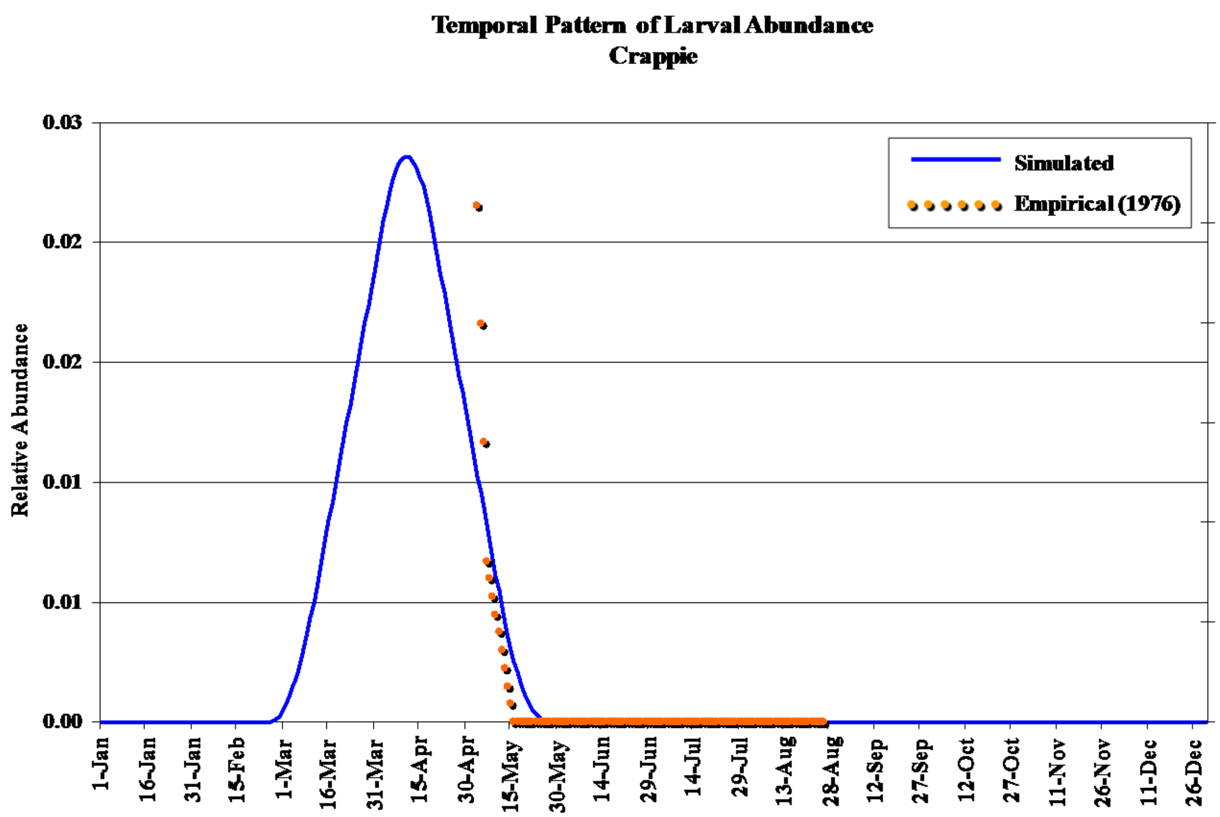


Figure L-4. Simulated and empirical temporal patterns of larval abundance for largemouth bass in the Broad River in the vicinity of Lee Nuclear Station.

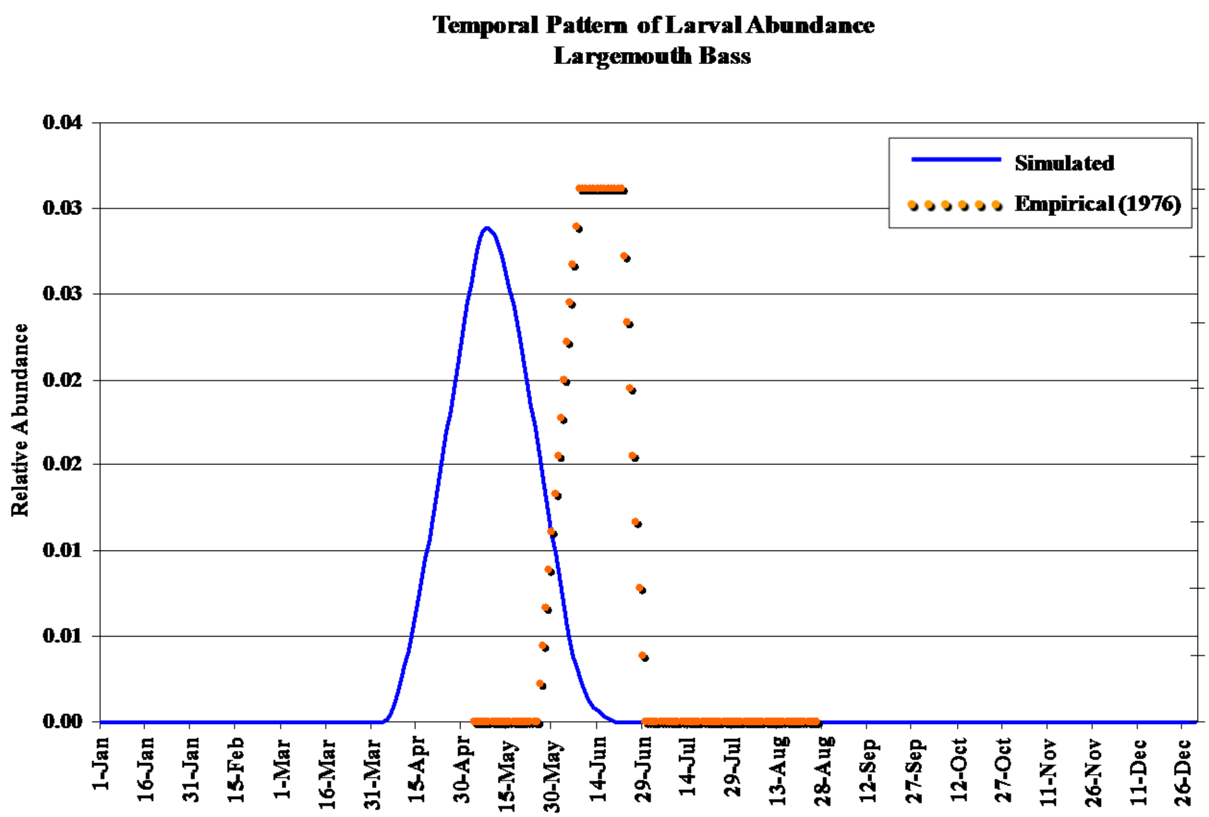


Figure L-5. Simulated and empirical temporal patterns of larval abundance for sunfish (all species combined) in the Broad River in the vicinity of Lee Nuclear Station.

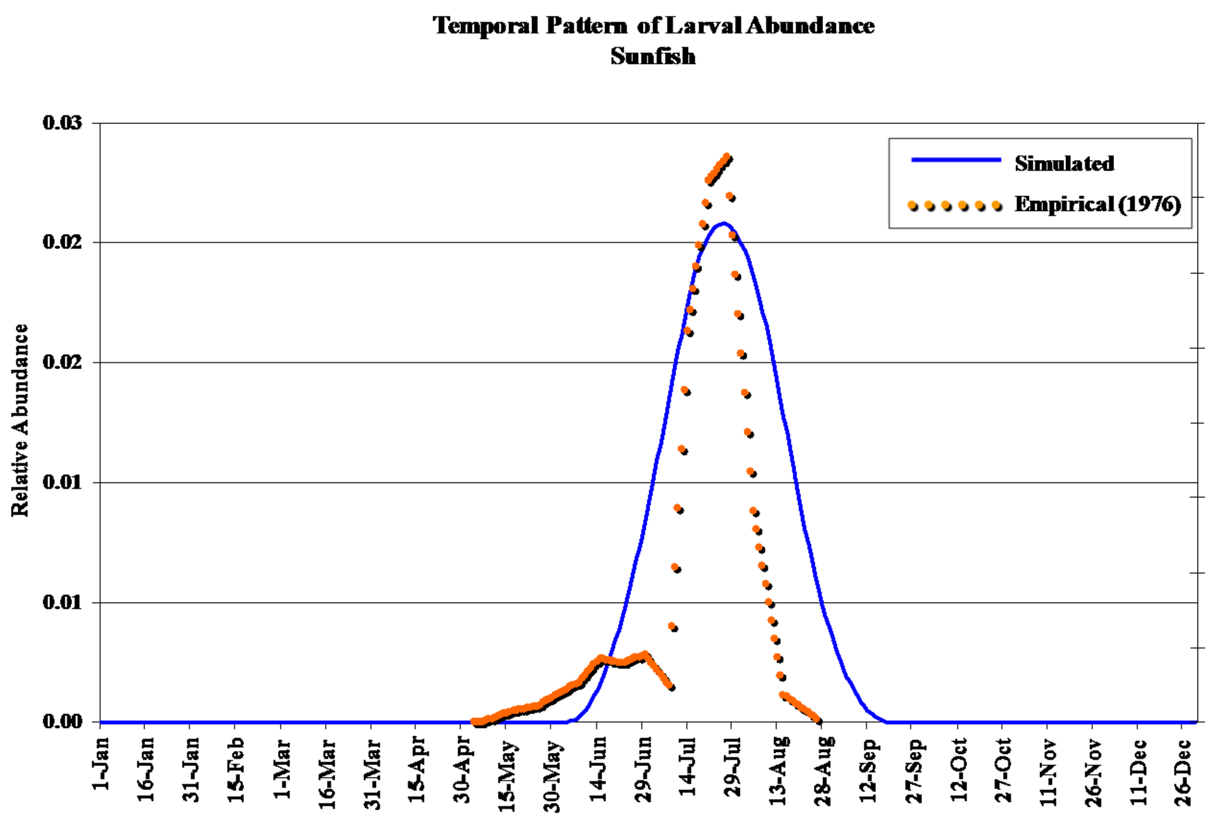


Figure L-6. Simulated and empirical temporal patterns of larval abundance for Dorosoma species (gizzard shad and related species) in the Broad River in the vicinity of Lee Nuclear Station.

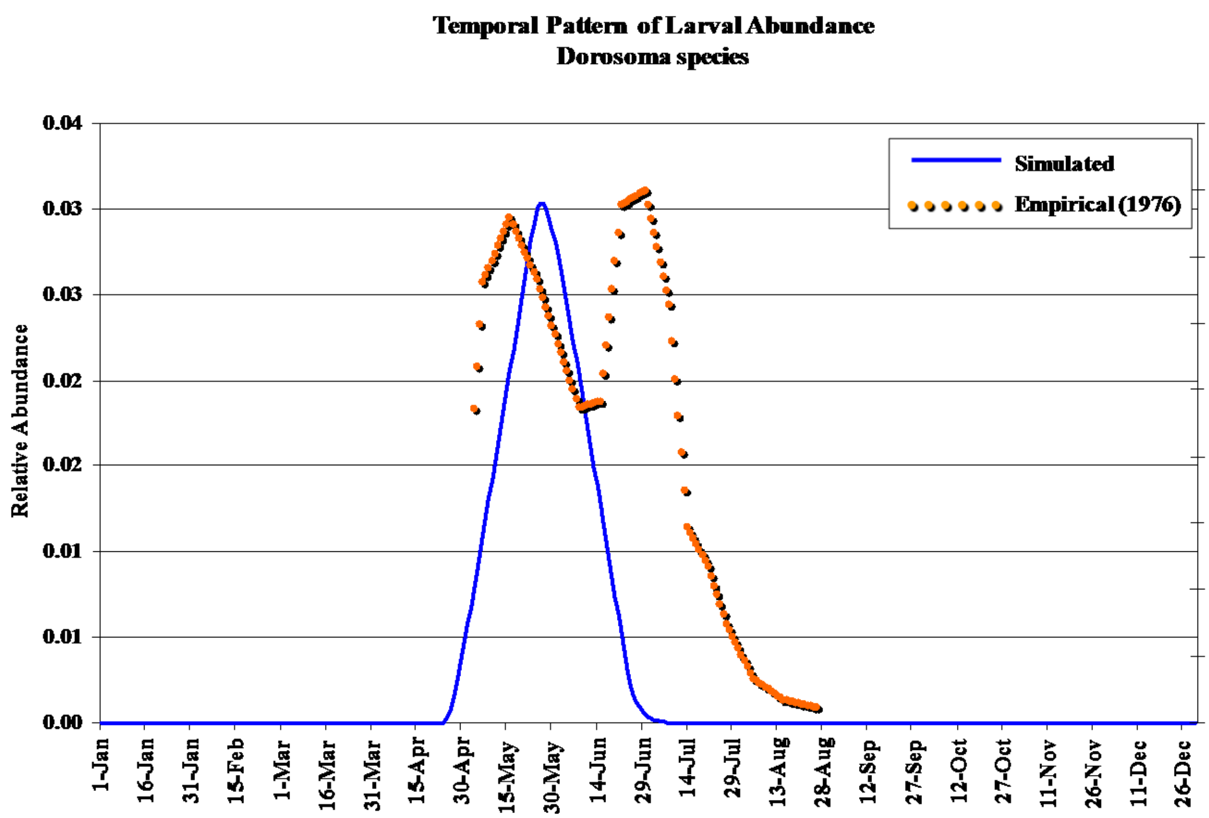


Figure L-7. Simulated and empirical temporal patterns of larval abundance for common carp in the Broad River in the vicinity of Lee Nuclear Station.

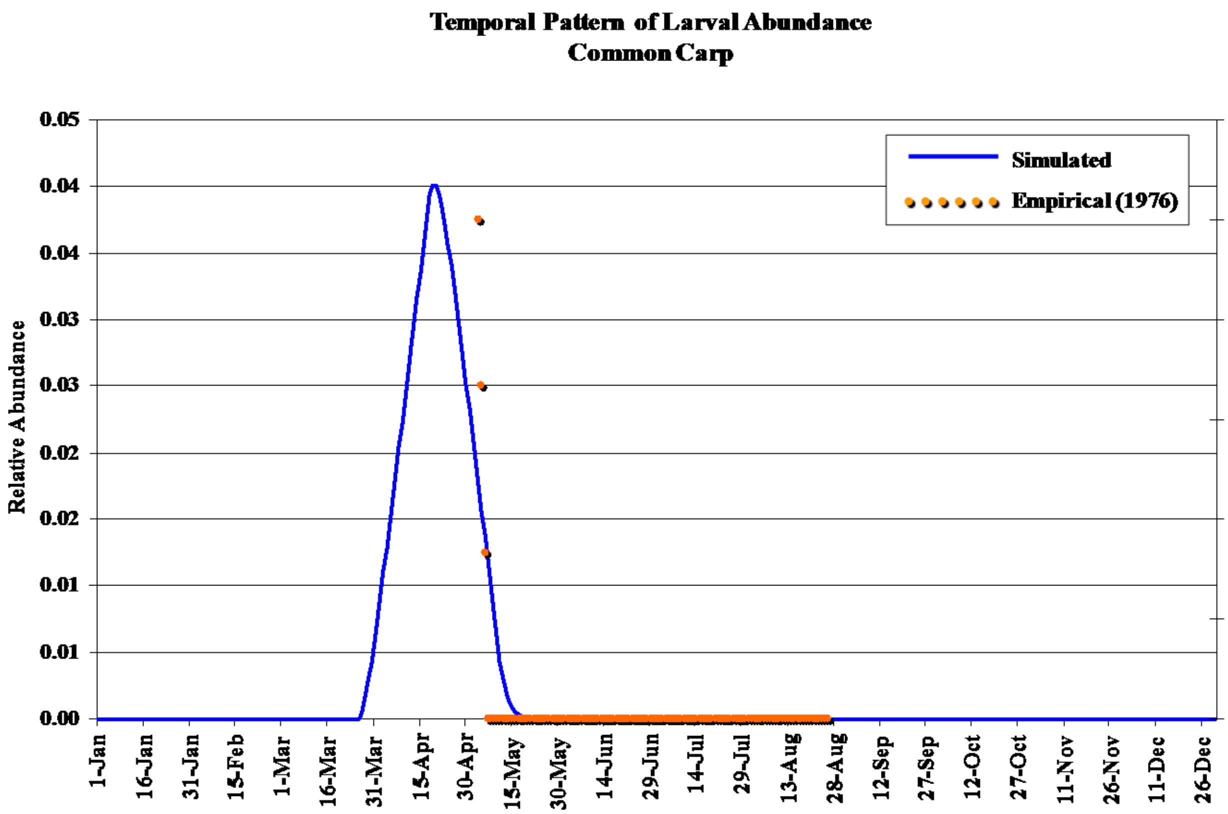


Figure L-8. Simulated and empirical temporal patterns of larval abundance for shiners (all species combined) in the Broad River in the vicinity of Lee Nuclear Station.

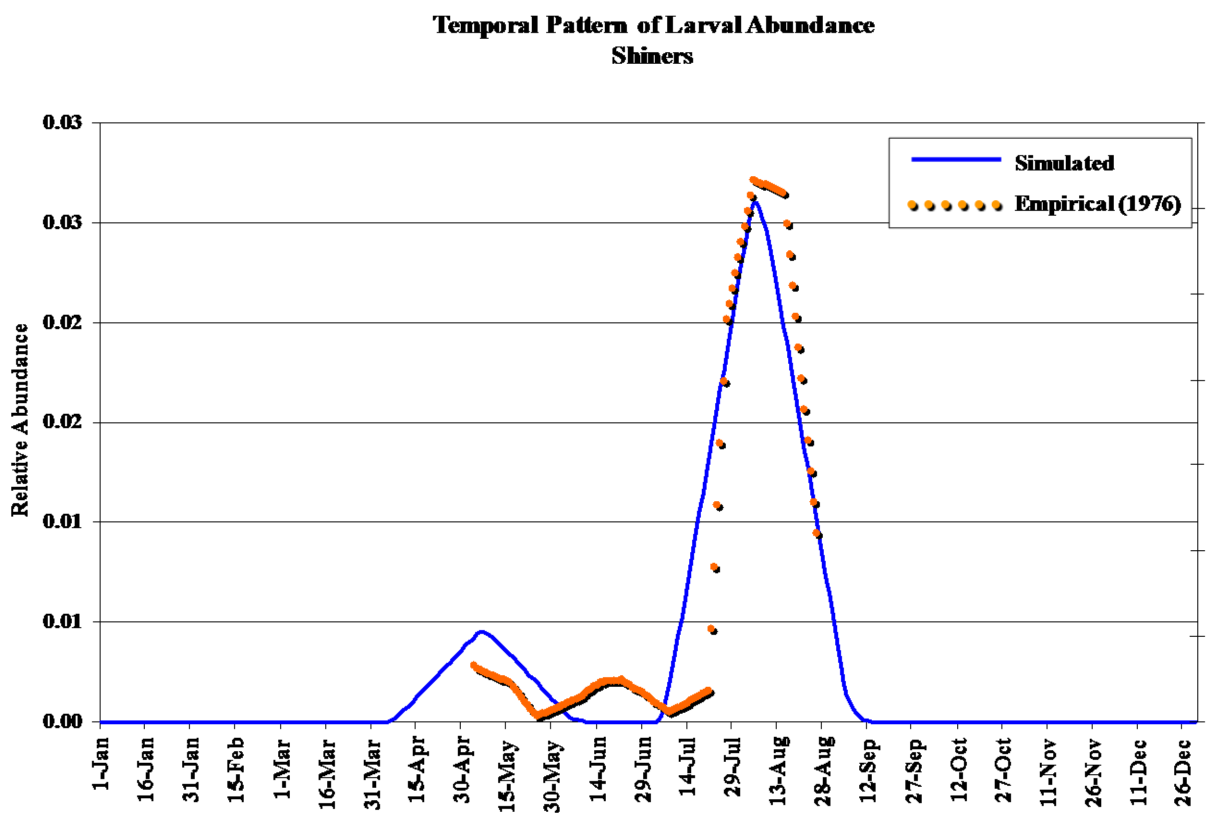


Figure L-9. Simulated and empirical temporal patterns of larval abundance for catfish (all species combined) in the Broad River in the vicinity of Lee Nuclear Station.

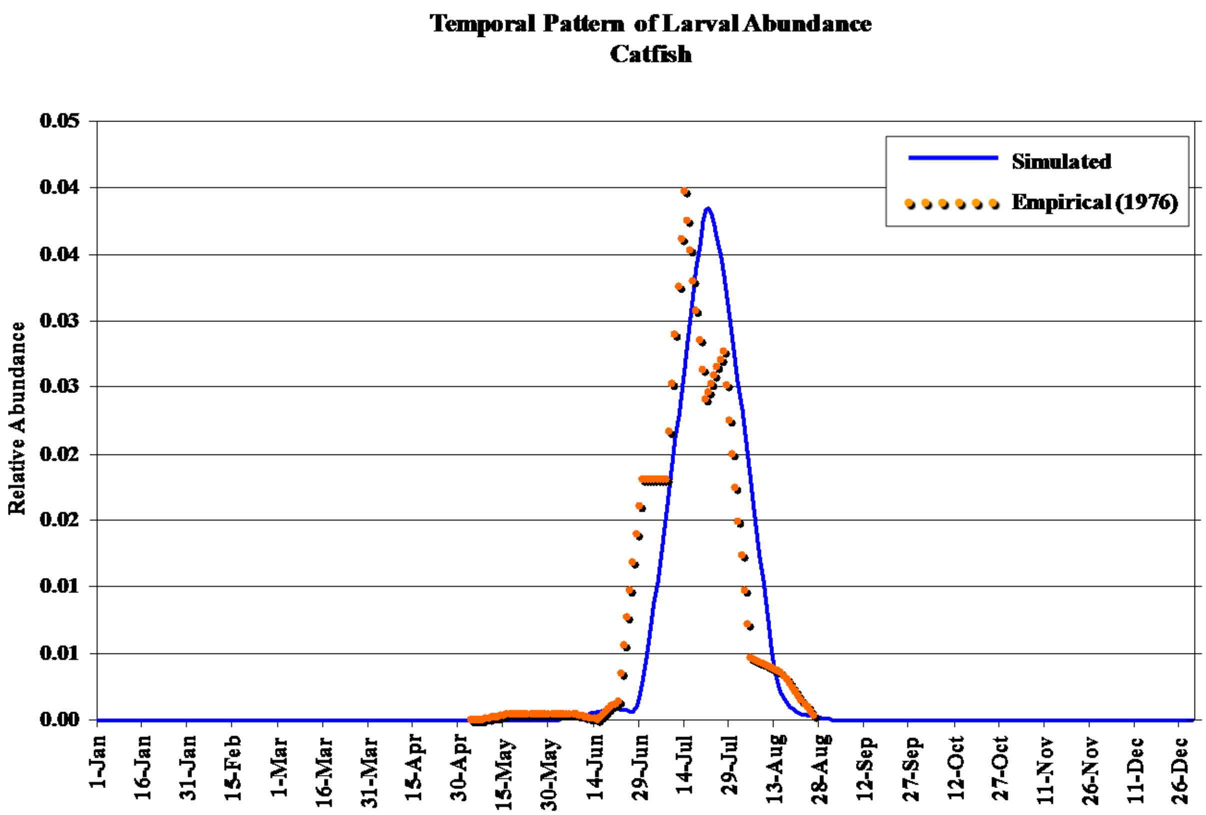


Figure L-10. Simulated and empirical temporal patterns of larval abundance for darters in the Broad River in the vicinity of Lee Nuclear Station.

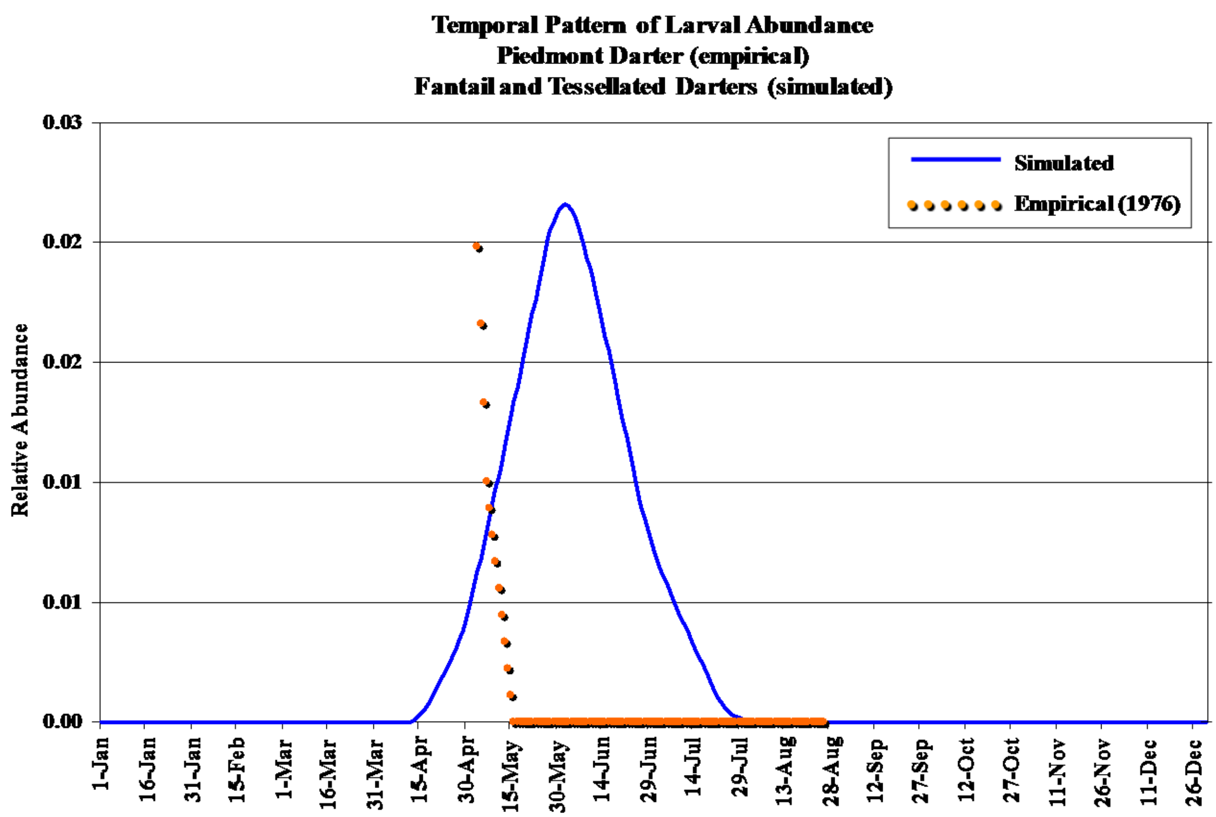


Figure L-11. Estimated species-specific weighting factors ($W_{2,k}$) for averaging levels of entrainment across species.

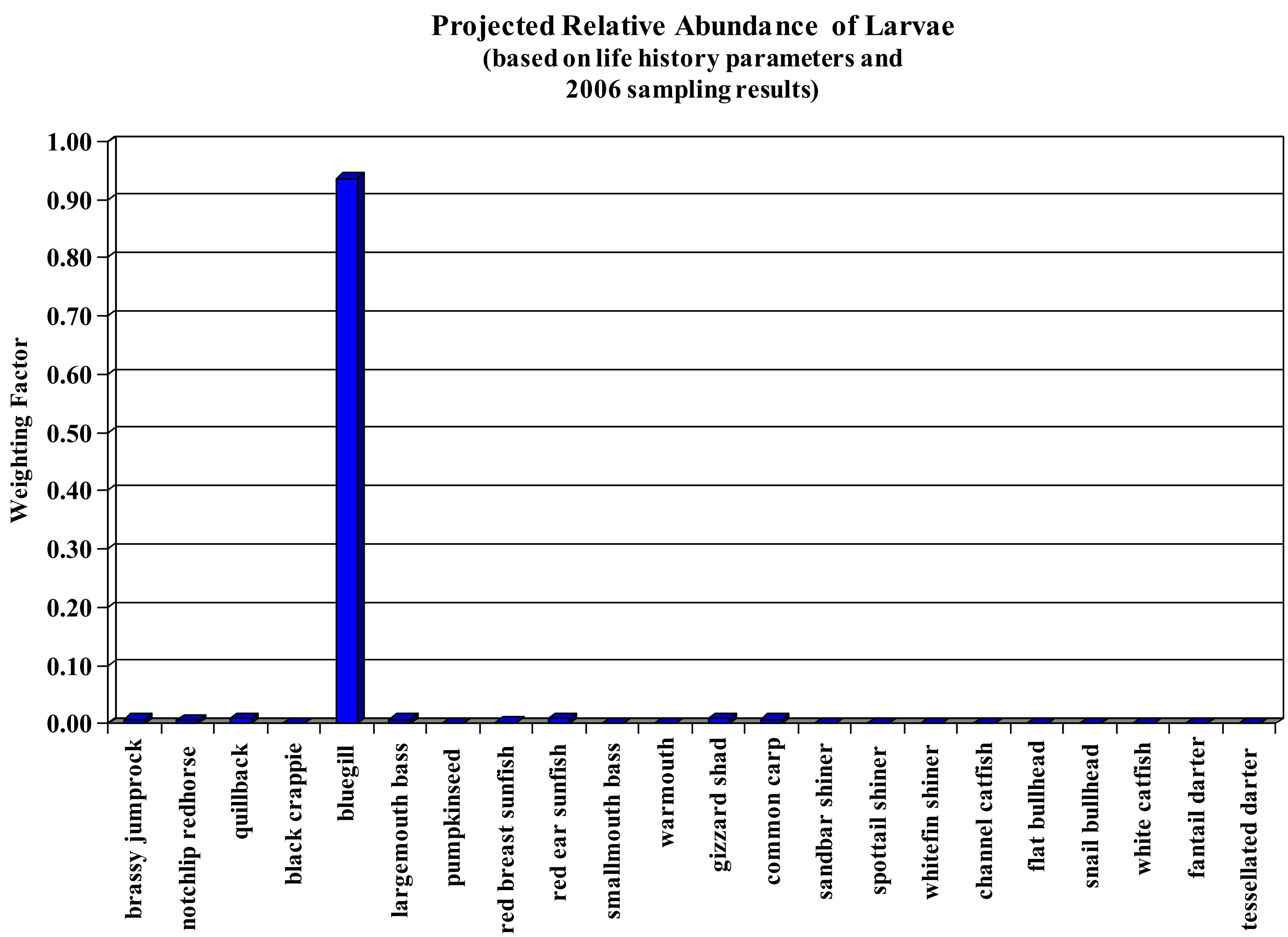


Figure L-12. Average (2001-2010) daily water withdrawals for Duke Energy's WMP, expressed as a proportion of Broad River flow past the Lee Nuclear Station site, in comparison to water withdrawals allowed by the EPA Track I scenario. Temporal pattern of larval abundance represents the expected period of entrainment vulnerability of species present in the Broad River in the vicinity of Lee Nuclear Station.

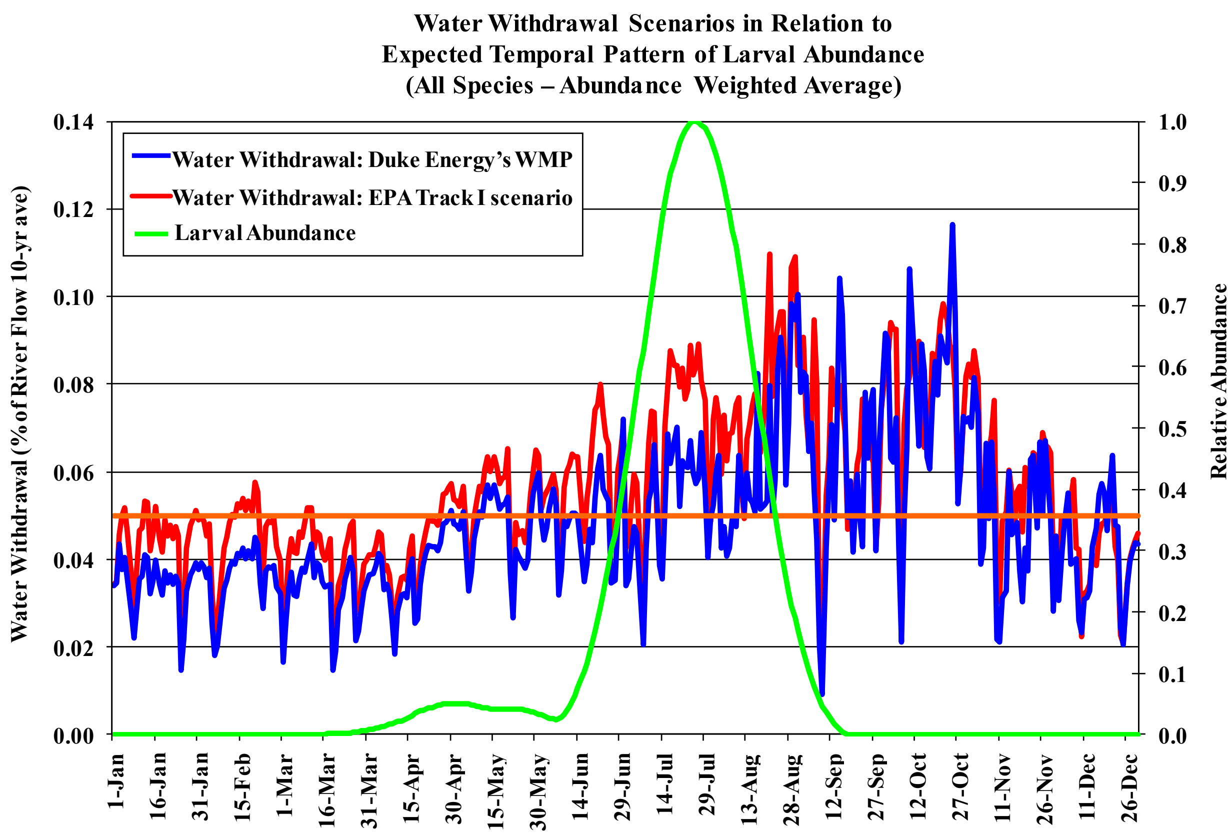


Figure L-13. Average (2001-2010) daily water withdrawals for Duke Energy's WMP, expressed as a proportion of Broad River flow past the Lee Nuclear Station site, in comparison to water withdrawals allowed by the EPA Track I scenario. Temporal pattern of larval abundance assumes every species is equally abundant (sensitivity analysis).

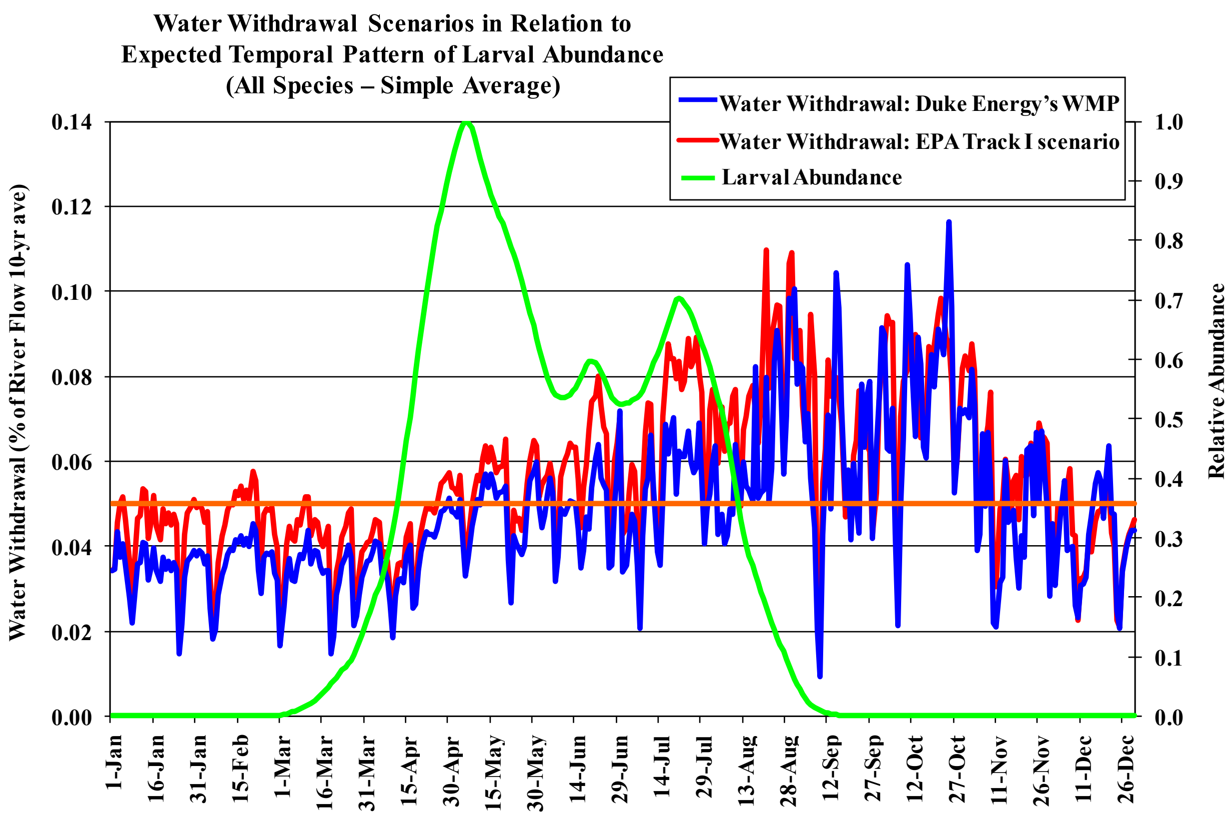


Figure L-14. Comparison of projected entrainment (abundance weighted average across species) under Duke Energy's WMP and projected entrainment that would be allowed by the EPA Track I scenario. Projected entrainment is expressed in terms of multiples of the average (over 10 years) entrainment allowed under the EPATrack I scenario.

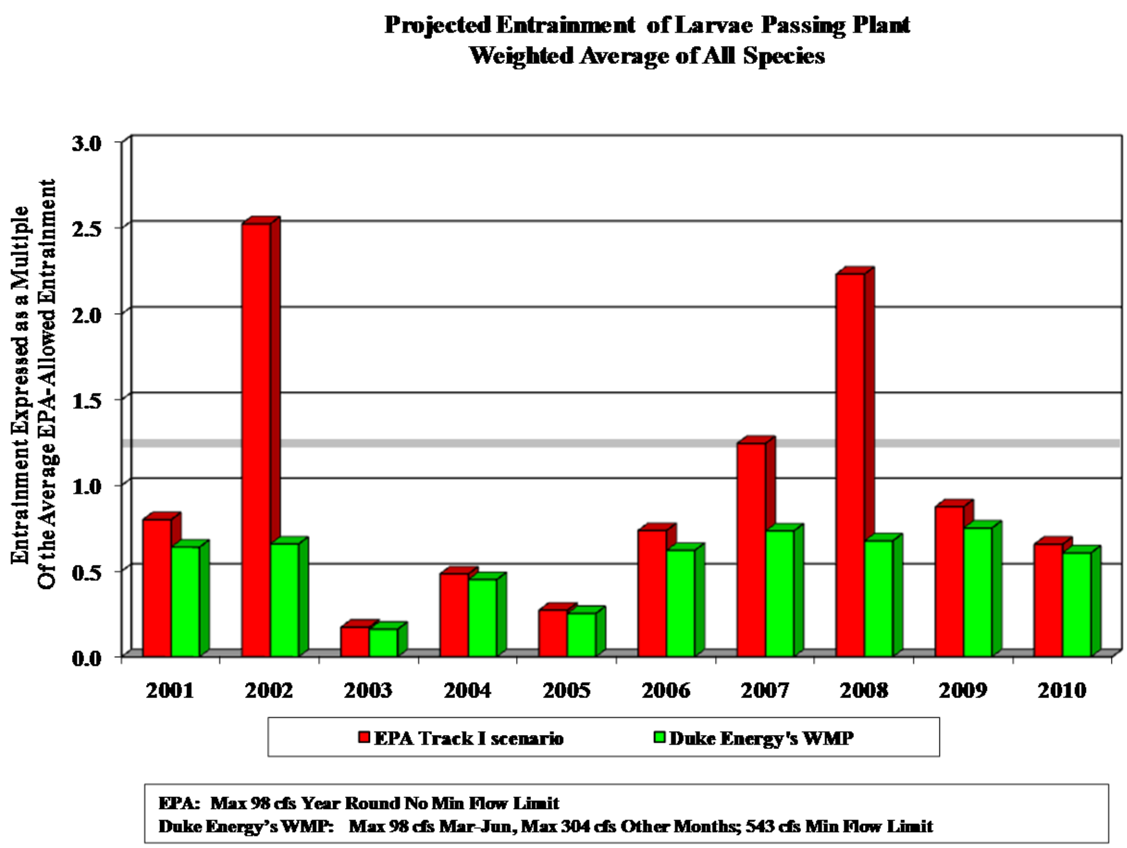
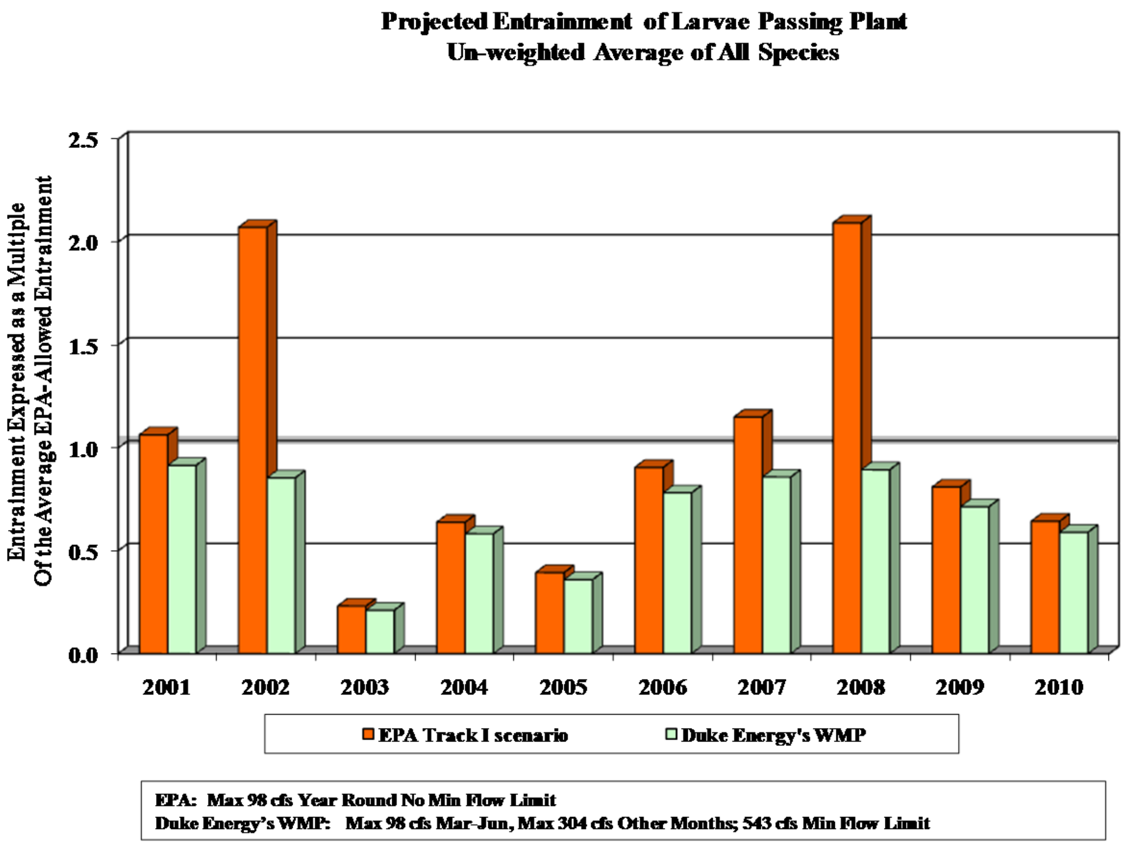


Figure L-15. Comparison of projected entrainment (simple average across species) under Duke Energy's WMP and projected entrainment that would be allowed by the EPA Track I scenario. Projected entrainment is expressed in terms of multiples of the average (over 10 years) entrainment allowed under the EPATrack I scenario.



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Attachment L.1

Literature Review of Eggs per Female Fish and Spawning Season

Prepared by
David Coughlin
Duke Energy

January 31, 2011

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Family and scientific name	Common name	Spawning period	Eggs/female	Reference
Clupeidae				
Dorosoma cepedianum	Gizzard shad	Spring	22,400 - 543,910	Jenkins and Burkhead (1994), Marcy et al. (2005), Rohde et al. (2009)
Cyprinidae				
Cyprinella nivea	Whitefin shiner	June to August	112 - 545 eggs per clutch, multiple clutches per year	Cloutman and Harrell (1987)
Cyprinus carpio	Common carp	Spring	100,000 - 500,000	Marcy et al. (2005), Rohde et al. (2009)
Notropis hudsonius	Spottail shiner	April and May	1,300 - 2,600	Marcy et al. (2005), Rohde et al. (2009)
Catostomidae				
Catostomids	Suckers	Spring		Marcy et al. (2005), Rohde et al. (2009)
Carpiodes cyprinus	Quillback	mid-April through May	15,235 - 63,779 depending on size, Woodward and Wissing have the linear (length and age) and polynomial (weight) equations to describe fecundity.	Jenkins and Burkhead (1994), Rohde et al. (2009), Woodward and Wissing (1976) TAFS 105(3):411-415
Moxostoma collapsum	Notchlip redhorse	March to early May	no information found	Rohde et al. (2009)
Moxostoma sp.	Brassy jumprock	April	no information found	Jenkins and Burkhead (1994)
Ictaluridae				
Ameiurus brunneus	Snail bullhead	May to early June	no information found	Rohde et al. (2009)
Ameiurus catus	White catfish	Late Spring to early Summer.	1,000 - 3,500	Marcy et al. (2005), Rohde et al. (2009)
Ameiurus platycephalus	Flat bullhead	June and July	207 - 1,742	Olmsted and Cloutman (1979)
Ictalurus punctatus	Channel catfish	Late Spring to early Summer.	2,000 - 7,000	Marcy et al. (2005), Rohde et al. (2009)

Family and scientific name	Common name	Spawning period	Eggs/female	Reference
Centrarchidae				
Lepomis auritus	Redbreast sunfish	May through July	963 @ age 2, 8,250 @ age 6	Jenkins and Burkhead (1994), Rohde et al. (2009)
Lepomis gibbosus	Pumpkinseed	April through August	1,800 - 14,100 depending on size	Marcy et al. (2005), Rohde et al. (2009)
Lepomis gulosus	Warmouth	April through August	798 - 34,257 depending on size	Marcy et al. (2005)
Lepomis macrochirus	Bluegill	May trough August	80,000 per year for a 120 mmTL female	Jenkins and Burkhead (1994), Rohde et al. (2009)
Lepomis microlophus	Redear sunfish	Late Spring to early Summer	15,001 - 30,144 depending on size	Jenkins and Burkhead (1994), Rohde et al. (2009)
Micropterus dolomieu	Smallmouth bass	April and early May	2,601 - 27,716	Jenkins and Burkhead (1994), Rohde et al. (2009)
Micropterus salmoides	Largemouth bass	March to May	17,501 - 21,751 eggs for Age 4 and 6 females, respectively	Jenkins and Burkhead (1994), SCDHEC, and Rohde et al. (2009)
Pomoxis spp.	Crappie	Late February to early May	6,100 - 109,000	Barwick 1981, Rohde et al. (2009)
Percidae				
Etheostoma flabellare	Fantail darter	April and May	average of 34 per spawn, 5 spawns per year	Jenkins and Burkhead (1994), Rohde et al. (2009)
Etheostoma olmstedi	Tessellated darter	Late March through June	97 - 1,435 (mean 727)	Rohde et al. (2009)

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Attachment L.2

Literature Review of
Egg and Larval
Life Stage Durations

Prepared by
AKRF, Inc.

January 31, 2011

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Family	Scientific name	Common Name	Life Stage Duration (days, temperature °C)		Reference
			eggs	larvae	
Catostomidae	Moxostoma collapsum	notchlip redhorse			
Catostomidae	Moxostoma sp./ Scartomyzon brassta	brassy jumprock			
Catostomidae	Catostomus commersoni	white sucker	8-11, 10-15		Scott and Crossman, 1973
Catostomidae	Catostomus commersoni	white sucker	7, 15.6; 5, 18.3; 4, 21.1		Smith, 1985

Family	Scientific name	Common Name	Life Stage Duration (days, temperature °C)		Reference
			eggs	larvae	
Centrarchidae	Lepomis auritus	redbreast sunfish			
Centrarchidae	Lepomis gibbosus	Pumpkinseed	3, 28		Scott and Crossman, 1973
Centrarchidae	Lepomis gibbosus	Pumpkinseed		22, 20.4	Houde and Zastrow, 1993
Centrarchidae	Lepomis gulosus	Warmouth	1 to 2, 25-26.4; 2, 25-27	5	Marcy et al., 2005; Merriner, 1971
Centrarchidae	Lepomis macrochirus	Bluegill	2, 25-27; 3 to 5		Merriner, 1971; Scott and Crossman, 1973
Centrarchidae	Lepomis macrochirus	Bluegill		30, 23.5	Houde and Zastrow, 1993
Centrarchidae	Lepomis microlophus	redear sunfish			
Centrarchidae	Micropterus dolomieu	smallmouth bass	4 to 10	12 to 19	Scott and Crossman, 1973
Centrarchidae	Micropterus dolomieu	smallmouth bass	7 to16		Smith, 1985
Centrarchidae	Micropterus salmoides	largemouth bass	2, 17-19; 3-4	19, 19.3	Merriner, 1971; Smith, 1985; Houde and Zastrow, 1993
Centrarchidae	Pomoxis nigromaculatus	Black Crappie	2, 17-19; 3-5		Merriner, 1971; Smith, 1985

Family	Scientific name	Common Name	Life Stage Duration (days, temperature °C)		Reference
			eggs	larvae	
Clupeidae	Dorosoma cependianum	gizzard shad	1.5, 27		Miller, 1960
Clupeidae	Dorosoma cependianum	gizzard shad	3.96,17	21, 25	Miller, 1960; Ogawa and Mitsch, 1979
Cyprinidae	Cyprinella nivea	whitefin shiner			
Cyprinidae	Cyprinus carpio	common carp	2-6, 18-30		Kaiola et al., 1993
Cyprinidae	Cyprinus carpio	common carp	3, 19-23		Marcy et al., 2005
Cyprinidae	Cyprinus carpio	common carp		13, 23	Houde and Zastrow, 1993
Cyprinidae	Notropis hudsonius	spottail shiner			
Cyprinidae	Notropis scepticus	sandbar shiner			

Family	Scientific name	Common Name	Life Stage Duration (days, temperature °C)		Reference
			eggs	larvae	
Ictaluridae	Ameiurus brunneus	snail bullhead			
Ictaluridae	Ameiurus catus	white catfish	6-7, 27		Marcy et al., 2005
Ictaluridae	Ictalurus punctatus	channel catfish	3 to 8	12 to 16	Stoeckel and Burr, 1999
Ictaluridae	Ictalurus punctatus	channel catfish	7	7 to 8	Pflieger, 1975
Ictaluridae	Ictalurus punctatus	channel catfish	5 to 10, 15.6-27.8		Scott and Crossman, 1973
Ictaluridae	Ameiurus platycephalus	flat bullhead			
Percidae	Etheostoma flabellare	fantail darter	21, 21.1		Scott and Crossman, 1973
Percidae	Etheostoma flabellare	fantail darter	30-35, 17-20; 21, 21-22; 14-16, 23.5		Lake , 1936
Percidae	Etheostoma flabellare	fantail darter	30-35,17.2-20;14-16, 23.3		Smith, 1985
Percidae	Etheostoma olmstedi	tessellated darter	21, 18.3		Smith, 1985

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