

Aquatic Resource Committee Report

1. Purpose

This Resource Committee Report is the bridge by which Catawba-Wateree (C-W) Relicensing study results are delivered to the relicensing stakeholder teams (State Relicensing Teams and Advisory Groups) for their use and consideration as they negotiate to develop the Agreement-In-Principle (AIP). It has been prepared by the Catawba-Wateree Relicensing Aquatic Resource Committee and supplements the detailed study reports available at www.catawbahydrolicensing.com. The purpose of this report is to:

- 1) consolidate and summarize key study findings,
- 2) merge the findings of several resource-related studies into a coordinated resource assessment
- 3) identify relationships with other resource areas (e.g., aquatics and terrestrial), and
- 4) provide the Resource Committee's assessment of potential resource protection, mitigation and enhancement opportunities supported by study findings.

The Aquatic Resource Committee was composed of numerous resource experts from North and South Carolina with representatives from Duke as well as several state and federal agencies. Following is a list of the Aquatic Resource Committee members:

Steve Johnson	Duke Power (Coordinator)
Chris Goudreau	North Carolina Wildlife Resources Commission
Todd Ewing	North Carolina Wildlife Resources Commission
Dick Christie	South Carolina Department of Natural Resources
Ron Ahle	South Carolina Department of Natural Resources
Steve Reed	North Carolina Division of Water Resources
Jim Mead	North Carolina Division of Water Resources
Amanda Hill	United States Fish and Wildlife Service
Mark Cantrell	United States Fish and Wildlife Service
Donley Hill	United States Forest Service
Dave Coughlan	Duke Power
Hugh Barwick	Duke Power
Gene Vaughan	Duke Power
Ty Ziegler	Devine Tarbell & Associates
Steve Arnold	Devine Tarbell & Associates
Gerrit Jobsis	Catawba Wateree Relicensing Coalition
Mark Giffin	South Carolina DHEC
Wayne Harden	South Carolina DHEC

2. Contents

This Aquatic Resource Committee Report includes:

- For each study within this Resource Committee's overview:
 - ⇒ A brief summary of each study's purpose(s)
 - ⇒ A brief summary of the methods/procedure used for each study
 - ⇒ A brief summary of the Key Findings for each study
- At the Resource Committee level, a coordinated resource assessment of any potential Protection or Mitigation needs or Enhancement opportunities that are supported by the study findings.

3. Study Summary – Purpose, Methods and Findings

This section extracts, condenses and summarizes information from the more detailed Study Reports without further assessment, evaluation or commentary. This section would be analogous to an Executive Summary of the Study Report.

3.1 Fish Community Assessment (Aquatics 01)

3.1.1 Study Purpose

The purpose of the Fish Community Assessment study was to evaluate the fish communities present within the Catawba – Wateree Project area. To achieve this purpose Duke conducted fish community surveys, including small non game species, in bypassed river reaches, tailrace areas, regulated riverine reaches, and major tributaries of the Catawba – Wateree Project. In addition Duke conducted field sampling to assess presence and relative abundance of fishes of special concern such as the robust and Carolina redhorses and highfin carpsuckers in the regulated river reaches downstream of the Bridgewater, Wylie, and Wateree Developments. Finally Duke developed a reservoir fishery assessment, using Duke Power's extensive historical database for the Catawba – Wateree reservoirs.

3.1.2 Study Methodology

Bypassed River Reaches of the Catawba River below Lake James, Paddy Creek below Lake James, below Mountain Island Hydro Spillway, and Great Falls Long Bypassed Reach: Backpack electrofishing in accordance with the North Carolina Division of Water Quality (NCDWQ) Index of Biotic Integrity (IBI) was used in a wadeable stretch of the Catawba River channel immediately downstream of the Catawba Dam on Lake James. Qualitative backpack electrofishing was used in other areas (Paddy Creek Bypassed Reach at Lake James, bypassed reach at Mountain Island Hydro, and the Great Falls Long Bypassed Reach) in order to characterize the fish community. In addition, rotenone sampling of pools was conducted in three sections of the Great Falls Long Bypassed Reach. The Wateree Bypassed Reach has not been sampled.

Regulated River Reaches downstream of Bridgewater, Oxford, Wylie, and Wateree Dams: Fish communities in regulated river reaches at Bridgewater and Wylie were documented by previous studies. The fish community in the regulated river reach downstream of Oxford Hydro was assessed by boat-mounted electrofishing during spring and summer of 2004 at three locations. The fish community downstream of Wateree Hydro was assessed using boat-mounted electrofishing at 5 locations in spring and summer of 2004. Additional fish community information was compiled during diadromous fish sampling at 5 locations in the Wateree River in 2004. Wateree River fish community information was supplemented in 2005 with electrofishing and gillnet information collected from six locations during diadromous fish sampling.

Tailraces at Rhodhiss, Lookout Shoals, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek Dams: Boat-mounted electrofishing was used in the immediate tailrace at these locations and compared to a reference station downstream.

Wadeable Tributary Streams including the Catawba River (above Lake James), Warrior Fork Creek, Johns River, Lower Little River, Balls Creek, Long Creek, Six Mile

Creek, Waxhaw Creek, Cane Creek, Fishing Creek, Big Wateree Creek, and Grannies Quarter Creek: Fish communities in these areas were sampled during the summer of 2004 with backpack electrofishing according to the IBI procedures developed by NCDWQ.

Rare Suckers: The presence of rare suckers (robust redhorse, Carolina redhorse, and highfin carpsucker) was evaluated via boat-mounted electrofishing in the Wylie and Wateree Regulated River Reaches at selected locations of appropriate habitat.

Reservoir Fishery Assessment: The fish communities of the Catawba – Wateree reservoirs were described and assessed based on existing Duke Power information and other related studies.

3.1.3 Fish Community Assessment – Key Findings

Bypassed River Reaches: Project bypassed reaches have been altered by Project operations. The Catawba River Bypassed Reach exhibits a marginal fish community, although the fish community further downstream improved dramatically as a result of additional flows from Muddy Creek. The majority of the Mountain Island Bypassed Reach and the Paddy Creek Bypassed Reach does not contain water. The majority of the Great Falls Bypassed Reach channel is dry and unavailable for fish habitat. Where flow is available the fish community is marginal. Following spill events in the Great Falls bypassed channel, the channel dries out and the isolated pools become adverse to aquatic life due to water quality conditions such as temperature.

Regulated River Reaches: Stream segments downstream of Bridgewater, Oxford, Wylie, and Wateree Dams were subject to altered flows, seasonal reductions in dissolved oxygen, and for the Bridgewater Regulated River Reach, reduced water temperatures. Fish communities in the Oxford, Wylie, and Wateree Regulated River Reaches were representative of southeastern fish communities but communities were not sampled during periods of low dissolved oxygen. The Oxford regulated river reach had fewer fish species than expected. The Bridgewater Regulated River Reach is managed as a coldwater fishery for trout by the North Carolina Wildlife Resources Commission.

Tailraces: In general, more fish species were collected in each tailrace than the associated downstream reservoir location. Catches of fish per hour of sampling time were higher in tailraces than the associated downstream location in summer and this same trend was generally true during spring as well.

Wadeable Tributary Streams: Index of Biotic Integrity (IBI) ratings for all the sampled tributary streams ranged from Poor to Excellent. Ratings in NC streams were generally Good to Excellent except below the Catawba Dam on the Catawba River Bypassed Reach which is rated Poor. This location had low dissolved oxygen, higher than normal conductivity, and limited upstream habitat. Ratings in SC streams were Poor to Excellent. All streams, except Grannies Quarter Creek, exhibited elevated conductivities indicative of man-induced impacts. In general, IBI scores reflected local impacts.

Rare Suckers: Surveys conducted for robust and Carolina redhorses and highfin carpsuckers in the vicinity of gravel bars, cobble, and boulders in spring (when fish should be concentrated in spawning aggregations) were inconclusive. Five species of suckers were collected in the Catawba River below the Wylie Dam and six species were collected in

the Wateree River but no individuals of the three targeted species were collected. Results indicate that the rare sucker species may be extremely uncommon or absent. .

Reservoir Fishery Assessment: The number of fish species, age class distribution, and their abundance varied substantially among the Catawba-Wateree Reservoirs (Table 1). Total fish abundance as measured by weight tended to increase as reservoir fertility increased. This trend suggests that food abundance was a significant factor. Largemouth bass, sunfish, crappie, and catfish abundance tended to increase with reservoir fertility. Factors other than fertility also may be regulating fish abundance in Fishing Creek Reservoir and the upper reaches of Lake Wateree.

Open water forage fish communities of Lakes James, Rhodhiss, Hickory, and Lookout Shoals consisted of primarily of gizzard and threadfin shad (Table 2). The relative abundance of these two species was extremely variable among years, potentially due to the susceptibility of threadfin shad to winter die-offs during cold winters. Stocking would also be expected to affect forage fish abundance and composition. The open water forage fish communities of Lakes Norman, Mountain Island, Wylie, and Wateree consisted almost entirely of threadfin shad. Alewife, an exotic and mobile species that affects fish population dynamics, was found in Lake Norman initially and has since spread to Mountain Island and Lake Wylie. The relative abundance of alewife on Lakes Norman and Mountain Island has increased rapidly since its introduction.

The reservoirs provide an important sport fishery. Crappie were the most frequently harvested fish in all of the reservoirs with the exception of Lake James (sunfish). Striped bass constituted the largest percentage of total sport fish harvest on Lakes Rhodhiss and Hickory, and are important on Lakes Wateree and Norman. On Lakes Norman, Mountain Island, Fishing Creek, Cedar Creek, and Wateree, crappie constituted the largest percentage of total harvest by weight. On Lake Wylie, both largemouth bass and crappie were major components of total harvest.

3.2 Reservoir Fish Habitat Assessment (Aquatics 02)

3.2.1 Study Purpose

The purpose of this study was to evaluate shallow water fish habitat within the drawdown zone of the Catawba – Wateree reservoirs in order to evaluate the effects of changes in water levels on fish habitat. Habitats evaluated included vegetation/stream confluence, large woody debris, riprap and piers, along with clay, sand, and cobble substrates which are included and defined in the Shoreline Management Plan.

3.2.2 Study Methodology

Operational records were used to identify magnitude, season, frequency, and duration of water level fluctuations in each reservoir on the Catawba-Wateree River. Current shallow water fish habitat maps delineating full pool distributions of the various types of habitat were the basis for all habitat surveys. From these maps, representative transects perpendicular to the shoreline were selected and habitat elevation extending through the drawdown zone was determined. The number of transects selected and their distribution throughout the reservoirs was determined from the total length of shoreline comprising each habitat type and its distribution throughout the reservoir. The vertical distributions of the habitats from the resulting transects were summarized by one-foot depth contours from full pool. This

information was incorporated into a GIS data base that also contains bathymetric data either previously collected or acquired from aerial photography. These data were used to estimate habitat at one-foot changes in reservoir water levels.

3.2.3 Reservoir Fish Habitat – Key Findings

- a) Water level fluctuations vary by lake and are specific to each based on the existing guide curve
- b) The quantity of shallow-water habitats generally decline as water levels recede
- c) The greatest declines in habitat usually occur at drawdowns of 1-3 feet
- d) Vegetation and stream confluence habitat is most affected by drawdowns; other habitats are available to fish at normal minimum pool elevations.

3.3 Diadromous Fish Studies (Aquatics 03)

3.3.1 Study Purpose

The purpose of this study was to evaluate the biological, engineering, and economic aspects of diadromous fish restoration to the Catawba-Wateree Project waters from Wateree Dam and ending at Wylie Dam for anadromous species. Anadromous target species for studies include: American shad, hickory shad, blueback herring, striped bass, shortnose sturgeon, and Atlantic sturgeon. Restoration of the catadromous American eel will also be considered throughout its historical range in the drainage. The following tasks were included as part of this assessment: a) evaluation of historical distributions of diadromous fish species, b) development of spawning and rearing habitat criteria, c) evaluate the availability of suitable spawning habitat in the Wateree River and the Catawba River and its reservoirs upstream of Wateree Dam, d) an engineering assessment, conceptual design, and cost estimates for fish passage facilities on the Catawba – Wateree Project, e) usage of the Wateree River by diadromous fish species, and f) development of various options for restoration.

3.3.2 Study Methodology

- a) A review of historical literature, museum collections, and other anecdotal sources of information was used to evaluate historical distributions of diadromous fish species.
- b) A review of existing literature and a diadromous fish habitat workshop was used for development of spawning and rearing habitat criteria.
- c) Instream flow studies (Aquatics 04) and reservoir fish habitat studies (Aquatics 02) were used for an evaluation of the availability of suitable spawning habitat in the Wateree River and the Catawba River and its reservoirs upstream of Wateree Dam.
- d) Fish passage engineering, conceptual designs and alternatives for fish passage facilities with the associated cost estimates were developed through an engineering assessment, conceptual design, and cost estimates for fish passage facilities on the Catawba – Wateree Project from Wateree through Fishing Creek.
- e) The Wateree River was electrofished in the spring of 2004 and 2005. Gillnets and eel traps were used to collect diadromous fishes in 2005. Diadromous species were captured, identified, measured, and their relative abundance evaluated by catch per hour of electrofishing statistics.
- f) Consultation with the Aquatics Resource Committee and mandatory conditioning agencies based on study results and cost-benefit analysis was used as part of an evaluation of Options for fish passage facilities.

3.3.3 Diadromous Fish Studies – Key Findings

Diadromous Fish Species in the Wateree River:

- a) Diadromous fish species collected in the Wateree River included the American eel, American shad, striped mullet, and blueback herring. Hickory shad, Atlantic sturgeon, and shortnose sturgeon have not been collected during the study.
- b) American eel were collected in low numbers. Historic accounts indicate that eel were once abundant in the Wateree River.
- c) Approximately 200,000-500,000 American shad are passed above the Santee-Cooper dams each spring.
- d) Adult American shad were predominantly found in the lower coastal plain reach of the Wateree River. Fewer shad were found in the lower Piedmont where they occurred historically.
- e) It was unexpected to find yearling American shad in freshwater environments in the spring and the rationale for this finding is poorly understood.
- f) Blueback herring were collected in low numbers throughout the Wateree River during a short period time. Blueback herring typically spawn within inundated floodplains when that habitat is available.
- g) Overall the numbers of diadromous fish at the Wateree dam were lower than expected based on the number of fish passed into the Basin.

Fish Passage Feasibility

- a) Historic distributions of shad and sturgeon are well documented in the Great Falls vicinity and into North Carolina near the town of Mt. Holly. American eel are documented throughout the Basin upstream as far as Marion, NC. Herring distributions are not well documented.
- b) Upstream and downstream passage methods for surface oriented shad and herring are well developed and readily applicable to Wateree River developments.
- c) Sturgeon upstream and downstream passage methods are not well developed, particularly downstream passage. Conceptual passage methods for sturgeon are actively being developed and tested.
- d) American eel upstream passage methods are well developed, and feasible for application to Catawba-Wateree Project, however, effective downstream passage methods are not as well developed.
- e) Fully developed and permanent upstream passage for shad and herring from Wateree through Fishing Creek developments has a conceptual level cost of at least \$32,468,500 to construct, plus operation and maintenance costs of \$434,200 annually.
- f) Fully developed and permanent downstream passage for shad and herring for Wateree through Fishing Creek developments has a conceptual level cost of at least \$6,405,500 to construct, plus operation and maintenance costs of \$340,500 annually.
- g) Fully developed and permanent upstream eel passage at all Catawba-Wateree Developments has a conceptual level cost of at least \$1,800,000 to \$2,600,000 to construct and operation and maintenance costs of \$132,000 to \$154,000 annually, depending on design selected.
- h) Downstream eel passage costs is very preliminary due to uncertainty of design. For an eel siphon type of downstream passage at all developments, a rough estimate of cost is at least \$8,000,000.

- i) The costs of ongoing fishway efficiency studies, energy loss, and the resulting fishway modifications are not included in the estimates above.

3.4 Instream Flow Studies (Aquatics 04)

3.4.1 Study Purpose

The purpose of the instream flow studies was to quantify or otherwise assess the relationship of flow to aquatic habitat in selected regulated river reaches and bypassed reaches of the Catawba-Wateree Project. In addition, downstream navigation studies were also conducted as part of the Aquatics 04 study plan.

3.4.2 Study Methodology

Instream flow needs, and downstream navigation flow needs, were assessed throughout the Catawba-Wateree Project using an assortment of habitat simulation models and other analytical techniques to predict the relationship between flow and aquatic habitat for various fish species and life stages. Models were based on data (flow, velocity, substrate, etc.) collected at various locations on each river section.

Techniques were selected in conjunction with the Instream Flow Study Team and based on the need for information at any given site. The following sites were studied: Catawba River Bypassed Reach (Bridgewater), Bridgewater Regulated River Reach, Oxford Regulated River Reach, Lookout Shoals Tailwater, Mountain Island Bypassed Reach, Wylie Regulated River Reach, Great Falls Long and Short Bypassed Reaches, and the Wateree Regulated River Reach.

Downstream navigation studies were conducted in the regulated river reaches below Wylie Hydro and Wateree Hydro.

3.4.3 Instream Flow Studies – Key Findings

Instream flow recommendations for the Catawba – Wateree Project are summarized in Table 3. Flow recommendations were based primarily on achieving habitat sufficient to support the most flow-sensitive species for each specific reach studied.

3.5 Fish Entrainment Evaluation (Aquatics 05)

3.5.1 Study Purpose

This study evaluated the potential for fish entrainment and turbine-induced mortality at the Catawba-Wateree Project using a literature-based approach drawing upon entrainment field studies completed at numerous other hydroelectric projects east of the Mississippi River, including several sites in the southeastern U.S. The principal objectives were to: (1) characterize and evaluate the potential for fish entrainment and mortality at the 13 project developments by applying common trends and data from entrainment and mortality field studies completed at other hydroelectric projects to site-specific considerations of the physical, operational, and fisheries characteristics of the Catawba-Wateree developments; and (2) assess the implications of potential entrainment to the out-migration needs of

representative diadromous¹ fish species being considered for possible restoration to Catawba-Wateree Project waters between Wateree Dam and Wylie Dam in South Carolina (Aquatics 03).

3.5.2 Study Methodology

Site visits were made to each development to observe the powerhouse, intake forebay, and reservoir habitat characteristics in the vicinity of the forebay. Existing information was gathered and reviewed, including physical, operational, and fisheries characteristics of the project reservoirs and developments; turbine entrainment and mortality field studies completed at other hydroelectric projects; and life history traits and out-migration patterns of six diadromous fish species identified by resource agencies as potential targets for fish passage restoration. Intake velocity profiles also were measured at each forebay under various operational scenarios. Data trends were applied to characterize potential fish entrainment occurring at each development (species, size composition, seasonal variation), evaluate potential mortality rates of fish passing through the turbines, evaluate the potential for entrainment and mortality of diadromous species should fish passage be provided above the lower Catawba-Wateree dams, and discuss potential impacts of continued Project operation to resident fish populations in the Project reservoirs.

3.5.3 Fish Entrainment Evaluation – Key Findings

- a) Continued operation of the Catawba-Wateree Project is not likely to affect resident fish populations and recreational fishing opportunities as a result of fish entrainment and turbine-induced mortality.
- b) Small and young fish likely comprise the majority of fish entrained by the Catawba-Wateree developments.
- c) Entrainment is likely numerically dominated by sunfish, shad, and catfish, and peak entrainment rates most likely occur in spring and summer, when young fish are most abundant and tend to be moving between habitats.
- d) Forage fishes, especially threadfin shad, may seasonally dominate entrainment at developments located on reservoirs supporting large, open-water forage fish populations.
- e) Juvenile sport-fishes, including bluegill, crappie, other sunfish, and catfish, may be entrained in substantial numbers, but largemouth bass, striped bass, and other species probably form relatively small proportions of sport-fish entrainment.
- f) The vast majority of entrained fish, because of their small size, are likely to survive turbine passage into downstream habitats. Small fish are less prone than larger fish to mechanical injury from turbine passage and to injury from shear stresses and rapid pressure changes.
- g) Turbine passage survival is likely to be relatively high at Cowans Ford because it uses large Kaplan turbines that generally contain fewer blades, rotate at slower speeds, and provide larger clearances than the Francis turbines at the other developments.
- h) Entrainment and turbine-induced mortality have the greatest likelihood to adversely affect species of fish that must migrate downstream from the project reservoirs to successfully complete their life cycles (e.g., diadromous species). Presently, there are no populations or coastal stocks of diadromous species that have access to the project area.

¹ Diadromous species migrate between freshwater and marine/estuarine environments to complete their life cycles. Examples include American shad, shortnose sturgeon, and American eel.

- i) If project-specific actions are undertaken to pass diadromous fish populations upstream of Catawba-Wateree dams, and these efforts are successful, then entrainment and turbine-induced mortality could significantly affect out-migrating juveniles and post-spawning adults of some anadromous species, and out-migrating pre-spawning adults of the catadromous American eel, unless alternative routes of downstream passage are also provided.

3.6 Mussel Survey (Aquatics 06)

3.6.1 Study Purpose

The purpose of the mussel survey was to identify the species and distribution of mussels at sites along the Catawba River that are within the project boundary or within the zone of Project influence or in selected tributaries. The surveys were conducted with special emphasis on RTE species of mussels.

3.6.2 Study Methodology

Mussel surveys were conducted at sites within and outside the Project. Surveys consisted of timed random searches of representative stream reaches with an effort concentrated in areas with the apparent best mussel habitat, by wading, SCUBA, mask and snorkel, or viewbox. In addition, representative samples of crayfish and snails encountered during mussel surveys were collected, identified, and included with data collected during the insect macroinvertebrate fieldwork for Aquatics 07.

3.6.3 Mussel Survey – Introduction (summarize (a) and (b) and delete the rest

The status of freshwater mussels in the United States, especially in the Southeast in particular, is well documented. North Carolina provides habitat for more than 60 freshwater mussel species and nearly half these species are designated endangered, threatened, or special concern. Most freshwater mussel species live for 10 or more years and have very complex life histories. Many mussels require a fish host species in order to successfully complete their life cycles. Juvenile mussels less than 20 mm in length are rarely seen on the stream or reservoir bottom. Although much has been learned about the life histories of some species, specific data for most Atlantic Slope species are lacking.

3.6.4 Mussel Survey – Key Findings

- a) The study documented seventeen freshwater mussel species of the twenty-four known from the Santee Basin: common elliptio, variable spike, Carolina lance, Atlantic spike, Roanoke slabshell, Carolina slabshell, pondhorn, paper pondshell, eastern floater, brook floater, creeper, Carolina heelsplitter, eastern pondmussel, eastern creekshell, notched rainbow, yellow lampmussel, and rayed pink fatmucket.
- b) The Catawba River Bypassed Reach supports five mussel species including three robust populations
- c) RTE species were found at the following locations: Linville River (brook floater, Eastern creekshell), Catawba River Bypassed Reach (creeper, Eastern creekshell, notched rainbow), Warrior Fork Creek (brook floater, Eastern creekshell, notched rainbow), Johns River (brook floater, Eastern creekshell, notched rainbow), Wylie Regulated River Reach (Roanoke slabshell, Eastern pondmussel (?), creeper, Eastern creekshell, rayed pink fatmucket), Waxhaw Creek (Carolina heelsplitter, Eastern creekshell), Gills Creek

(Carolina heelsplitter, Eastern creekshell, Carolina creekshell), Fishing Creek (Carolina heelsplitter, creeper, Eastern creekshell, Carolina creekshell), Wateree Regulated River Reach (Carolina slabshell, Roanoke slabshell, Eastern pondmussel (?), rayed pink fatmucket), Twelvemile Creek (Eastern creekshell, notched rainbow, Carolina creekshell, yellow lampmussel)

3.7 Macroinvertebrate Survey Study (Aquatics 07)

3.7.1 Study Purpose

The purpose of the Macroinvertebrate Survey Study was to provide basic information about benthic macroinvertebrate (aquatic insects and other bottom-dwelling organisms) communities and evaluate any potential Project-related effects on these resources.

3.7.2 Study Methodology

Macroinvertebrate Bioassessment Sampling: Aquatic macroinvertebrate bioassessment sampling was conducted in accordance with the Standard Operating Procedures for Benthic Macroinvertebrates developed by the North Carolina Division of Water Quality (NCDENR, 2003). This sampling protocol used a combination of kicknets, sweepnets, and fine-mesh samples. In addition samples were collected in sand and leaf pack habitats.

Regulated River Reaches (Quantitative macroinvertebrate sampling): The effects of Project operations on benthic macroinvertebrates was evaluated by assessing their abundance and biomass as well as the presence of upstream to downstream gradients, in the invertebrate communities below Bridgewater, Oxford, and Wylie hydros (Wateree Hydro was initially considered as another possible quantitative sample site, but due to the voluntary mid-March thru May continuous releases for striped bass spawning, conditions were untenable for this type sampling). A reference site on the Dan River near Danbury, NC was compared to the tailwater data.

Tailraces and Selected Tributaries of Lakes James and Rhodhiss:

Qualitative bioassessment samples were collected in streams upstream of Lake James and Lake Rhodhiss and in the tailraces of the Rhodhiss, Lookout Shoals, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek hydroelectric facilities on the Catawba/Wateree River. Although the bioassessment sampling technique was developed for rivers it was adapted for use in lakes.

3.7.3 Macroinvertebrate Assessment – Key Findings

Regulated River Reaches:

- a) Densities and species diversity of macroinvertebrates generally increased with increasing distance from the dam.
- b) Densities of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) taxa were generally lower immediately below each dam than at the location farthest downstream.–
- c) Diversities and densities of insects collected from the Dan River control location were generally lower relative to downstream Catawba-Wateree locations.

- d) Sampling was not conducted during the periods of low dissolved oxygen (late summer and fall)
- e) Biotic index scores for regulated reaches generally showed 'Fair' water quality classifications while scores for upper Catawba River tributaries generally scored 'Good/Fair' to 'Good' classifications.

Tailraces:

- a) Insect numbers and diversity collected below the dams suggests a typical population in these areas, albeit not quantifiable using standard protocol.
- b) No rare, threatened, or endangered species were collected in this study.

4. Resource Assessment

4.1 Overall Condition of the Resource

Reservoirs: Reservoir fish communities are similar to reservoirs in the Southeast that have similar nutrient loadings. One exception may be at Fishing Creek Reservoir where pounds of fish in the reservoir appear to be somewhat less than might be expected. This may be due to high nutrient loading and consequent overabundance of blue-green algae populations or other such biological factors. Shallow water fish habitat is also typical for reservoirs. Predicted probabilities of fish entrainment and mortality for the Project do not indicate a problem.

Reservoir Tailrace Areas: Fish communities at the Rhodhiss, Lookout Shoals, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek tailrace areas were higher in relative abundance and number of species than in areas downstream in the associated reservoirs. This difference could be ascribed to several factors, but is likely related to the fact that the tailrace areas typically have a greater diversity of habitats and tend to attract and hold more fish, even when water quality values are depressed. Another factor may be that certain species of fish may inhabit these tailrace areas in response to the instinct to move upstream. The tailrace macroinvertebrate communities were generally diverse and fall within those expected for a river reach (more diverse) and those of a reservoir (less diverse). Mussel numbers were generally low in the tailraces.

Regulated River Reaches: Regulated river reaches in the Project are varied. The reach downstream of the Bridgewater Development is considered "atypical" but high quality since it provides a very good trout fishery. Aquatic insects in this area are low nearest the dam and increase downstream. Mussels are absent in this reach, probably due to the coldwater releases. This resource is atypical in the sense that if not for the hypolimnetic release from Lake James, the Catawba River in this reach would be a warmwater stream. The regulated river reach downstream of the Oxford Development could also be considered depressed since sampling produced fewer species of fish than might be expected in this area of the river. The change in aquatic habitat produced by the creation of two reservoirs with a 3-mile section of regulated river like the Oxford Regulated River Reach between may preclude restoration of true riverine aquatic communities, regardless of enhancements to flows or water quality. Fish communities in the Wylie and Wateree Regulated River Reaches were representative of southeastern fish communities but Wateree communities were not sampled during periods of low dissolved oxygen. Freshwater mussels were generally low in

these river reaches and macroinvertebrates recovered with increasing distance from the dam. Diadromous fish species were less abundant than expected below Wateree Dam and absent in the remainder of the project area.

Bypassed River Reaches: These habitats have been altered due to the loss of flow and the associated ecological changes which follows such physical changes. In general, aquatic resources are altered due to lack of instream flows and poor water quality; and the aquatic communities reflect these altered conditions. While these areas are considered depressed, the Catawba Bypassed Reach at the Bridgewater Development is of note because of the persistence of a diverse freshwater mussel community.

Tributary Streams: Aquatic communities were sampled in selected tributary streams. The aquatic communities in these streams seem to be related to water quality and the physical habitat rather than Project operations. The resources in these streams are considered typical for such streams. The presence of the Project has changed the tributary stream habitat available in the Project area. Protection and enhancement projects in such streams may help reconnect or restore some stream habitats.

4.2 Resource Problems, Causes, and Needs

Reservoirs:

- Fish communities in certain Catawba-Wateree Reservoirs may benefit from managing water levels during spawning and rearing seasons to provide spawning adult fish and young-of-the-year fish with better access to shallow water habitats during spring.

Regulated River Reaches:

- The primary resource need in these areas is improving aquatic habitats through enhanced releases from the upstream hydro stations.
- Conditions in the Bridgewater Regulated Reach could also be improved by increasing the dissolved oxygen levels of the releases during late summer through early fall.

Bypassed River Reaches:

- The most obvious resource need for bypassed stream reaches is enhanced flows of suitable water quality.
- The Catawba Bypassed Reach at the Bridgewater Development may require special consideration due to the warmwater needs of the freshwater mussel communities in this area which must be balanced with the need for cold water by a downstream trout fishery; both of which must be balanced with potential changes to Lake James caused by any additional downstream releases.
- There is a well established terrestrial vegetation community which is currently managed to protect the endangered Schweinitz's sunflower in the Mountain Island Bypassed Reach. Any aquatic habitat flows in this reach may need to be considered for potential effects on this sunflower population.

Tailrace Areas:

- Fish communities in these areas may benefit by enhancing water quality of releases.

Tributary Streams:

- Tributary streams are not impacted by project operations, although the presence of the reservoir could represent a barrier to migrating stream fish.

Special Interest Species:

- The status of rare suckers in the Catawba-Wateree System is uncertain. Since these are riverine species, enhanced flow regimes should provide benefits to existing or future populations of these species.
- While diadromous fish species are largely absent from the Catawba River upstream of Wateree Development, the Wateree River appears to provide good habitat for diadromous fish species although the abundance of these species is less than expected. Habitat, usage, and physical conditions in the Wateree River contributing to these low levels need to be understood relative to potential upstream fish passage.

4.3 Assessment of Resource Improvement Options

Based on the above assessment of aquatic resources in the Catawba – Wateree Project, there are several options for enhancing these valuable resources. The Resource Improvement Options listed in this report represent a menu of initiatives for consideration by the State Relicensing Teams and Regional Advisory Groups as they negotiate the Agreement-in-principle (AIP). It is not necessary or expected for all these initiatives to be included in the AIP. Also, other initiatives in combination with or in lieu of the options listed in this report may be included in the AIP.

4.3.1 Consensus Improvement Options: Reservoirs/Tailrace Areas

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
1	Enhance reservoir level management program to stabilize lake levels during spawning period	0	CHEOPS
2	Modify Normal Target Elevations for selected reservoirs to take advantage of the vegetated area shelves which have become established just above normal lake levels to provide enhanced spawning and rearing habitat for fish	0	CHEOPS
3	Establishment of a watershed management fund for certain reservoirs to support initiatives that reduce nutrient and sediment impacts	to be negotiated	to be negotiated
4	Provide additional funding for the Habitat Enhancement Program (HEP) (established by Duke, North Carolina Wildlife Resources Commission, South Carolina Department of Natural Resources, and the United States Fish and Wildlife Service in conjunction with stakeholders	to be negotiated	to be negotiated
5	Support resource agency fish stocking programs and other management programs and partnerships	to be negotiated	to be negotiated
6	Enhancement and protection of near-shore and shallow water habitats	to be negotiated	to be negotiated

4.3.2 Consensus Improvement Options: Regulated River Reaches

- Aquatic habitat could be improved through enhanced flow regimes and improving dissolved oxygen.

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
7	Meet downstream flow objectives by raising the Normal Target Elevation in the winter	TBD	CHEOPS
8	Meet downstream flow objectives by reducing Normal Minimum Elevation in the summer	TBD	CHEOPS
9	Provide continuous minimum flows at Bridgewater, Oxford, Wylie, and Wateree Regulated River Reaches to produce habitat values sufficient to support the most flow-sensitive species	TBD	CHEOPS
10	Optimize the design of the new Linville flow release equipment in order to meet instream and recreation flows	TBD	CHEOPS
11	Enhance dissolved oxygen levels of releases to meet regulatory requirements	to be negotiated	to be negotiated
12	Provide flows for the Wateree River floodplain habitat	to be negotiated	CHEOPS
13	Reduce sediment loading contributions from Muddy Creek into the regulated river reach through passive sediment removal methods	to be negotiated	

4.3.3 Consensus Improvement Options: Bypassed River Reaches:
Bridgewater Development:

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
14	Provide seasonally variable flows to the Catawba Bypassed Reach at temperatures that consider resources in the reservoir, bypassed reach and the regulated river	\$500,000	CHEOPS

4.3.4 Consensus Improvement Options: Bypassed River Reaches:
Mountain Island Development

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
15	Restoration of XX cfs to the Mountain Island spill channel for aquatic habitat (with potential need to relocate rare sunflowers)	\$550,000	CHEOPS

4.3.5 Consensus Improvement Options: Bypassed River Reaches:
Great Falls/Dearborn Development

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
16	Provide seasonally variable flows apportioned to the Long Bypassed Reach and Short Bypassed Reach in order to maximize aquatic habitat	To be determined	CHEOPS
17	Establishment of Rocky Shoals Spider Lily research and restoration program	to be negotiated	to be negotiated

4.3.6 Consensus Improvement Options: Bypassed River Reaches:

Wateree Development:

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
18	Provide a seasonal flow of 2500 cfs to the Wateree bypassed reach for shortnose sturgeon and striped bass spawning (subtracted from any continuous releases from the Powerhouse).	\$500,000	CHEOPS
19	Provide seasonably variable year-round flow from the dam (subtracted from any continuous releases from the Powerhouse).	to be negotiated	CHEOPS

4.3.7 Consensus Improvement Options: Tributary Streams:

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
20	Provide watershed enhancement fund to enhance aquatic communities of key streams.	to be negotiated	to be negotiated
21	Provide funding for Carolina heelsplitter (and other freshwater mussels) research and restoration, and other resource enhancements	to be negotiated	to be negotiated

4.3.8 Consensus Improvement Options: Special Interest Species: Rare Sucker

Species

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
22	Establish research and restoration program for rare sucker species.	to be negotiated	CHEOPS

4.3.9 Consensus Improvement Options: Special Interest Species: Diadromous Fish Species

Option #	Option Description	Initial Cost Estimate	Annual Cost Estimate
23	Develop and implement a fish restoration program with the following elements : <ul style="list-style-type: none"> • Cooperative research focused on the Santee-Cooper Basin Diadromous Fish Passage Restoration Plan • A cooperative, basin-wide approach to diadromous fish restoration involving all resource agencies and utilities • Research focused on restoration of diadromous species entering the Wateree River • A phased approach to fish passage based on population triggers and the Santee-Cooper Basin Fish Passage Restoration Plan • Reasonable cost limitations and maintenance and upgrades of any facilities constructed. 	to be negotiated	to be negotiated

4.3.10 Non-consensus Improvement Options: Regulated River Reaches

24	Use existing equipment at Wylie and Wateree to meet downstream flows through pulsing operations	to be negotiated	CHEOPS
25	Reduce the effects on aquatic resources by altering the magnitude, frequency and rate of change of peak flows	to be negotiated	CHEOPS
26	Provide sediment transport flows at the Catawba Bypassed Reach and Bridgewater regulated river reach	to be negotiated	CHEOPS

Table 1. Mean density, biomass, and taxonomic composition of littoral fish communities of Catawba-Wateree reservoirs based on electrofishing data.

Lake	Region	Mean littoral fish density, fish per kilometer of shoreline	Mean littoral fish biomass, kg per kilometer of shoreline	Taxa comprising 10% or more of total density	Taxa comprising 10% or more of total biomass
James	Upper Catawba arm	667	191	Bluegill (23%), redbreast sunfish (12%), notchlip redhorse (10%)	Common carp (31%), notchlip redhorse (29%), largemouth bass (12%)
James	Lower Catawba arm	260	47	Redbreast sunfish (30%), bluegill (26%), largemouth bass (16%)	Largemouth bass (34%), notchlip redhorse (19%), common carp (13%), smallmouth bass (12%)
James	Linville arm	184	34	Redbreast sunfish (35%), bluegill (19%), smallmouth bass (18%), largemouth bass (12%)	Largemouth bass (30%), smallmouth bass (24%), common carp (21%)
Rhodhiss	Lower lake	903	174	Bluegill (38%), redbreast sunfish (21%), largemouth bass (16%), yellow perch (10%)	Largemouth bass (40%), common carp (31%)
Hickory	Upper lake	564	101	Bluegill (31%), redbreast sunfish (19%), yellow perch (14%), largemouth bass (12%), gizzard shad (11%)	Largemouth bass (33%), common carp (23%), white catfish (11%)
Hickory	Lower lake	556	94	Bluegill (34%), redbreast sunfish (33%), largemouth bass (17%)	Largemouth bass (46%), common carp (15%), white catfish (13%)
Lookout Shoals	Lakewide	314	43	Bluegill (41%), yellow perch (17%), largemouth bass (15%), redbreast sunfish (14%)	Largemouth bass (46%), common carp (17%)
Norman	Marshall Steam Station	525	37	Bluegill (35%), largemouth bass (14%), redbreast sunfish (14%), whitefin shiner (13%)	Largemouth bass (39%), common carp (35%)
Norman	Midlake reference area	445	32	Bluegill (32%), redbreast sunfish (14%), largemouth bass (13%), whitefin shiner (13%)	Common carp (34%), largemouth bass (33%)
Norman	McGuire Nuclear Station	481	20	Bluegill (34%), whitefin shiner (16%), redbreast sunfish (15%)	Largemouth bass (35%), common carp (25%)
Mountain Island	Lower lake	528	46	Redbreast sunfish (41%), bluegill (22%), largemouth bass (21%)	Common carp (40%), largemouth bass (33%), redbreast sunfish (10%)
Wylie	Plant Allen	1,132	132	Bluegill (56%), largemouth bass (12%)	Largemouth bass (38%), common carp (19%), white catfish (16%)
Wylie	Buster Boyd Bridge area	878	123	Bluegill (56%), largemouth bass (14%)	Largemouth bass (47%), white catfish (20%)
Wylie	Catawba Nuclear Station	753	89	Bluegill (58%), largemouth bass (11%)	Largemouth bass (41%), bluegill (11%), gizzard shad (11%)
Fishing Creek	Lakewide	475	93	Bluegill (41%), largemouth bass (15%), gizzard shad (12%)	Largemouth bass (37%), common carp (30%)
Great Falls-Dearborn	Lakewide	267	83	Bluegill (21%), largemouth bass (14%), redear sunfish (14%), gizzard shad (11%)	Common carp (48%), largemouth bass (18%)
Cedar Creek Reservoir	Lakewide	407	96	Bluegill (36%), largemouth bass (18%)	Largemouth bass (48%), common carp (34%)
Lake Wateree	Upper lake	584	81	Bluegill (23%), gizzard shad (22%)	Common carp (43%), largemouth bass (33%)
Lake Wateree	Lower lake	1,487	165	Bluegill (27%), gizzard shad (25%), threadfin shad (17%)	Common carp (42%), largemouth bass (28%)

Table 2. Density and taxonomic composition of limnetic forage fish communities of Catawba-Wateree reservoirs based on hydroacoustics and purse seine sampling.

Lake	Mean forage fish density, fish per hectare	Range of annual estimates of forage fish density, fish per hectare	Mean taxonomic composition of limnetic forage fish based on purse seine		
			Gizzard shad	Threadfin shad	Alewife
James	2,524	887 - 4,380	67%	33%	(not observed)
Rhodhiss	24,172	6,510 - 41,834	56%	44%	(not observed)
Hickory	20,806	11,173 - 30,438	49%	51%	(not observed)
Lookout Shoals	7,016	5,377 - 8,655	49%	51%	(not observed)
Norman	6,126	5,087 - 7,229	0%	93%	7%
Mountain Island	3,102	998 - 4,554	2%	86%	12%
Wylie	4,686	3,036 - 6,336	0%	100%	0%
Fishing Creek Reservoir	17,885	3,163 - 32,606	(no data)	(no data)	(no data)
Great Falls- Dearborn	(no data)	(no data)	(no data)	(no data)	(no data)
Cedar Creek Reservoir	(no data)	(no data)	(no data)	(no data)	(no data)
Lake Wateree	29,252	7,402 - 51,102	6%	94%	(not observed)

Table 3: Recommended flows for Catawba – Wateree Hydro Projects

Flows (Cubic Feet per Second¹)

Regulated River or Bypassed Reach	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
Linville	115	120	130	100	95	80	65	55	55	55	70	105	87
Catawba (Below Muddy Creek)	320	320	295	240	280	260	240	205	200	200	220	295	257
Paddy Creek Bypass	-	-	-	-	-	-	-	-	-	-	-	-	
Old Catawba Channel Bypass	205	200	165	140	185	180	175	150	145	145	150	190	170
Oxford	870	905	870	875	885	805	785	695	665	625	730	850	741
Lookout Shoals	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Mountain Island Spill Channel	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Wylie ²	2160	2500	2500	2500	2500	2000	1080	1080	1080	1080	1080	1625	1765
Wylie – navigation	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
Great Falls Long Bypass	450	450	450	450	450	450	450	450	450	450	450	450	450
Great Falls Short Bypass	500	500	500	500	500	500	500	500	500	500	500	500	500
Wateree ³	2300	2850	2850	2850	2850	2250	1160	1160	1160	1160	1160	1750	1958
Wateree Spill Channel ⁴	-	2500	2500	2500	2500	2500	-	-	-	-	-	-	1042
Wateree Navigation	930	930	930	930	930	930	930	930	930	930	930	930	930

¹ Flow figures based on meeting criterion of 80% of habitat values available in an unregulated flow regime

² Flow in spring adjusted upward from the 80% unregulated flow criterion to provide for sturgeon and striped bass spawning habitat

³ Flow in spring adjusted upward from the 80% unregulated flow criterion to provide for sturgeon and striped bass spawning habitat

⁴ PHABSIM surrogate reach results for sturgeon spawning and rearing habitat at approximately 80% of habitat available at unregulated flow