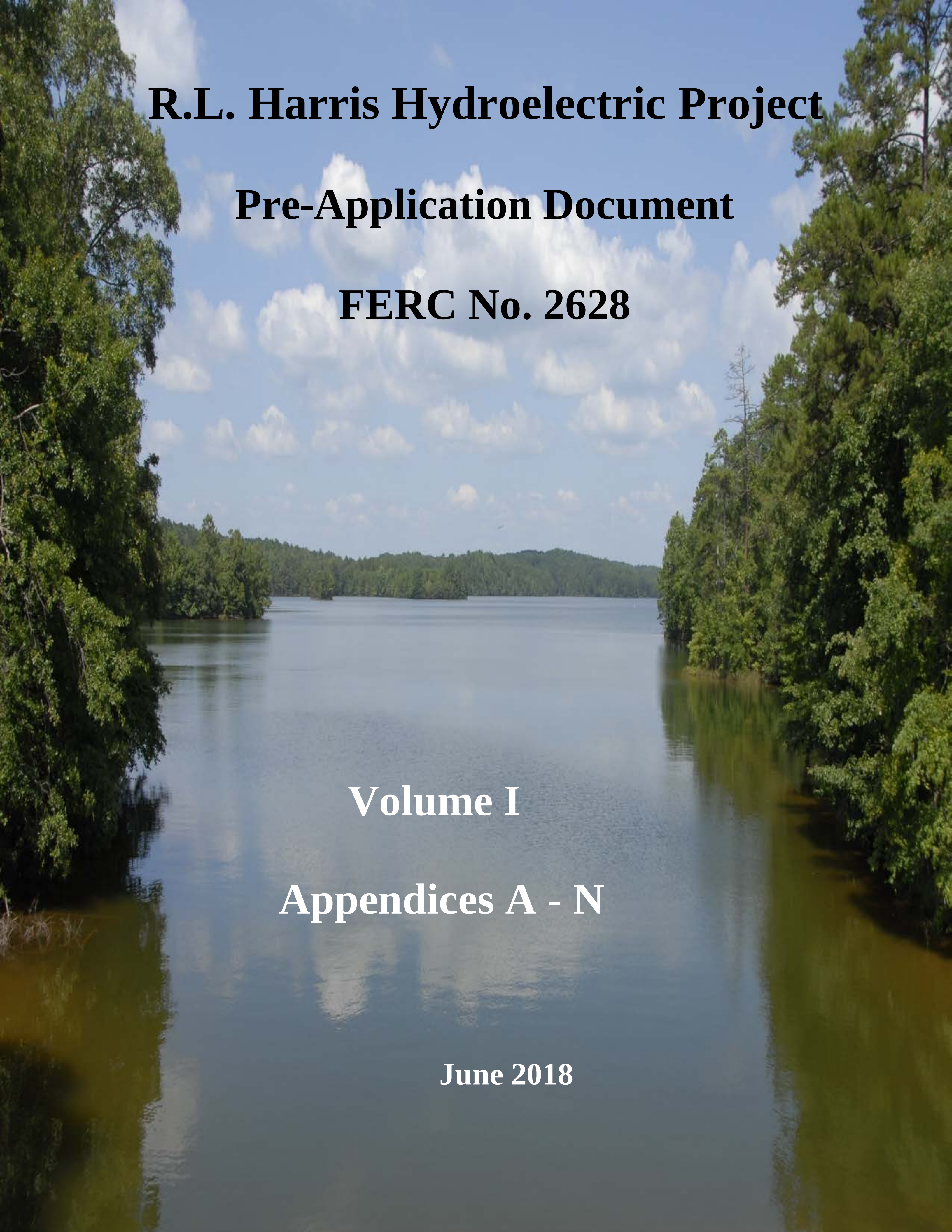

R.L. Harris Hydroelectric Project

Pre-Application Document

FERC No. 2628

Volume I

Appendices A - N

June 2018

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Appendix A
Terms and Definitions

TERM	DEFINITION
A	
Acre (ac)	A measure of land area equal to 43,560 square feet.
Acre-feet (af)	The amount of water it takes to cover one acre to a depth of one foot; equal to 43,560 cubic feet or 1,233.5 cubic meters.
Active Storage	The volume of water in a reservoir between the minimum operating elevation and the maximum normal operating elevation.
Alluvium	Material (e.g. sand, silt, or clay) deposited on land by water, such as on floodplains.
Anadromous fish	Fish that live in saltwater habitats most of their lives but periodically migrate into freshwater to spawn and develop to the juvenile stage (e.g., alewife).
Automatic/ Semi-automatic/ Manual Powerhouses	An automatic powerhouse can be started and stopped and have its load and voltage changed from a remote or master station (e.g. via supervisory control). A semiautomatic powerhouse with Supervisory Control and Data Acquisition (SCADA) may allow a remote station to change load and/or voltage and may allow a remote shutdown but must be started manually. A semi-automatic powerhouse without SCADA will send alarms to a remote or master station. A manual powerhouse must have all its functions performed at the powerhouse.
Aquatic Life	Any plants or animals that live at least part of their life cycle in water.
APE	Area of Potential Effects as pertaining to Section 106 of the National Historic Preservation Act.
B	
Baseline	A set of existing environmental conditions upon which comparisons are made during the NEPA process.
Base Load	A power plant that is planned to run continually except for maintenance and scheduled or unscheduled outages. Also refers to the nearly steady level of demand on a utility system.
Benthic	Associated with lake or river bottom or substrate.
Black Start Capability	The ability of a unit to start up without the use of an external transmission or distribution electrical supply.
Benthic Macroinvertebrates	Animals without backbones that are visible to the eye and live on, under, and around rocks and sediment on the bottoms of lakes, rivers, and streams.
C	
Capacity	The load for which an electric generating unit or other electrical equipment or power line is rated
Catadromous fish	Fish that live in freshwater most of their lives but periodically migrate to the sea to spawn (e.g., American eel)
Critical Energy Infrastructure Information (CEII)	Project-related documents related to the design and safety of dams and appurtenant facilities that are restricted from public viewing in accordance with FERC regulations (18 CFR 388.113) to protect national security and public safety.
Cubic Feet (cf)	The volume of a cube with edges one foot in length.

TERM	DEFINITION
C.F.R.	U.S. Code of Federal Regulations
Clean Water Act (CWA)	The Federal Water Pollution Control Act of 1972 and subsequent amendments in 1977, 1981, and 1987 (commonly referred to as the Clean Water Act [CWA]). The CWA established a regulatory system for navigable waters in the United States, whether on public or private land. The CWA set national policy to eliminate discharge of water pollutants into navigable waters, to regulate discharge of toxic pollutants, and to prohibit discharge of pollutants from point source without permits. Most importantly, it authorized the Environmental Protection Agency (EPA) to set water quality criteria for states to use to establish water quality standards.
Colluvium	Soil material and/or rock fragments moved by gravity, such as during creep, slide, or localized washouts, that is deposited at the base of steep slopes.
Combustion Turbine	A fuel-fired turbine engine used to drive an electric generator.
Commission	Federal Energy Regulatory Commission, also referenced as FERC.
Conduit	A tunnel or pipe used for diverting or moving water from one point to another; typically used when there is no existing streambed or waterway.
Conservation	A process or program designed to increase the efficiency of energy and water use, production, or distribution.
Cubic feet per Second (cfs)	A measurement of water flow representing one cubic foot of water moving past a given point in one second; equal to 0.0283 cubic meters per second and 0.646 million gallons per day (mgd).
Cultural Resources	Includes items, structures, etc. of historical, archaeological, or architectural significance.
Cumulative Impact	The effect on the environment resulting from the incremental impact of the action when added to other past, present, and reasonably foreseen future actions; can result from individually minor but collectively significant actions that take place over a time.

TERM	DEFINITION
D	
Dam	A structure constructed across a water body typically used to increase the hydraulic head at hydroelectric generating units. A dam typically reduces the velocity of water in a particular river segment and increases the depth of water by forming an impoundment behind the dam. It also generally serves as a water control structure.
Demand	The rate at which electric energy is delivered to or by a system at a given instant or averaged over a designated period, usually expressed in kilowatts or megawatts.
Dependable Capacity	The maximum dependable megawatt (MW) output of a generator or group of generators during the critical hydrologic period coincident with peak electrical system load.
Dike	A raised bank, typically earthen, constructed along a waterway to impound the water and to prevent flooding.
Dissolved Oxygen (DO)	Perhaps the most commonly employed measure of water quality. Low DO levels adversely affect fish and other aquatic life. The total absence of DO leads to the development of an anaerobic condition and the eventual development of odor and aesthetic problems.
Distribution Lines	Power lines, such as those in neighborhoods, used to distribute moderate voltage electricity that is "stepped down" to household levels by transformers on power poles.
Distribution System	The substations, transformers, and lines that distribute electricity from high-voltage transmission lines to the consumer.
Drawdown	The distance the water surface of a reservoir is lowered from a given elevation as the result of releasing water.
E	
Emergent Aquatic Vegetation	Plants rooted in substrate covered by shallow water (up to 6.6 feet depth) with most of its parts out of the water.
Energy	Average power production over a stated interval of time, expressed in kilowatt-hours, megawatt-hours, average kilowatts, and average megawatts.
Eutrophic	Waters with a high concentration of nutrients and a high level of primary production.
Evapotranspiration	The evaporation from all water, soil, snow, ice, vegetation, and other surfaces, plus transpiration.
Extant	Still in existence; surviving.
F	
°F	Degrees Fahrenheit
Federal Energy Regulatory Commission	The governing federal agency responsible for overseeing the licensing, relicensing, and operation of non-federal hydroelectric projects in the United States.
Federal Power Act (FPA)	Federal statute enacted in 1920 that established the Federal Power Commission (now the FERC) and the statutes for licensing hydroelectric projects.

TERM	DEFINITION
Federal Power Commission (FPC)	Predecessor of the FERC.
Federal Register	A publication of the federal government that includes official transactions of the U.S. Congress and all federal agencies. Copies of the Federal Register are usually available at large public and university libraries.
Flow	The volume of water passing a given point over a given amount of time.
Flow Duration Curve	A graphical representation of the percentage of time in the historical record that a flow of any given magnitude has been equaled or exceeded.
Forebay	A reservoir upstream from a powerhouse from which water is drawn into a tunnel or penstock for delivery to the powerhouse
Francis turbine	A radial-inflow reaction turbine in which the flow through the runner is perpendicular to the turbine shaft.
G	
GIS	Geographic Information System
Generation	The process of producing electricity from other forms of energy, such as steam, heat, or water. Generation refers to the amount of electric energy produced; expressed in kilowatt-hours.
Generator	A machine that converts mechanical energy into electricity; often powered by a turbine.
Gross Storage	The sum of the inactive storage and the active storage volumes of a reservoir; the total amount of water contained in a reservoir at its maximum normal operating elevation.
H	
H-Frame Structure	A transmission line structure that consists of two wood poles with a horizontal cross arm above the conductor.
Habitat	The locality or external environment in which a plant or animal normally lives and grows.
Harris Dam	Refers to the R.L. Harris Dam structure; includes the dam, spillway, and powerhouse.
Harris Project	Refers to all the lands, waters, and structures enclosed within the FERC Project Boundary, which includes both Lake Harris and Skyline.
Harris Reservoir	Refers to the 9,870-acre reservoir impounded by the Harris Dam.
Head	The distance that water falls in passing through a hydraulic structure or device such as a hydroelectric plant. Gross head is the difference between the headwater and tailwater levels; net head is the gross head minus hydraulic losses, such as friction, incurred as water passes through the structure; rated head is the head at which the full-gate discharge of a turbine will produce the rated capacity of the connected generator.
Headwater	The waters immediately upstream of a dam; for hydroelectric dams, referred to as the water in the impoundment that supplies the turbines (see also forebay).
Horsepower (hp)	A measure of power; equal to about 746 watts.
Hydraulic	Relating to water in motion.

TERM	DEFINITION
Hydroelectric Plant	A facility where the turbine generators are driven by falling water.
Hydroelectric Power	Capturing flowing water to produce electrical energy.
Hydrologic Unit Code (HUC)	Developed by the Water Resources Council; corresponds to a hierarchal classification of hydrologic drainage basins in the United States. Each hydrologic unit is identified by a unique hydrologic unit code (HUC).
Hypolimnetic	The deeper, cooler portions of a reservoir or lake that result from stratification.
I	
Impoundment	The body of water created by a dam.
Inactive Storage	The volume of water in a reservoir below the minimum operating elevation.
Induced Surcharge Curve	A set of lake level elevations used to manage flows during periods of high inflow to ensure protection of downstream lands from flooding.
Installed Capacity	The nameplate MW rating of a generator or group of generators.
Integrated Licensing Process (ILP)	The ILP is the default process by which a hydroelectric project obtains a new license to operate.
Interested Parties	Individuals who have expressed an interest in the relicensing proceeding.
K	
Kilovolts (kV)	A unit of pressure, (or push) of an electric current equal to 1,000 volts.
Kilovolt-ampere (kVA)	A unit of apparent power equal to 1000 volt-ampere.
Kilowatt (kW)	A unit of electrical power equal to 1,000 watts or 1.341 horsepower.
Kilowatt-hour (kWh)	Basic unit of electric energy equal to an average of one kilowatt of power applied over one hour.
L	
Lacustrine	Pertaining to or living in lakes or ponds.
Lake Harris	Refers to the 9,870-acre reservoir, adjacent 7,3921 acres, and the dam, spillway, and powerhouse.
Lake Guide Curve	A set of target lake level elevations that vary seasonally; the lake level normally maintained at or below the elevations specified by the guide curve, except when storing floodwater. Guide curves are often set by federal agencies responsible for operating storage reservoirs, such as the U.S. Army Corps of Engineers.
Lentic	Standing or still water, including lakes, ponds, and swamps.
License Application	Application for a new license that is submitted to the FERC no less than two years in advance of expiration of an existing license.
License	FERC authorization to construct a new project or continue operating an existing project. The license contains the operating conditions for a term of 30 to 50 years.
Licensee	Alabama Power Company
Littoral	Associated with shallow (shoreline area) water (e.g., the littoral zone of an impoundment).
Load	The total consumer demand of electric service at any given time.

TERM	DEFINITION
Lotic	Flowing or actively moving water including rivers and streams.
M	
Mainstem	The main channel of a river as opposed to the streams and smaller rivers that feed into it.
Megawatt (MW)	A unit of electrical power equal to one million watts or 1,000 kW.
Megawatt-hour (MWh)	A unit of electrical energy equal to 1 MW of power used for one hour.
N	
Nameplate Capacity	A measurement indicating the approximate generating capability of a project or unit, as designated by the manufacturer. In many cases, the unit is capable of generating substantially more than the nameplate capacity since most generators installed in newer hydroelectric plants have a continuous overload capacity of 115 percent of the nameplate capacity; also called Installed Capacity.
National Environmental Policy Act (NEPA)	A law passed by the U.S. Congress in 1969 to establish methods and standards for the review of development projects requiring federal action such as permitting or licensing.
Non-Governmental Organization (NGO)	Local, regional, and national organizations such as conservation, sportsman's, or commerce groups.
Normal Operating Elevation	The reservoir elevation approximating the average surface elevation at which a reservoir is kept.
Normal Operating Elevation Range	The elevation difference between the normal maximum and normal minimum operating elevations.
O	
Off Peak	A period of relatively low demand for electrical energy, such as the middle of the night.
On Peak	A period of relatively high demand for electrical energy.
Outage	The period during which a generating unit, transmission line, or other facility is out of service.
P	
Palustrine Emergent Wetland	Contains rooted herbaceous vegetation that extends above the water's surface (i.e., cattails, sedges).
Palustrine Scrub/Shrub Wetland	Dominated by woody vegetation less than 20 feet tall (i.e., willows, dogwood).
Palustrine Forested Wetland	Comprised of woody vegetation that is 20 feet tall or greater (i.e., American elm, swamp white oak).
Peaking Operations	A power plant scheduled to operate during peak energy demand; operation of generating facilities to meet maximum instantaneous electrical demands.
Peak Demand	A one-hour period in a year representing the highest point of customer consumption of electricity.
Pool	Refers to the reservoir or an impounded body of water.
Powerhouse	The building that typically houses electric generating equipment.

TERM	DEFINITION
Power Factor	The ratio of actual power to apparent power. Power factor is the cosine of the phase angle difference between the current and voltage of a given phase. Unity power factor exists when voltage and current are in phase.
Power Pool	A regional organization of electric companies interconnected for the sharing of reserve generating capacity.
Pre-Application Document (PAD)	A document required by FERC when relicensing a project that brings together all existing, relevant, and reasonably available information about the project and its effects on resources; includes a well-defined process plan that sets the schedule for developing the license application and a list of preliminary studies and issues.
Probable Maximum Flood (PMF)	A statistical formula used to calculate a hypothetical flood event that could occur on a particular river basin over a particular duration; derived from the probable maximum precipitation over time.
Project	All the components of a hydropower development (i.e., dam, powerhouse, transmission junctions, reservoir, rights-of-way, lands).
Project Area	The geographic area comprised of the lands and waters in the Project Boundary and those lands immediately adjacent to the Project Boundary.
Project Boundary	The boundary defined in the project's license issued by FERC outlining the geographic area needed for project operations and maintenance.
Project Drainage Basin	The land area from which surface water flows to the project.
Project Vicinity	Refers to a larger geographic area near a project, such as a county.
Project Viewshed	An area from which project features are visible; the land base from which the project may be seen.
Project Works	All the infrastructure associated with the operations of the project and included in the project license.
Public Reference File	A listing of important materials pertaining to the relicensing.
Public Utility	A business enterprise rendering a service considered essential to the public and, as such, is subject to regulation.
R	
Ramping	The act of increasing or decreasing stream flows from a powerhouse, dam, or diversion structure.
Regulated Hydrology	The hydrology of project-affected streams subsequent to construction of the project.
Relicensing	The administrative proceeding in which FERC, in consultation with other federal and state agencies, decides whether and on what terms to issue a new license for an existing hydroelectric project at the expiration of the original license.
Relicensing Participants	Individuals who actively participate in the relicensing proceedings.
Reserve Capacity	Extra generating capacity available to meet unanticipated demand for power or to generate power in the event of loss of generation.
Reservoir	A man-made lake into which water flows and is stored for future use.
Reservoir Useable Capacity	A volume measurement of the amount of water that can be stored for generation, down to a minimum level.

TERM	DEFINITION
Resident Fish	Fish that spend the entire life cycle in freshwater, such as trout and bass.
Resource Agency	A federal, state, or interstate agency with responsibilities in the areas of flood control, navigation, irrigation, recreation, fish or wildlife, water resource management, cultural, or other relevant resources of the state in which a project is or will be located.
Riparian Area	A specialized form of wetland with characteristic vegetation restricted to areas along, adjacent to, or contiguous with rivers and streams. Also, periodically flooded lake and reservoir shore areas, as well as lakes with stable water.
River Miles (RM)	Miles from the mouth of a river; for upstream tributaries, miles from the confluence with the main river.
R.L. Harris Project	FERC No. 2628. R.L. Harris Project refers to all the lands, waters, and structures enclosed within the FERC Project boundary, which includes both Lake Harris and Skyline.
Run-of-River	A term used to describe the operation of a hydroelectric project in which the quantity of water discharged from the project essentially equals the flow in the river.
Runner	The rotating part of a turbine.
S	
Scoping Document 1 (SD1)	A document prepared by FERC as part of NEPA environmental review that initially identifies issues pertinent to the FERC's review of a project. The FERC circulates the SD1 and holds a public meeting to obtain the public's comment.
Scoping Document 2 (SD2)	A revision of the SD1 that takes into account public comment on that document.
Scoping process	The process of identifying issues, potential impacts, and reasonable alternatives associated with the operation of a hydroelectric project. "Scoping" is a process required when any federal agency is taking an action that might affect the quality of the human environment, pursuant to the National Environmental Policy Act (NEPA) of 1969. In the case of hydroelectric projects, FERC’s issuance of an operating license qualifies as a federal action.
Secchi Depth	Average depth that a standard sized black and white disk disappears and reappears when viewed from the lake surface as the water is lowered; an indicator of water clarity.
Seepage	The amount of water that leaks through a structure, such as a dam.
Skyline	Refers to the 15,063 acres of Project land within the Skyline Wildlife Management Area in Jackson County, Alabama.
Skyline Wildlife Management Area (WMA)	Refers to the 59,063-acre James D. Martin-Skyline Wildlife Management Area (Skyline WMA) located in Jackson County, Alabama, which is managed by the Alabama Department of Conservation and Natural Resources.
Spawn	The act of fish releasing and fertilizing eggs.
Spillway	A passage for releasing surplus water from a reservoir or canal.

TERM	DEFINITION
Stakeholder	Any individual or organization (government or non-governmental) with an interest in a hydroelectric project.
State	State of Alabama
Stock	The existing density of a particular species of fish in an aquatic system.
STORET	USEPA's computerized water quality data storage system.
Stratification	A physical and chemical process that results in the formation of distinct layers of water within a lake or reservoir (i.e., epilimnion, metalimnion, and hypolimnion).
Streamflow	The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (cfs).
Study Description	A detailed description of an individual study.
Study Plan	The aggregate of all study descriptions.
Submerged Aquatic Vegetation	Plants with rigid stems and/or leaves rooted in substrate and generally covered by deep water (greater than 6.6 feet depth) with all of the plant parts covered by water.
T	
Tailrace	The channel located between a hydroelectric powerhouse and the river where the discharged water passes through the turbines.
Tailwater	The waters immediately downstream of a dam; for hydroelectric dams, also referred to as the water discharged from the draft tubes.
Tainter Gate	A gate with a curved skin or face plate and is connected with steel arms to an axle. The gate is usually lifted or lowered by a cable that is connected to a hook at the top of the gate rotating on the axle as it is moved.
Taxon	Refers to a set of animals or plants of related classification, such as all the species (i.e., brook trout, lake trout) in a genus (trout); or all the genera (all trout and salmon) in a family of fishes (salmonidae); plural form of taxon is taxa.
Transformer	Equipment vital to the transmission and distribution of electricity designed to increase or decrease voltage.
Transmission	The act or process of transporting electric energy in bulk from one point to another in the power system rather than to individual customers.
Transmission Lines	Power lines normally used to carry high voltage electricity to substations, where it is "stepped down" for distribution to individual customers.
Transpiration	The process where water is absorbed by plants and is converted to vapor and discharged to the atmosphere.
Trash Rack	A series of vertical steel bars found on a dam or intake structure that clears the water of debris before the water passes through the structure.
Turbidity	A measure of the extent to which light passing through water is reduced due to suspended materials.

TERM	DEFINITION
Turbine	A machine for generating rotary mechanical power from the energy in a stream of fluid (such as water, steam, or hot gas). Turbines covert the energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.
V	
Vantage Point	The location from which a viewer sees the landscape.
Volt (V)	The unit of electromotive force or electric pressure, akin to water pressure in pounds per square inch.
W	
Warmwater Fish	Species tolerant of warm water (e.g., bass, sunfish, catfish, sucker).
Watershed	An entire drainage basin including all living and nonliving components of the system.
Wetlands	Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; 3) the substrate is on soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Appendix B
PAD Distribution List

R.L. Harris PAD Distribution List	
Damon Abernathy Alabama Department of Conservation and Natural Resources 64 North Union Street Suite 551 Montgomery, AL 36130	Roy Adamson City of Lineville 60151 Highway 49 N P.O. Box 247 Lineville, AL 36266
Sue Agnew 1131 Lake Geneva Drive Wedowee, AL 36278	Bob Allen U.S. Army Corps of Engineers 109 Saint Joseph Street, P.O. Box 2288 Mobile, AL 36628-0001
Brian Atkins Alabama Department of Economic and Community Affairs P. O. Box 5690 Montgomery, AL 36103-5690	Stan Austin U.S. National Park Service 100 Alabama Street SW 1924 Building Atlanta, GA 30303
Paul Backhouse Seminole Tribe of Florida 6300 Stirling Road Hollywood, FL 33024	Earl Barby Tunica-Biloxi Tribe 150 Melacon Road Marksville, LA 71351
James Barker Alabama Forestry Commission, Cleburne County 513 Madison Avenue Montgomery, AL 36104	Crystal Barnes Hunter Bend Realty 25 Main Street Wedowee, AL 36278
Kenneth and Linda Barnes Barnes Construction 608 Country Road 248 Newell, AL 36280	Roby Bart bart.roby@msn.com
Joshua Benefield Alabama Forestry Commission, Clay County 513 Madison Avenue Montgomery, AL 3610	Bill Boozer Alabama Water Watch Trainer- Lake Wedowee Area Lake Watch P.O. Box 55 Wedowee, AL 36278
Pare Bowlegs Seminole Nation of Oklahoma P.O. Box 1498 Wewoka, OK 74884	Bruce Bradford Alabama Forestry Commission, Jackson County 513 Madison Avenue Montgomery, AL 36104
Sherry Bradley Alabama Department of Public Health P.O. Box 303017 RSA Tower Montgomery, AL 36130-3017	Eleanor Brannon 84 Arrowhead Drive Wedowee, AL 36278
Matt Brooks Alabama Law Enforcement Agency 1830 Constellation Ave. Alpine, AL 35014	Coty Brown Alabama Law Enforcement Agency 1830 Constellation Ave Alpine, AL 35014

R.L. Harris PAD Distribution List	
Karen Brunso Chickasaw Nation P.O. Box 1548 Ada, OK 74820	Steve Bryant Alabama Department of Conservation and Natural Resources 4101 Alabama Highway 21 Jacksonville, AL 36265
Richard Burnes 190 Hummingbird Drive Wedowee, AL 36278	Nancy Burnes Lake Wedowee Property Owners Association 190 Hummingbird Drive Wedowee, AL 36278
Richard Burnes 190 Hummingbird Drive Wedowee, AL 36278	RaeLynn Butler Muscogee (Creek) Nation of Oklahoma P.O. Box 580 Okmulgee, OK 74447
Jim Byard Alabama Department of Economic and Community Affairs P. O. Box 5690 Montgomery, AL 36103-5690	Jim Candler P.O. Box 548 349 Wild Cherry Parkway Wedowee, AL 36278
Todd Carla Jackson County Chamber of Commerce 500 Commerce Street Jackson, AL 36545	Ken Carleton Mississippi Band of Choctaw Indians P.O. Box 6257 Choctaw, MS 39350
Curt Chaffin Alabama Rivers Alliance 2014 6th Avenue N, Suite 200 Birmingham, AL 35203	Mary Lynn Chandler 274 Twin Oaks Drive Wedowee, AL 36278
Chief Oscola Clayton Sylestine Alabama-Coushatta Tribe of Texas 571 State Park Road 56 Livingston, TX 77351	Charles Gary Clark 3938 County Road 49 Wadley, AL 36276
Maria Clark U.S. Environmental Protection Agency 61 Forsyth Street South West Atlanta, GA 30303	Gary Clark Lineville Public Library, Clay County 60119 Highway 49 Lineville, AL 36266
Cleburne County 102 Ross Street Heflin, AL 36264	Tim Coe Mayor of Wedowee 1484 Maine Street, S. Wedowee, AL 36278
Evan Collins U.S. Fish and Wildlife/ Daphne ES Field Office 1208-B Main Street Daphne, AL 36526	Commanding Officer U.S. Coast Guard 1500 S Broad St # 102 Mobile, AL 36605-1804
Patty and Ken Cook 2427 Hurdon Road Snellville, GA 30078	Stan Cook Alabama Department of Conservation and Natural Resources 5937 Union Academy Road Hope Hull, AL 36043

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Fred Couch Alabama Scenic River Trail P.O. Box 182 Choccolocco, AL 36254	Jill Crawford Coushatta Indian Tribe P O Box 10 Elton, LA 70532
Michael Creswell U.S. Army Corps of Engineers 109 Saint Joseph Street P.O. Box 2288 Mobile, AL 36628-0001	Doug and Jan Crisp 265 Sweetwater Drive Lineville, AL 36266
Leon Cromartie U.S. Army Corps of Engineers 109 Saint Joseph Street P.O. Box 2288 Mobile, AL 36628-0001	Gene Crouch Keller Williams 158 Bluebird Drive Wedowee, AL 36278
Jesse Cunningham 783 Ridge Road Dadeville, AL 36853	Crystal Davis Alabama Department of Economic and Community Affairs 401 Adams Avenue P.O. Box 5690 Montgomery, AL 36103-5690
Bob Davis Lake Wedowee Property Owners Association P.O. Box 55 Wedowee, AL 36278	Eldred Davis 315 Wild Turkey Lane Wedowee, AL 36278
Cody Deal 13 Turtle Cove Wedowee, AL 36278	Glenda Dean Alabama Department of Environmental Management P.O. Box 301463 Montgomery, AL 36130-1463
Doug Deaton Alabama Department of Conservation and Natural Resources 64 North Union Street Suite 464 Montgomery, AL 36130	Chris Decker U.S. Environmental Protection Agency 61 Forsyth Street, SW Atlanta, GA 30303
George Detweiler U.S. Coast Guard, Navigation Standards Division 2100 2nd St. SW STOP 7580 Washington, DC 20593	Dennis DeVries Auburn University 311 Swingle Hall School of Fisheries, Aquaculture & Aquatic Sciences Auburn University Auburn, AL 36849

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Mike Dollar 226 Tanglewood Lane Dadeville, AL 36853	Jeff Duncan U.S. National Park Service 100 West Martin Luther King, Jr. Blvd, Suite 214 Chattanooga, TN 37402
Jake Durham Cleburne County Commission 6751 Highway 78 Heflin, AL 36264	John Eddins Advisory Council on Historic Preservation 401 F Street N.W. Suite 308 Washington, DC 20001-2637
Carl and Mary Ann Enstrom P.O. Box 663 Wedowee, AL 36278	Derek Farr Randolph County Commission 32801 Highway 48 Graham, AL 36263
Nan Ferebee Lake Wedowee Property Owners Association P.O. Box 55 Wedowee, AL 36278	Andy Ford U.S. Fish and Wildlife Service/ Daphne ES Field Office 1208-B Main Street Daphne, AL 36526
Steve Forehand Russell Lands 2544 Willow Point Road Alexander City, AL 35010	John Free Alabama Public Service Commission P.O. Box 304260 Montgomery, AL 36130-4260
Sylvia French Lake Wedowee Property Owners Association 111 Laurel Drive Wedowee, AL 36278	Tom Garland Lake Wedowee Property Owners Association P.O. Box 55 Wedowee, AL 36278
Keith Gauldin Alabama Department of Conservation and Natural Resources 64 North Union Street Montgomery, AL 36130	Trey Glenn U.S. Environmental Protection Agency, Region 4 61 Forsyth Street SW Atlanta, GA 30303
Taconya Goar Alabama Department of Conservation and Natural Resources 64 North Union Street Montgomery, AL 36130	Lisa Perras Gordon U.S. Environmental Protection Agency/ Water Protection Division 61 Forsyth Street Atlanta, GA 30303
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Jennifer Grunewald U.S. Fish and Wildlife Service Daphne ES Field Office 1208-B Main Street Daphne, AL 36526	Alan Gurganus Alabama Environmental Council 2717 7th Ave. S. Suite 300 Birmingham, AL 35233

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Jimmy Hall 350 Halloway Road Wedowee, AL 36278	Evelyn Hamrick 141 Hill Crest Court Wedowee, AL 36278
Larry Hanks 47W855 Timberview Drive Big Roack, IL 60511	Don Hardwick 300 Creekview Drive Wedowee, AL 36278
Sid and Susan Hare 1263 Main Street Roanoke, AL 36274	Randall Harvey U.S. Army Corps of Engineers 109 Saint Joseph Street P.O. Box 2288 Mobile, AL 36628-0001
Jennifer Haslbauer Alabama Department of Environment Management P.O. Box 301463 Montgomery, AL 36130	Stacye Hathorn Alabama Historical Commission 468 South Perry Street Montgomery, AL 36104
James Hathorn U.S. Army Corps of Engineers 109 St. Joseph Street Mobile, AL 36607	Dan Hayba United States Geological Survey 12201 Sunrise Valley Drive Reston, VA 20192
Dave Heinzen 316 Magnolia Drive Dadeville, AL 36853	Keith Henderson Alabama Department of Conservation and Natural Resources 64 N. Union Street, Suite 584 Montgomery, AL 36130
Mekko Tiger Hobia Kialegee Tribal Town of the Muscogee (Creek) Nation P.O. Box 332 108 N. Main Street Wetumka, OK 74883	Matthew Hodges Jackson County Commission 102 E Laurel Street Suite 47 Scottsboro, AL 35768
Brigadier General Diana M. Holland U.S. Army Corps of Engineers, South Atlantic Division 60 Forysth Street SW, Room 9M15 Atlanta, GA 30303	Michael Holley Alabama Department of Conservation and Natural Resources 64 North Union Street Montgomery, AL 36130
Daniel Holliman U.S. Environmental Protection Agency, Region 4 61 Forsyth Street, SW Atlanta, GA 30303	Sonja Hollomon P.O. Box 734 Wedowee, AL 36278
Lynn and Ronnie Horton Lake Wedowee Property Owners Association 8425 Mill Run Tr. Whiteburg, GA 30185	Jim Howard Alabama B.A.S.S. Nation 3838 Hwy 92 Douglasville, GA 30135

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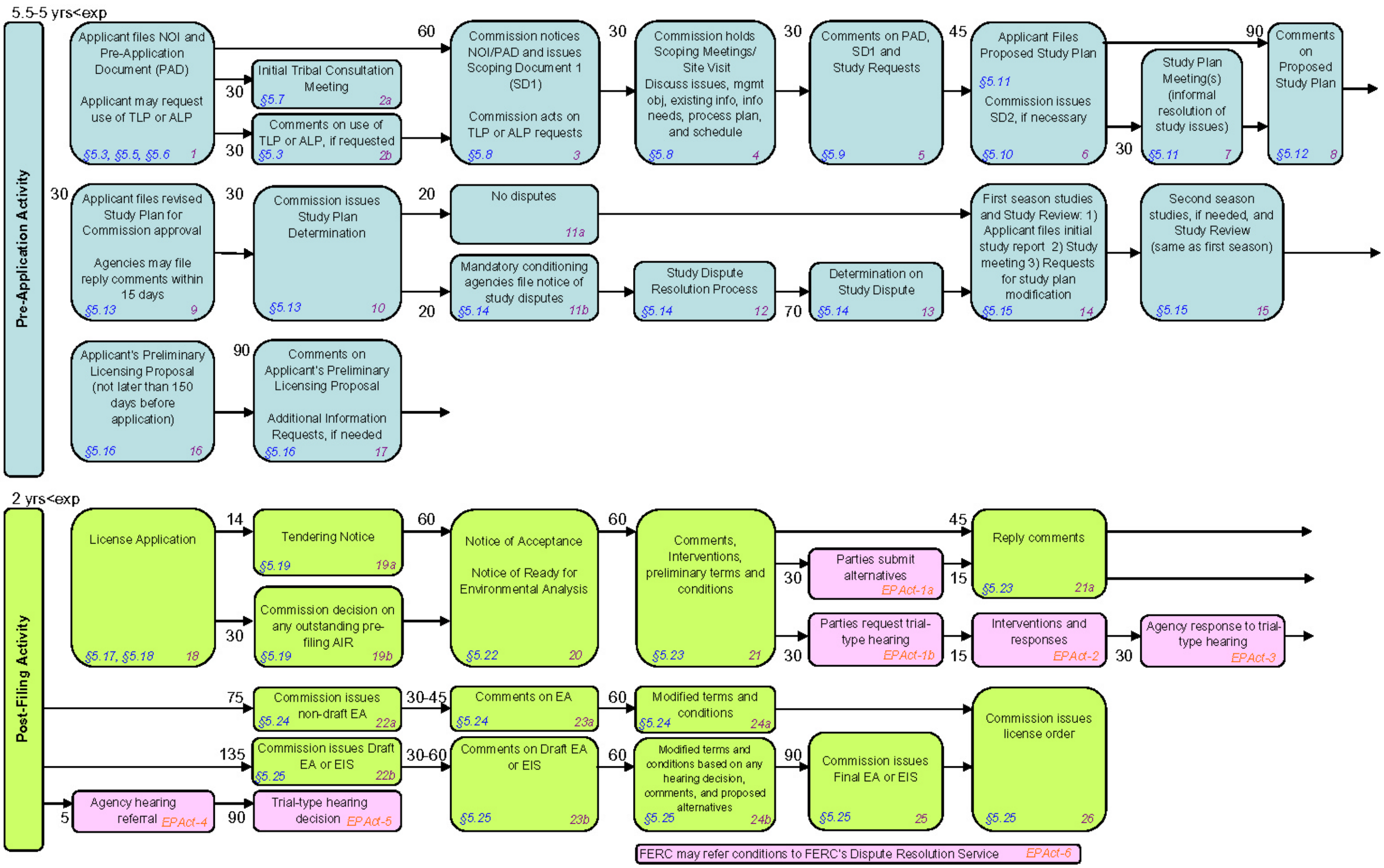
Appendix C
FERC Integrated Licensing Process Schematics

Appendix C

Integrated Licensing Process and Section 241 of the Energy Policy Act of 2005

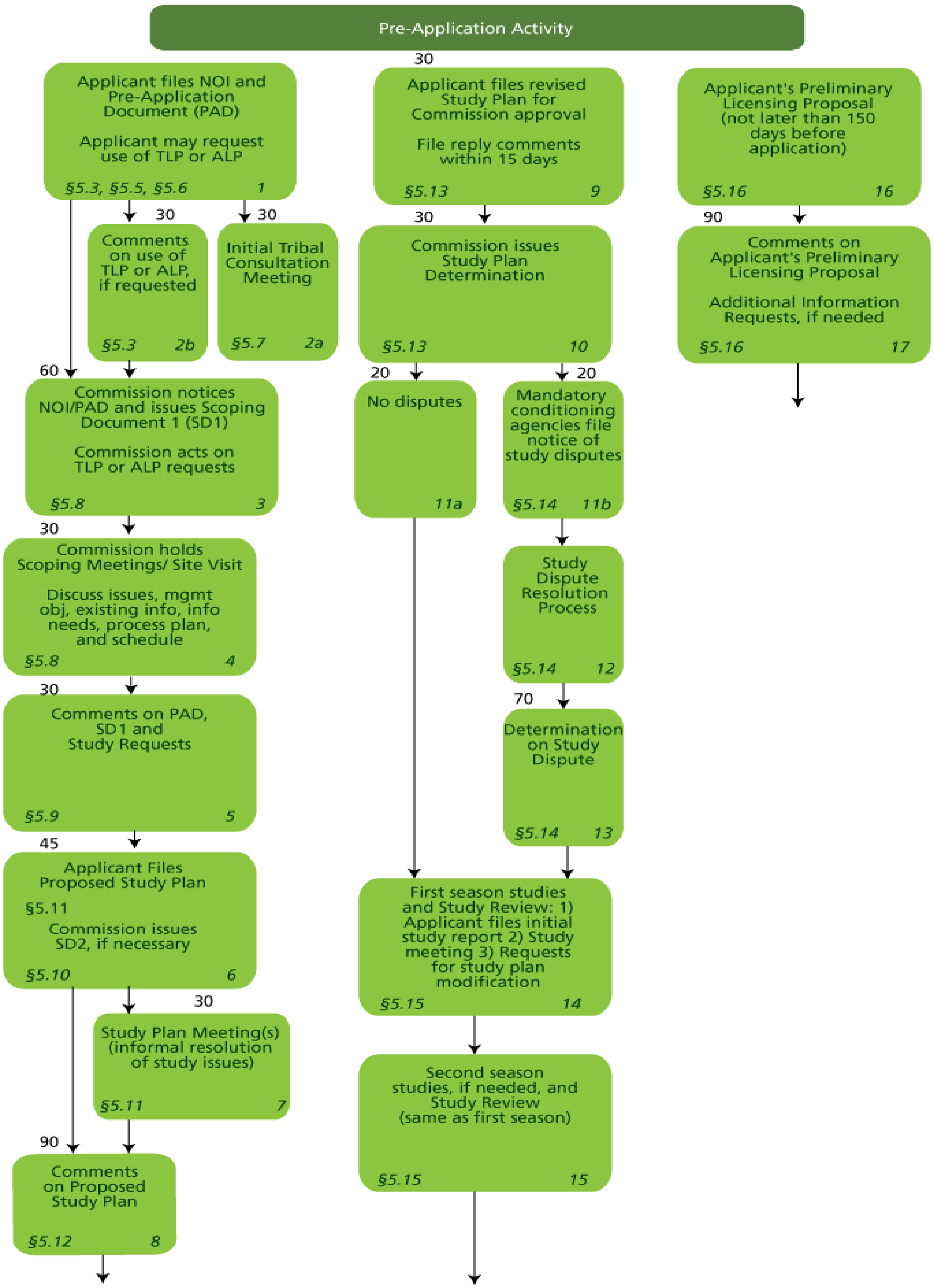


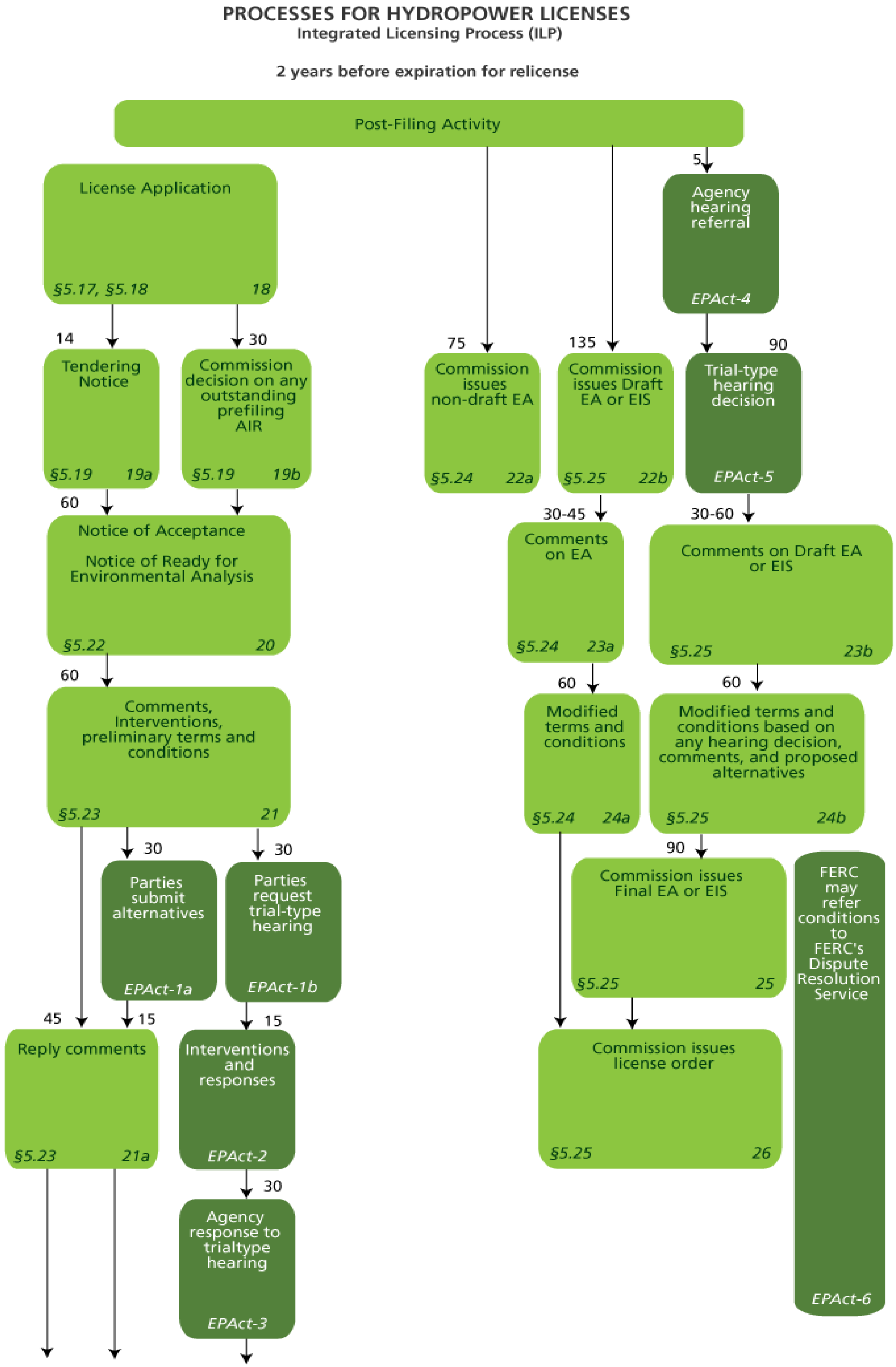
*Section 241 of the Energy Policy Act of 2005 in pink.

PROCESSES FOR HYDROPOWER LICENSES

Integrated Licensing Process (ILP)

5.5-5 years before expiration for relicense




PROCESSES FOR HYDROPOWER LICENSES
Integrated Licensing Process (ILP)
2 years before expiration for relicense
Post-Filing Activity
License Application
§5.17, §5.18
18
14
Tendering Notice
§5.19
19a
30
Commission decision on any outstanding prefiling AIR
§5.19
19b
60
Notice of Acceptance
Notice of Ready for Environmental Analysis
§5.22
20
60
Comments, Interventions, preliminary terms and conditions
§5.23
21
30
Parties submit alternatives
EPAct-1a
30
Parties request trial-type hearing
EPAct-1b
45
15
Reply comments
§5.23
21a
15
Interventions and responses
EPAct-2
30
Agency response to trialtype hearing
EPAct-3
75
Commission issues non-draft EA
§5.24
22a
135
Commission issues Draft EA or EIS
§5.25
22b
5
Agency hearing referral
EPAct-4
90
Trial-type hearing decision
EPAct-5
30-45
Comments on EA
§5.24
23a
30-60
Comments on Draft EA or EIS
§5.25
23b
60
Modified terms and conditions
§5.24
24a
60
Modified terms and conditions based on any hearing decision, comments, and proposed alternatives
§5.25
24b
90
Commission issues Final EA or EIS
§5.25
25
Commission issues license order
§5.25
26
FERC may refer conditions to FERC's Dispute Resolution Service
EPAct-6

Appendix D
Alabama ACT-Drought Response Operations Plan, November 2016 Revision

Alabama-ACT Drought Response Operations Plan (ADROP)

Overview

Alabama Power Company (APC) operates eleven hydropower dams in the Alabama-Coosa-Tallapoosa (ACT) River Basin. On the Tallapoosa River, Alabama Power operates the Harris, Martin, Yates and Thurlow hydroelectric dams and their reservoirs. On the Coosa River APC operates the Weiss, Neely Henry, Logan Martin, Lay, Mitchell, Jordan, and Bouldin hydroelectric dams and their reservoirs. The Coosa and Tallapoosa Rivers converge to form the Alabama River at Montgomery, Alabama. Alabama Power operates no reservoirs on the Alabama River, but its upstream operations can impact Alabama River flows and elevations. In addition to requirements contained in Alabama Power's Federal Energy Regulatory Commission ("FERC") licenses for its dams, Alabama Power provides flows to the Alabama River consistent with the U.S. Army Corps of Engineers (USACE) Water Control Manual (WCM) for the ACT river basin.

The Alabama-ACT Drought Response Operations Plan (ADROP) provides a plan for managing APC's reservoirs within the ACT Basin during drought conditions. APC and the Alabama Office of Water Resources (OWR), along with state and federal resource agencies[1], will monitor defined rain and stream flow indicators within the ACT basin. When drought indicators reach specified levels, drought intensity level responses are triggered, resulting in pre-determined incremental reductions or increases of flow from APC's reservoirs.

ADROP provides for three incremental drought intensity level (DIL) and corresponding DIL responses based on the severity of drought conditions. These incremental DIL responses are not rigid but provide a bracketed range of operations allowing for flexibility and smoother transitions in and out of a drought and from level to level. ADROP's drought response triggers are primarily based on past operating experiences and lessons learned during 2007, the current drought of record for the basin. ADROP is a dynamic plan; it may evolve or be expanded in the future as requirements within the basin may shift. Moving forward, any substantive revisions made to ADROP will be made in consultation with OWR and the resource agencies. Any provisions that will affect APC's federal hydropower license requirements will be filed with the FERC for prior approval.

The following provides a snapshot of operations for normal water years, an explanation of ADROP's drought indicators, triggers for each of the three incremental drought response levels, and a summary of operations at each drought response level.

[1] Resource Agencies to be included are US Fish and Wildlife Service (USFWS), Alabama Department of Conservation and Natural Resources (ADCNR), Alabama Department of Environmental Management (ADEM) and US Army Corps of Engineers (USACE).

Normal Conditions

During a normal water year, APC releases a weekly target of 32,480 cubic feet per second-days (a measure of volume) out of Bouldin, Jordan and Thurlow dams into the Alabama River. This release equates to a 7 day average flow target of 4,640 cubic feet per second (cfs).

In accordance with FERC requirements to protect threatened and endangered species downstream of Jordan Dam on the Coosa River, APC provides a minimum continuous flow of 2,000 cfs from July through March. From April 1st through May 31st, in order to provide for recreation and attraction flows for fish spawning, APC releases a continuous base flow of 4,000 cfs for 18 hours per day and an 8,000 cfs pulse flow for the rest of the day. During the month of June, the base and pulse flows are reduced incrementally to a continuous base flow of 2,000 cfs. From April 1st to October 31st, and on weekends and special holidays, additional recreational flows are released from Jordan Dam as scheduled in APC's FERC license guidelines. APC provides a year-round minimum continuous flow release from Thurlow Dam on the Tallapoosa River.

Drought Indicators

Drought indicators are used to describe the onset, magnitude, duration, severity and extent of a drought. Because there is a well-established rain and stream gauging network in the ACT basin, ADROP relies on precipitation and stream flow indicators. Observations of precipitation and stream flow will be used to indicate when the ACT is entering into (or recovering from) a drought. ADROP's precipitation indicator is based on the average of normal monthly rainfall at the following airport rain gages: Rome, Anniston, Shelby County and Montgomery. ADROP's stream flow indicator is based on the U.S. Geological Survey ("USGS") real-time gauging system[2]. USGS gages to be monitored are as follows[3]:

On the Coosa River

- 02397000: Mayo's Bar – Coosa River
- 02397530 State Line, AL/GA – Coosa River
- 02398300: Gaylesville – Chattooga River
- 02399200: Blue Pond – Little River
- 02401390: Ashville - Big Canoe Creek
- 02401000: Crudup – Big Wills Creek
- 02404400: Jackson Shoals – Choccolocco Creek
- 02405500: Vincent - Kelly Creek
- 02407514: Westover – Yellowleaf Creek
- 02406500: Alpine – Talladega Creek
- 02408540: Rockford – Hatchet Creek

On the Tallapoosa River

- 02412000: Heflin – Tallapoosa River
- 02413300: Newell – Little Tallapoosa River
- 02415000: Hackneyville – Hillabee Creek

[2] Real-time data for each of these gages is available on the USGS's National Water Information System website at http://waterdata.usgs.gov/al/nwis/rt.
[3] Gages used as indicators may be added or removed in the future needs.

- 02418230: Loachapoka – Sougahatchee Creek
- 02418760: Chewacla – Chewacla Creek
- 02419000: Tuskegee – Uphapee Creek
- 02419890: Montgomery Water Works, Tallapoosa River

On the Cahaba, Alabama and Tensaw Rivers

- 02425000: Marion Junction – Cahaba River
- 02428400: Claiborne L&D – Alabama River
- 02471019: Mount Vernon – Tensaw River

Precipitation and stream flow indicators are outlined by month in Table 1. The top line shows the combined normal average precipitation at the ACT rainfall gages listed above. The second line shows ranges of flow percentiles that will be used to indicate when the ACT is entering a drought. The third line shows ranges of flow percentiles used to determine when the ACT is emerging from a drought.

ADROP Implementation and Notification

APC continually records and monitors the drought indicators within ADROP for its reservoirs located in the ACT basin for potential and ongoing drought operations. On the first and third Tuesday of each month, APC evaluates the DIL utilizing the ADROP Decision Tool. DIL are further explained below and can also be found in Table 2. The ADROP Decision tool was developed between APC and the Mobile USACE District to implement portions of the WCM into real time operations. The output from the decision tool shows the sum of the DILs that are true along with the corresponding Alabama River flow target. The results from the ADROP Decision Tool and the supporting data are sent to the Mobile USACE District.

As conditions begin to decline, OWR will schedule and facilitate meetings of the Alabama Drought Monitoring & Impact Group (MIG) a subcommittee of the Alabama Drought Assessment and Planning Team (ADAPT). The role of the MIG is to analyze data that reflects past and current drought efforts and to assist with decisions concerning drought declarations levels for the State of Alabama. The MIG is comprised of federal, state, and local agencies and other water resources professionals. During these meetings, APC will discuss current project operations, the results of the ADROP Decision Tool, and future changes to operations. In addition to these scheduled meetings, when a DIL is triggered, APC will provide OWR, USFWS, ADCNR and ADEM with a report containing the latest weather forecast, hydrologic conditions, operations for Coosa and Tallapoosa River projects, and an update of the most recent ADROP Decision Tool. Additionally, APC provides industrial users on the Alabama River the results of the ADROP Decision Tool. These notification paths will continue until the ADROP Decision Tool shows that the basin has returned to normal operations. When normal operations have returned for APC reservoirs, a final communication will be sent to OWR and the resource agencies that drought coordination has ended. APC will continue to participate and provide information to MIG meetings until the OWR declares the State of Alabama has emerged from drought conditions and the MIG meetings will end. At this time, APC and OWR will continue to monitor drought indicators for future drought development.

Explanation of Drought Intensity Level (DIL) Triggers

*DIL 1 Trigger: Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow*

The trigger for the DIL 1 response is one of the following criteria is met:

- Inflow into the basin is less than the total needed to meet the 7 day average flow target of 4,640 cubic feet per second ("cfs") and to fill APC's reservoirs (see Table 4)
- A basin-wide composite storage equal to or less than drought contingency elevation/volumes (see Figure 1)
- A flow at or below the 7Q10 flows for Rome, Georgia as measured at the Alabama/Georgia state line gage (see Table 5)

*DIL 2 Trigger: DIL 1 criteria **+** (Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow)*

The trigger for the DIL 2 response is two of the criteria in DIL1 are met.

*DIL 3 Trigger: Low Basin Inflows **+** (Low Composite Storage **+** Low State Line Flow)*

The trigger for DIL 3 is the combination of DIL 1 criteria and **both** of the following:

- A basin-wide composite storage equal to or less than drought contingency elevation/volumes (see Figure 1)
- A flow at or below the 7Q10 flows for Rome, Georgia as measured at the Alabama/Georgia state line gage (see Table 5)

Explanation of Drought Intensity Level (DIL) Responses

The following explains how flows will change throughout the year at the different drought intensity levels. Table 3 is a matrix of the operational response to drought intensity levels.

Drought Intensity Level 1 Response

- **Coosa River Operations:** From July 1st through March 31st, 2,000 cfs will be released from Jordan Dam. From April 1st through June 15th, 4,000 cfs will be released from Jordan Dam as base flows. From June 15th to July 1st, releases from Jordan Dam will be ramped down to the 2,000 cfs minimum flow. Any inflow into the Coosa River basin in excess of these Jordan Dam minimum releases may be used to refill upstream reservoirs or discharged through Jordan Dam or Bouldin Dam above the corresponding targeted Alabama River release. [4]
- **Tallapoosa River Operations:** From May 1st through December 31st, half of all inflows into Yates Dam will be released from Thurlow Dam. From January 1st through April 30th, the greater of either half the inflows into Yates Dam or two times inflows as

[4] In all drought intensity levels, fish attraction pulses and recreational releases are suspended; however, flows above those needed to fill and meet the base minimum flow may be used for pulsing, recreational or flushing releases.

measured at the Heflin, Alabama gage will be released. During this time, Thurlow Dam releases will be greater than 350 cfs. Any inflow into the Tallapoosa River basin in excess of these Thurlow Dam minimum releases may be used to refill upstream reservoirs or discharged through Thurlow Dam above the corresponding targeted Alabama River release.

- **Alabama River Flows:** A 10% reduction in APC's release into the Alabama River will be in effect from October 1st through April 30th. From May 1st through September 30th, the full targeted release will be maintained.
- **Rule Curve Variances:** APC will seek variances from the USACE and FERC as needed to improve the likelihood of filling APC's reservoirs to full summer pool elevations.

Drought Intensity Level 2 Response

- **Coosa River Operations:** From October 1st through March 31st, flows in a range between 1,600 and 2,000 cfs will be released from Jordan Dam. From April 1st through June 15th, 2,500 cfs will be released from Jordan Dam as base flows. From June 15th to July 1st, releases from Jordan Dam will be ramped down to the 2,000 cfs minimum flow. From July 1st to September 30th, flows will be 2000 cfs. Any inflow into the Coosa River basin in excess of these Jordan Dam minimum releases may be used to refill upstream reservoirs or discharged through Jordan Dam or Bouldin Dam above the corresponding Alabama River release target.
- **Tallapoosa River Operations:** Releases from Thurlow Dam will be 350 cfs from October 1st through April 30th. From May 1st through September 30th, half of the inflows into Yates Dam will be released. Any inflow into the Tallapoosa River basin in excess of these Thurlow Dam minimum releases may be used to refill upstream reservoirs or discharged through Thurlow Dam above the corresponding targeted Alabama River release.
- **Alabama River Flows:** A 20% reduction in APC's targeted release into the Alabama River will be in effect from October 1st through May 31st. From June 1st through September 30th, a 10% reduction in the targeted release will be in effect.
- **Rule Curve Variances:** APC will seek variances from the USACE and FERC as needed to improve the likelihood of filling APC's reservoirs to full summer pool elevations.

Drought Intensity Level 3 Response

- **Coosa River Operations:** From October 1st through November 30th, 1,800 cfs will be released from Jordan Dam. From December 1st through March 31st, 1,600 cfs will be released from Jordan Dam. From April 1st through June 30th, releases from Jordan Dam will be made in a range between 1,600 and 2,000 cfs. From July 1st through September 30th, 2,000 cfs will be released from Jordan Dam. Any inflow into the Coosa River basin in excess of these Jordan Dam minimum releases may be used to refill upstream reservoirs or discharged through Jordan Dam or Bouldin Dam above the corresponding targeted Alabama River release.
- **Tallapoosa River Operations:** From October 1st through June 30th, a flow of 400 cfs will be maintained at the Montgomery Water Treatment Plant. During this time, releases from Thurlow Dam may occasionally be less than 350 cfs. From July 1st through September 30th, 350 cfs will be released from Thurlow Dam. Any inflow into

the Tallapoosa River basin in excess of these Thurlow Dam minimum releases may be used to refill upstream reservoirs or discharged through Thurlow Dam above the corresponding targeted Alabama River release.

- **Alabama River Flows:** From October 1st through April 30th, APC's targeted release will be reduced to an average 2,000 cfs into the Alabama River. During May and June, a 20% reduction in the targeted release will be in effect. From July 1st through September 30th, a 10% reduction in the targeted release will be in effect.
- **Rule Curve Variances:** APC will seek variances from the USACE and FERC as needed to improve the likelihood of filling APC's reservoirs to full summer pool elevations.

Table 1: Indicators

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rain*	**<5.3**	**<5.1**	**<6.1**	**<4.6**	**<4.0**	**<3.9**	**<4.7**	**<3.5**	**<3.6**	**<2.7**	**<4.3**	**<4.7**
Flow**	**10th – 25th**	**10th – 25th**	**10th – 25th**	**10th – 25th**	**10th – 25th**	**<10th**	**<10th**	**<10th**	**<10th**	**10th – 25th**	**10th – 25th**	**10th – 25th**
	50th –75th	**50th –75th**	**50th –75th**	**50th –75th**	**50th –75th**	**25th –50th**	**25th –50th**	**25th –50th**	**25th –50th**	**50th –75th**	**50th –75th**	**50th –75th**

*Average normal rainfall of 4 meteorological stations within ACT Basin
**Lower range of percentiles indicates basin is moving into drought; Upper range of percentiles indicates basin is coming out of drought

Table 2: Drought Intensity Levels Triggers

DIL 1 Trigger	Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow
DIL 2 Trigger	DIL 1 criteria **+** (Low Basin Inflows or Low Composite Storage **or** Low State Line Flow)
DIL 3 Trigger	Low Basin Inflows + Low Composite Storage + Low State Line Flow

Table 3: Drought Intensity Level Response Matrix[1]

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Drought Intensity Level Triggers	Normal Operations											
	DIL 1: Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow											
	DIL 2: DIL 1 criteria **+** (Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow)											
	DIL 3: Low Basin Flows **+** Low Composite Storage **+** Low State Line Flow											
Coosa River Flow[2]	Normal Operations 2000 cfs			4000 (8000)		4000 - 2000	Normal Operations 2000 cfs					
	Jordan 2000 +/- cfs			Jordan 4000 +/- cfs		6/15 Linear Ramp down	Jordan 2000 +/- cfs			Jordan 2000 +/- cfs		
	Jordan 2000 +/- cfs			Jordan 2500 +/- cfs		6/15 Linear Ramp down	Jordan 2000 +/- cfs			Jordan 2000 – 1600 +/- cfs		
	Jordan 1600 +/- cfs			Jordan 1600 - 2000 +/- cfs			Jordan 2000 +/- cfs			Jordan 1800 +/- cfs		Jordan 1600 +/- cfs
Tallapoosa River Flow[3]	Normal Operations 1200 cfs											
	Greater of: ½ Yates Inflow **or** 2 x Heflin Gage (Thurlow releases > 350 cfs)				½ Yates Inflow					½ Yates Inflow		
	Thurlow 350 cfs				½ Yates Inflow					Thurlow 350 cfs		
	Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)						Thurlow 350 cfs			Maintain 400 cfs at Montgomery WTP (Thurlow release 350 cfs)		
Alabama River Flow[4]	Normal Operations 4640 cfs											
	4200 cfs (10% Cut) - Montgomery				4640 cfs - Montgomery					Reduce 4640 cfs – 4200 cfs Montgomery		
	3700 cfs (20% Cut) - Montgomery					4200 cfs (10% Cut) - Montgomery				Reduce: 4200 cfs - 3700 cfs Montgomery (1 Week ramp)		
	2000 cfs Montgomery				3700 cfs Montgomery		4200 cfs (10% Cut) Montgomery			Reduce 4200 cfs - 2000 cfs Montgomery (1 Month ramp)		
Guide Curve Elevation	Normal Operations: Elevations follow Guide Curves as prescribed in License (Measured in Feet)											
	USACE Variances: As Needed; FERC Variance for Martin											
	USACE Variances: As Needed; FERC Variance for Martin											
	USACE Variances: As Needed; FERC Variance for Martin											

1. **Note these are base flows that will be exceeded when possible**
2. **Jordan flows are based on a continuous +/- 5% of target flow**
3. **Thurlow flows are based on a continuous +/-5% of target flow; Flows are reset on noon each Tuesday based on the prior day's daily average at Heflin or Yates**
4. **Alabama River flows are 7-Day Average Flow**

Table 4: Low Basin Inflows Guide

Month	Coosa Filling Volume	Tallapoosa Filling Volume	Total Filling Volume	Montgomery Flow Target	*Total Basin Inflow Needed
January	628	0	628	4640	5268
February	626	120	747	4640	5387
March	603	2900	3503	4640	8143
April	1683	2585	4269	4640	8909
May	248	0	248	4640	4888
June	0	0	0	4640	4640
July	0	0	0	4640	4640
August	0	0	0	4640	4640
September	-612	-1304	-1916	4640	2724
October	-1371	-2132	-3503	4640	1137
November	-920	-2186	-3106	4640	1534
December	-821	0	-821	4640	3819

- Total Basin Inflow needed is sum of Total Filling Volume + 4640 cfs Release.
- All numbers are in cfs-days.
- Numbers are connected to reservoir rule curves; assumption that all are at top of rule curve elevation.
- When new rule curves are put into effect, numbers will need to be modified.

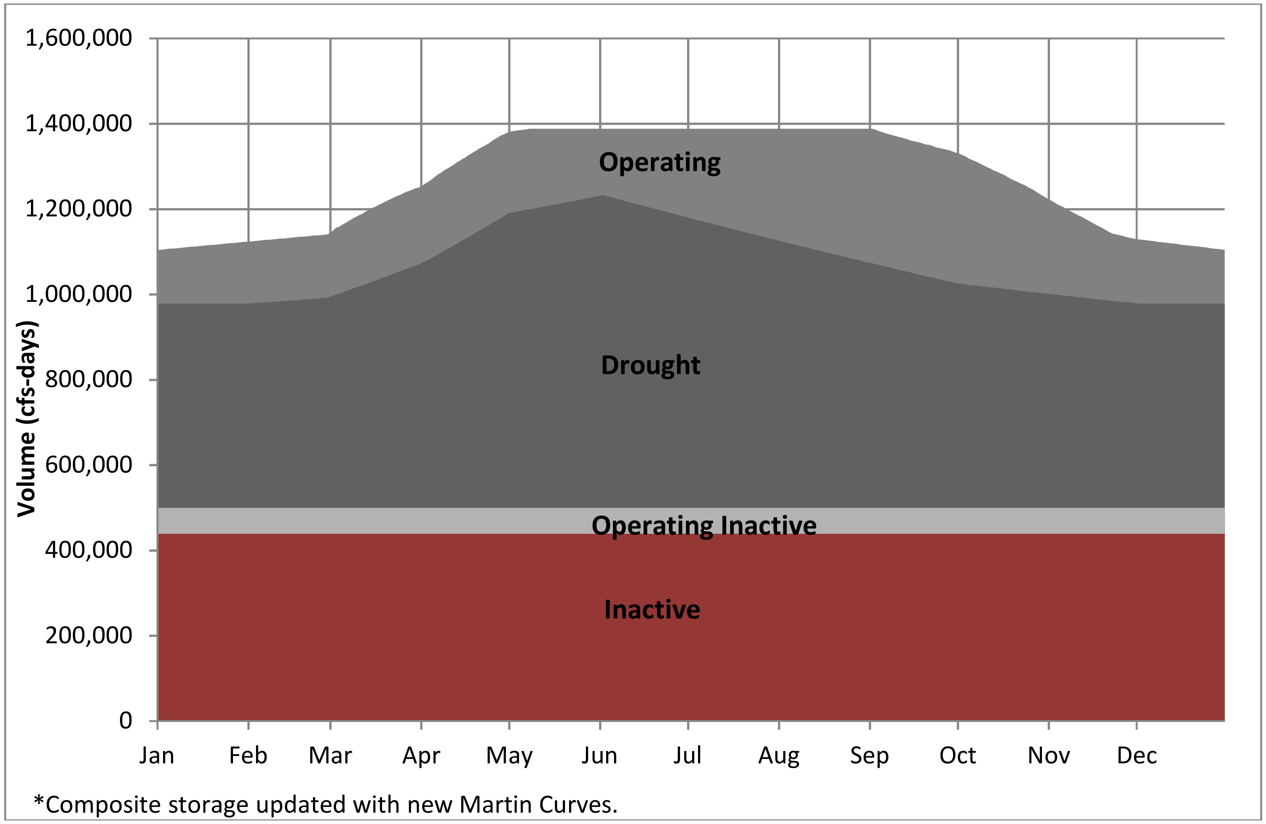
Table 5: Low State Line Flow

A Low State Line Flow occurs, when the Mayo’s Bar gage measures a flow below the monthly historical 7Q10 flow. 7Q10 is defined as the lowest flow over a 7 day period that would occur once in 10 years.

Month	Mayo's Bar (cfs-days)
January	2544
February	2982
March	3258
April	2911
May	2497
June	2153
July	1693
August	1601
September	1406
October	1325
November	1608
December	2043

USACE Computation 1949 - 2006

Figure 1: Low Composite Storage



Low Composite Storage occurs when APC composite storage is less than or equal to the storage available within the drought contingency curves for APC's reservoirs. Composite storage is the sum of the amounts of storage available at the current elevation for each reservoir down to the drought contingency curve at each APC plant.

Appendix E
Summary of R.L. Harris Downstream Flow Adaptive Management History and Research

Appendix E

DOWNSTREAM FLOW ADAPTIVE MANAGEMENT HISTORY AND RESEARCH

R.L. HARRIS HYDROELECTRIC PROJECT

FERC NO. 2628

Prepared for:

ALABAMA POWER COMPANY

BIRMINGHAM, ALABAMA

Prepared by:

Kleinschmidt

April 2018

ALABAMA POWER COMPANY
BIRMINGHAM, ALABAMA

R.L. HYDROELECTRIC HARRIS PROJECT
FERC No. 2628

DOWNSTREAM FLOW ADAPTIVE MANAGEMENT HISTORY AND RESEARCH

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DOWNSTREAM FLOW ADAPTIVE MANAGEMENT HISTORY AND RESEARCH

1.0 INTRODUCTION

Alabama Power Company (Alabama Power) is initiating the Federal Energy Regulatory Commission (FERC) relicensing of the 135-megawatt (MW) R.L. Harris Hydroelectric Project (Harris Project), FERC Project No. 2628. The Harris Project consists of a dam, spillway, powerhouse, and those lands and waters necessary for the operation of the hydroelectric project and enhancement and protection of environmental resources. These structures, lands, and water are enclosed within the FERC Project Boundary. Under the existing Harris Project license, the FERC Project Boundary encloses two distinct geographic areas, described below.

Harris Reservoir is the 9,870-acre reservoir (Harris Reservoir) created by the R.L. Harris Dam (Harris Dam). Harris Reservoir is located on the Tallapoosa River, near Lineville, Alabama. The lands adjoining the reservoir total approximately 7,392 acres and are included in the FERC Project Boundary. This includes land to 795 feet mean sea level (msl)[1], as well as natural undeveloped areas, hunting lands, prohibited access areas, recreational areas, and all islands.

The Harris Project also contains 15,063 acres of land within the James D. Martin-Skyline Wildlife Management Area (Skyline WMA) located in Jackson County, Alabama. These lands are located approximately 110 miles north of Harris Reservoir and were acquired and incorporated into the FERC Project Boundary as part of the FERC-approved Harris Project Wildlife Mitigative Plan and Wildlife Management Plan. These lands are leased to, and managed by, the State of Alabama for wildlife management and public hunting and are part of the Skyline WMA (ADCNR 2016b).

For the purposes of this technical report, “Lake Harris” refers to the 9,870-acre reservoir, adjacent 7,392 acres of project land, and the dam, spillway, and powerhouse. “Skyline” refers to the 15,063 acres of project land within the Skyline WMA in Jackson County. “Harris Project” refers to all the lands, waters, and structures enclosed within the FERC Project Boundary, which includes both Lake Harris and Skyline. “Harris Reservoir” refers to the 9,870-acre reservoir only; Harris Dam refers to the dam, spillway, and powerhouse. The “Project Area” refers to the land and water in the Project Boundary and immediate geographic area adjacent to the Project Boundary (Alabama Power Company 2018).

Lake Harris and Skyline are located within two river basins: the Tallapoosa and Tennessee River Basins, respectively. The only waterbody managed by Alabama Power as part of their FERC license for the Harris Project is the Harris Reservoir.

[1] Also includes a scenic easement (to 800 feet msl or 50 horizontal feet from 793 feet msl, whichever is less, but never less than 795 feet msl)

The Harris Project is a peaking hydroelectric project that generally operates Monday through Friday to meet peak power demands. Although not a license requirement, in the late 1990s, Alabama Power worked with stakeholders including, among others, the Alabama Department of Conservation and Natural Resources (ADCNR), U.S. Fish and Wildlife Service (USFWS), and Alabama Cooperative Fish and Wildlife Research Unit (ACFWRU) at Auburn University, to develop a plan for specific daily and hourly releases to improve downstream fisheries conditions. In 2005, Alabama Power began implementing a pulsing operations scheme known as the "Green Plan," and the ACFWRU began monitoring conditions downstream of the dam. Since 2005, Alabama Power has continued these pulsing operations and, together with ADCNR, provided funding for monitoring and research on the effects of this operation scheme. This research has resulted in numerous theses, dissertations, reports, presentations at professional meetings, and articles in peer-reviewed journals.

To support the relicensing process and provide baseline information for the Pre-Application Document (PAD), Kleinschmidt Associates (Kleinschmidt) summarized the history of the development of the "Green Plan" and the research conducted from 2005-2017 as part of monitoring efforts in the Tallapoosa River below Harris Dam.

2.0 ADAPTIVE MANAGEMENT PROCESS HISTORY

The original operating license for the Harris Project, issued by FERC in 1973, required a minimum flow of 45 cfs at the Wadley gauge located downstream of Harris Dam. The original license also required Alabama Power to file a revised Exhibit S, FERC's environmental report of project effects and measures to mitigate impacts. Between 1973 and 1984, during consultation related to revising Exhibit S of the license application, resource agencies asserted that the 45 cfs minimum flow was inadequate and asked FERC to require Alabama Power to perform studies to determine an appropriate minimum flow. At the time, FERC denied the agencies' request, citing a lack of information that demonstrated a need for additional studies, and ordered that the minimum flow remain at 45 cfs (FERC 1984). The agencies noted that additional information was being developed but was not yet available at the time FERC was considering their request.

Example of Re-regulation Dam

Research was conducted by scientists from Auburn University, ACFWRU, and the U.S. Geological Survey (USGS) on the Tallapoosa River below Harris between 1983 and 1998. In the early 1990s, the Corps was beginning the process of updating the water control manual for the Alabama-Coosa-Tallapoosa (ACT) basin. As part of that process, the Corps was developing a formula to allocate water for various uses in the basin. In the late 1990s, ADCNR and USFWS requested that Alabama Power discuss minimum flows prior to formulation of the ACT allocations (ADCNR 1999). Agencies were concerned that not having a higher minimum flow at the Harris Project would result in smaller water allocation from Georgia. In a December 6, 1999 letter to Alabama Power, the USFWS asserted that the 45 cfs minimum flow license requirement was inadequate and that peaking operations had resulted in negative impacts to aquatic resources. The USFWS suggested higher minimum flows and periods of flow stabilization (USFWS 1999).

In the late 1990s, Alabama Power held informal discussions with resource agency personnel about operations at the Harris Project. In these initial discussions, Alabama Power explored potential methods to address resource agency concerns, including re-regulation dams (pictured above), geotubes (pictured below), installation of a "house" turbine, spillway gate modifications, and pulsing. However, these concepts did not move forward for further evaluation at that time.

Example of Geotube

On August 8, 2000, ADNCR organized and facilitated a public meeting in Wadley, Alabama, to discuss flows below the dam with interested stakeholders. At the meeting, Alabama Power presented conceptual plans for a re-regulation dam downstream of Harris. Elise Irwin, a fisheries biologist with ACFWRU, presented a conceptual plan to adaptively manage flows from Harris Dam. A later version of this plan was published in 2002 as an article in *Conservation Biology* (Irwin and Freeman 2002). The article cited depleted flows, flow instability, and thermal regime alteration as factors affecting fish abundance and diversity in the Tallapoosa River below Harris Dam. The proposed adaptive management process included four main steps: (1) develop and agree to management objectives; (2) model hypothesized relations between dam operations and management objectives; (3) implement changes in dam operations; and (4) evaluate biological responses and other stakeholder benefits.

On April 30 and May 1, 2003, stakeholders participated in a facilitated workshop at Auburn University. The workshop was attended by representatives from Alabama Power, state and federal resource agencies, local governments, and non-governmental organizations (NGOs). Attendees discussed membership in, and governance of, a "Stakeholder Board" as the formal entity to oversee the adaptive management process. Attendees also identified objectives for numerous resources, including a desire to maximize 1) economic development, 2) floral/faunal diversity, 3) reservoir water levels, 4) water quality, 5) boating and angling opportunities, and

6) operational flexibility. They also expressed a desire to minimize 1) downstream bank erosion, 2) river fragmentation, 3) consumptive uses, and 4) costs to Alabama Power.

Following the Auburn workshop, a Stakeholder Board was formed and held several meetings in 2003 to discuss potential methods to reduce the effects of peaking, including the construction of re-regulation dams and/or geotubes in the Tallapoosa River. Participants also discussed the components of a Bayesian belief network[2] model that would be used to select flow scenarios that optimized various overlapping and competing management objectives identified by stakeholders.

In 2004, Alabama Power evaluated the methods identified and proposed by the Stakeholder Board to provide continuous flows or re-regulation of peaking flows from Harris Dam. The evaluated methods included: geotubes; a re-regulation dam in the Tallapoosa River; and modifications to the dam, powerhouse, and trash gate. Alabama Power performed numerous hydraulic modeling runs (HEC-RAS) of various flow scenarios in evaluating potential re-regulation structures. Many of the methods evaluated were deemed unfeasible due to engineering (structural) or cost considerations. In the case of re-regulation structures, stakeholders indicated opposition to further impoundment and fragmentation of stream habitat. In addition, model results indicated that re-regulation structures would not result in the desired improvements to aquatic habitat.

After ruling out potential physical modifications to the dam and river downstream, in January 2005 the stakeholders met to discuss proposed modifications to operations at Harris Dam as part of the adaptive management process. The group formed a technical committee consisting of representatives from ADCNR, USFWS, ACFWRU, and Alabama Power. The group considered several continuous minimum flow and pulsing scenarios. Based on results of the decision support model that evaluated the operating scenarios, the group decided and Alabama Power agreed to implement a plan to provide flow pulses whose magnitude and duration were tied to unregulated flows measured at a gage upstream of Harris Reservoir (Heflin) and generation needs. This plan became known as the Harris "Green Plan[3]" and is included as Appendix A[4] of this report. Based on a monitoring plan developed by the technical committee and discussed at a stakeholder meeting in August 2005, ACFWRU began conducting research focused on detecting changes in the aquatic community downstream of Harris Dam associated with the Green Plan. This research was primarily funded by Alabama Power and ADCNR.

Stakeholders reconvened in August 2007 following two years of implementing the Green Plan flows and monitoring. The ACFWRU provided a summary of its research, and Alabama Power presented a summary of Green Plan operations since 2005. Stakeholders met again in May 2009, and ACFWRU, ADCNR, and Alabama Power provided updates on recent and ongoing research and operations.

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[2] A model that represents a set of variables and how they are affected by one another.

[3] When the scenarios were considered by the group at that time, they were color-coded to make comparison and discussion more expedient. A "red plan" and "blue plan" were also considered; the color coding had no relation to the merits of each plan.

[4] In 2007, the Green Plan was modified to include criteria for Green Plan operations during periods of drought.

In 2011, ACFWRU published a report examining results of monitoring efforts from 2005 to 2010. In the report, ACFWRU calculated index of biotic integrity (IBI) scores using a modified IBI developed by Bowen et al. (1996). The report noted IBI scores at sites downstream of Harris Dam were lower than reference site scores, although scores appeared highly variable among and within sites, seasons, and years. The report also suggested that periods of stable river flows might enhance fish spawning success (Irwin et al. 2011).

At a June 2013 stakeholder meeting, attendees noted positive ecosystem response in terms of increased physical habitat diversity resulting from implementing the Green Plan; however, concerns about the effects of water temperature on fish spawning and recruitment led to the formation of a small technical team. This technical team was tasked with examining potential optimizations to the Green Plan that could affect downstream water temperatures. In 2016 and 2017, Alabama Power experimented with the timing of pulses based on recommendations from the technical team.

On January 31, 2018, in preparation for the Harris relicensing process, Alabama Power held a Stakeholder Informational meeting. In this meeting, Alabama Power provided an overview of the Harris Project operations and the history of the adaptive management process. Appendix B includes a copy of the adaptive management process presentation.

3.0 IMPLEMENTATION AND RESEARCH

The descriptions and data presented in this section represent a summary of work that has been conducted since the implementation of Green Plan operations in 2005, and includes data through 2017, where available.

3.1 GREEN PLAN FLOWS

Alabama Power began operating the Harris Project according to the Green Plan in 2005. These operations are governed by a set of release criteria, which are provided in Appendix A. Additionally, the release criteria allow for a temporary suspension of these flows for flood control operations, fish spawning (lake-level stabilization), and when conditions exist that would jeopardize the ability to fill Harris Reservoir. Table 3-1 provides a summary of operations since implementation of the Green Plan in 2005.

TABLE 3-1 SUMMARY OF OPERATIONS AT R.L. HARRIS DAM SINCE IMPLEMENTATION OF THE GREEN PLAN

Year	Pulse	Non-Pulse	Spawn	Flood
2005	106	165	14	35
2006	175	164	20	6
2007	289	76	0	0
2008	244	122	14	0
2009	131	197	14	37
2010	134	194	14	23
2011	180	177	14	8
2012	270	64	14	18
2013	49	283	14	33
2014	120	190	14	41
2015	167	172	15	11
2016	247	71	14	34
2017	224	93	14	34
Average	**180**	**151**	**8**	**22**

3.2 FISHERIES STUDIES

The ACFWRU has sampled fish communities at 6 sites since 2005 (Figure 3-1). Four of the sites were located on the Tallapoosa River between Harris Dam and Lake Martin: Malone, Wadley, Griffin Shoals, and Peters Island (known collectively as Middle Tallapoosa or MT). Two unregulated sites were sampled as reference sites – one upstream of Harris on the Tallapoosa River near Heflin, Alabama (Upper Tallapoosa or UT) and one on Hillabee Creek (HC), a tributary to the Tallapoosa River near Alexander City, Alabama. The sites generally consisted of shallow reaches of riffles and shoals. The sites were sampled using pre-positioned area electrofishing (PAE; Bowen et al. 1998; Freeman et al. 2001) one to two times per year, typically in the late spring or early summer and/or late summer or fall. Fish specimens were identified to species and measured for total length.

Catch rates from ACFWRU samples ranged 1.3 to 81.6 fish per unit effort and were typically highest and most variable at the Upper Tallapoosa and Hillabee Creek sites. Among the Middle Tallapoosa sites, catch rates were generally highest at Wadley and lowest at the Griffin Shoals and Peters Island sites.

A list of the 51-fish species collected at all sites since 2005 is presented in Table 3-1. A total of 45 fish species were collected at the Hillabee Creek site, 43 species were collected at the Middle Tallapoosa sites, and 42 species were collected at the Upper Tallapoosa site. The most abundant species collected from 2005 - 2015 included Alabama Shiner (*Cyprinella callistia)* (n=12,949), Lipstick Darter (*Etheostoma chuckwachatte*) (n=12,710), and Bronze Darter (*Percina palmaris)* (n=11,730). Combined, these three species comprised almost 50 percent of all fish collected.

Alabama Power sampled fish communities in 2017 using standardized methods developed by the Geological Survey of Alabama (GSA) and ADCNR (O'Neil 2006). Briefly, this method involves 10 backpack electrofishing sampling efforts at 10 riffle, 10 run, and 10 pool reaches, as well as 2 shoreline sampling efforts. This sampling method is commonly referred to as the "30 + 2" method. Samples were collected at the Malone and Wadley sites along the Middle Tallapoosa in the spring and fall and the Upper Tallapoosa sites in July and October.

A total of 23 species, representing 7 families, were collected at the Middle Tallapoosa sites during the spring and fall of 2017 compared with a total of 31 species, representing 8 families, collected at the Upper Tallapoosa sites. The most common species collected along the Middle Tallapoosa were the Redbreast Sunfish (*Lepomis auritus*) (n=112), Lipstick Darter (*Etheostoma chuckwachatte*) (n=105), and the Bronze Darter (*Percina palmaris*) (n=62). The most common species collected at the upstream sites were Speckled Darter (*Etheostoma stigmaeum*) (n=98), Tallapoosa Shiner (*Cyprinella gibbsi*) (n=87), Redbreast Sunfish (*Lepomis auritus*) (n=61), Muscadine Darter (*Percina smithvanizi*) (n=56), and Lipstick Darter (*Etheostoma chuckwachatte*) (n=46). IBI scores at the Middle Tallapoosa sites during the spring and fall ranged from 30 (poor) to 38 (Fair). However, three of the four collections resulted in poor scores. Scores at the upstream sites were 40 (fair) and 36 (fair) during the summer and fall respectively.

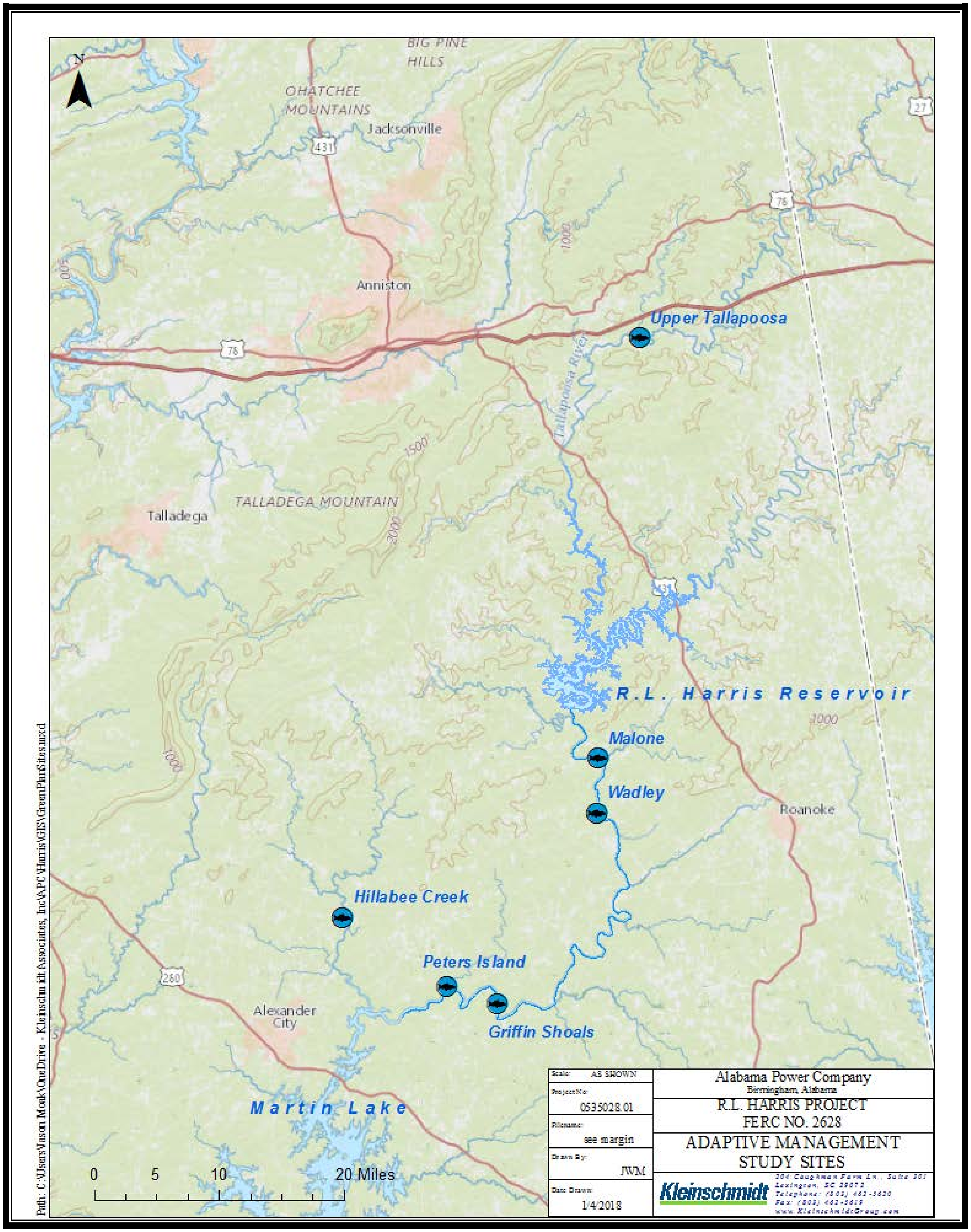
Alabama Power's 2017 sampling added new occurrence records for one specie at the Upper Tallapoosa River site (Spotted Sucker) that had not been previously collected during ACFWRU's sampling efforts from 2005 to 2015.

According to the GSA's protocols developed for the Ridge and Valley/Piedmont ichthyo-region (O'Neil and Shepard 2011), IBI scores were calculated based on ACFWRU fish collections at the upstream, downstream, and Hillabee Creek sites for each collection year[5]. Although ACFWRU's collection methods differed from the protocols required by the GSA, the methods were consistently applied at each site and over time. Therefore, IBI scores could be calculated and used to compare sites and years within this robust dataset. According to the protocol, IBI scores are classified into one of five ranges:

Very Poor ≤ 26
Poor 27 – 34
Fair 35 – 42
Good 43 – 50
Excellent ≥ 50

IBI scores for the Upper Tallapoosa, Malone, and Wadley sites appeared similar, with Hillabee Creek having consistently higher scores (Figure 3-3). The Upper Tallapoosa site had an average score of 36 over the 11-year period, while the Malone and Wadley sites both had average scores of 35. Hillabee Creek had an average score of 43. No clear long-term trends were apparent, and IBI scores were variable within and among sites, seasons, and years.

[5] It should be emphasized that the IBI scores described here are separate from the scores described in Section 2.0 of this document.



Source: Kleinschmidt 2018

FIGURE 3-1 ADAPTIVE MANAGEMENT STUDY SITES

TABLE 3-2 FISH SPECIES COLLECTED DURING ADAPTIVE MANAGEMENT STUDIES (2005 – 2015; 2017)

Common Name	Scientific Name	UT	MT	HC
Clupeidae				
Gizzard Shad	*Dorosoma cepedianum*		X	
Threadfin Shad	*Dorosoma petenense*		X	
Cyprinidae				
Largescale Stoneroller	*Campostoma oligolepis*	X	X	X
Alabama Shiner	*Cyprinella callistia*	X	X	X
Tallapoosa Shiner	*Cyprinella gibbsi*	X	X	X
Blacktail Shiner	*Cyprinella venusta*	X	X	X
Lined Chub	*Hybopsis lineapunctata*	X	X	X
Striped Shiner	*Luxilus chrysocephalus*			X
Pretty Shiner	*Lythrurus bellus*	X		X
Coosa Chub	*Macrhybopsis etnieri*		X	X
Bluehead Chub	*Nocomis leptocephalus*	X		X
Golden Shiner	*Notemigonus crysoleucas*		X	
Burrhead Shiner	*Notropis asperifrons*			X
Rough Shiner	*Notropis baileyi*	X	X	X
Silverstripe Shiner	*Notropis stilbius*	X	X	X
Weed Shiner	*Notropis texanus*	X	X	X
Riffle Minnow	*Phenacobius catostomus*	X	X	X
Creek Chub	*Semotilus atromaculatus*	X		X
Bullhead Minnow	*Pimephales vigilax*	X	X	X
Catostomidae				
Alabama Hog Sucker	*Hypentelium etowanum*	X	X	X
Spotted Sucker	*Minytrema melanops*	X		X
Black Redhorse	*Moxostoma duquesnei*	X	X	X
Golden Redhorse	*Moxostoma erythrurum*	X	X	X
Blacktail Redhorse	*Moxostoma poecilurum*	X	X	X
Ictaluridae				
Yellow Bullhead	*Ameiurus natalis*	X	X	X
Channel Catfish	*Ictalurus punctatus*	X	X	X
Speckled Madtom	*Noturus leptacanthus*	X	X	X
Black Madtom	*Noturus funebris*	X	X	X
Flathead Catfish	*Pylodictis olivaris*	X	X	X
Fundulidae				
Stippled Studfish	*Fundulus bifax*	X	X	X
Blackspotted Topminnow	*Fundulus olivaceus*	X	X	X
Poeciliidae				
Western Mosquitofish	*Gambusia affinis*	X	X	X
Cottidae				
Tallapoosa Sculpin	*Cottus tallapoosae*	X	X	X

Common Name	Scientific Name	UT	MT	HC
Percidae				
Lipstick Darter	*Etheostoma chuckwachatte*	X	X	X
Speckled Darter	*Etheostoma stigmaeum*	X	X	X
Tallapoosa Darter	*Etheostoma tallapoosae*	X	X	X
Yellow Perch	*Perca flavescens*	X		
Mobile Logperch	*Percina kathae*	X	X	X
Bronze Darter	*Percina palmaris*	X	X	X
Muscadine Darter	*Percina smithvanizi*	X	X	X
Centrarchidae				
Shadow Bass	*Ambloplites ariommus*	X	X	X
Redbreast Sunfish	*Lepomis auritus*	X	X	X
Green Sunfish	*Lepomis cyanellus*	X	X	X
Warmouth	*Lepomis gulosus*			X
Bluegill	*Lepomis macrochirus*	X	X	X
Longear Sunfish	*Lepomis megalotis*		X	X
Redear Sunfish	*Lepomis microlophus*	X	X	X
Tallapoosa Bass	*Micropterus tallapoosae*	X	X	X
Alabama Bass	*Micropterus henshalli*	X	X	X
Largemouth Bass	*Micropterus salmoides*	X	X	X
Black Crappie	*Pomoxis nigromaculatus*		X	
TOTAL # of SPECIES		**42**	**43**	**45**

TABLE 3-3 RELATIVE ABUNDANCE OF 10 MOST COMMON FISH SPECIES COLLECTED DURING SURVEYS, 2005-2015

Common Name	Upper Tallapoosa	Middle Tallapoosa	Hillabee Creek	Total
Alabama Shiner	12.59%	21.22%	16.92%	17.16%
Lipstick Darter	11.45%	19.64%	18.85%	16.84%
Bronze Darter	8.30%	25.72%	10.90%	15.54%
Largescale Stoneroller	16.01%	3.56%	7.45%	8.67%
Bullhead Minnow	12.59%	0.42%	8.32%	6.74%
Speckled Darter	11.89%	3.18%	3.67%	6.04%
Tallapoosa Shiner	3.10%	1.47%	9.27%	4.48%
Muscadine Darter	3.55%	6.01%	2.68%	4.18%
Silverstripe Shiner	1.87%	3.06%	6.02%	3.64%
Alabama Hog Sucker	6.43%	2.56%	1.29%	3.36%

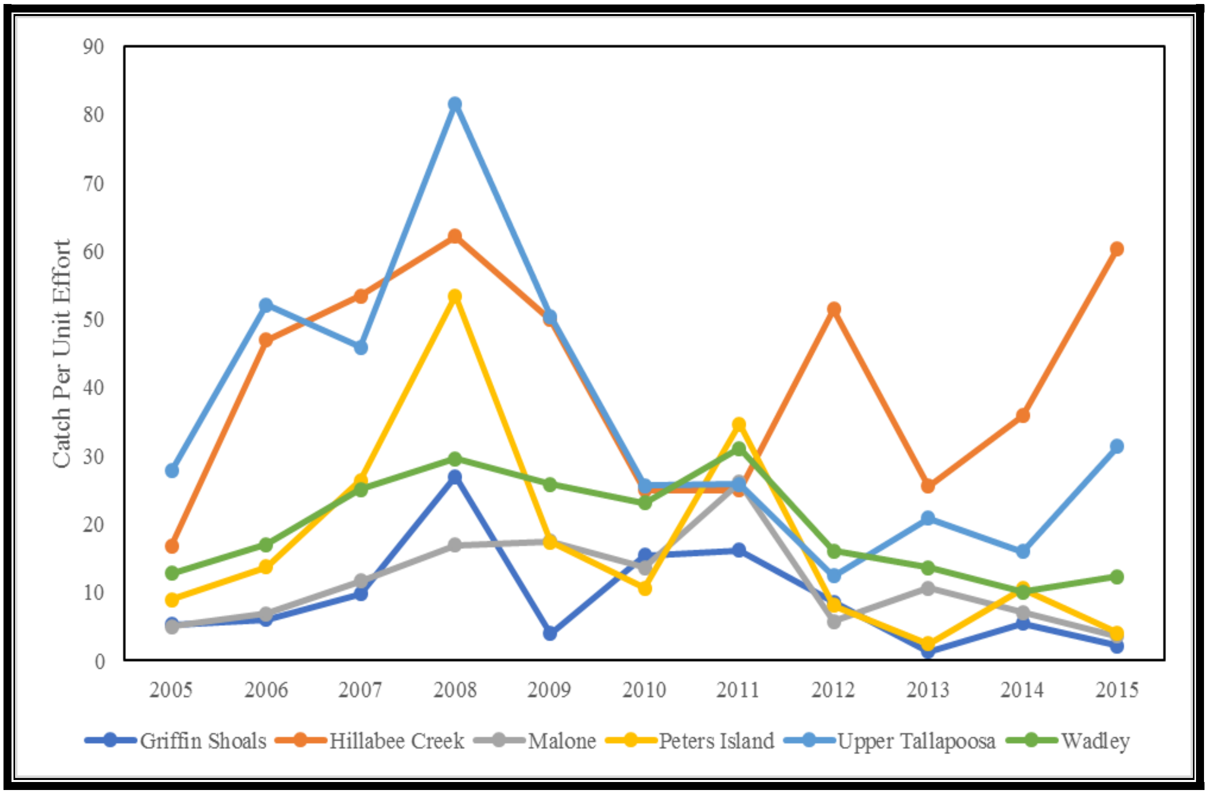


FIGURE 3-2 CATCH RATES FOR 2005-2015 FISH COMMUNITY SAMPLES AT ADAPTIVE MANAGEMENT STUDY SITES

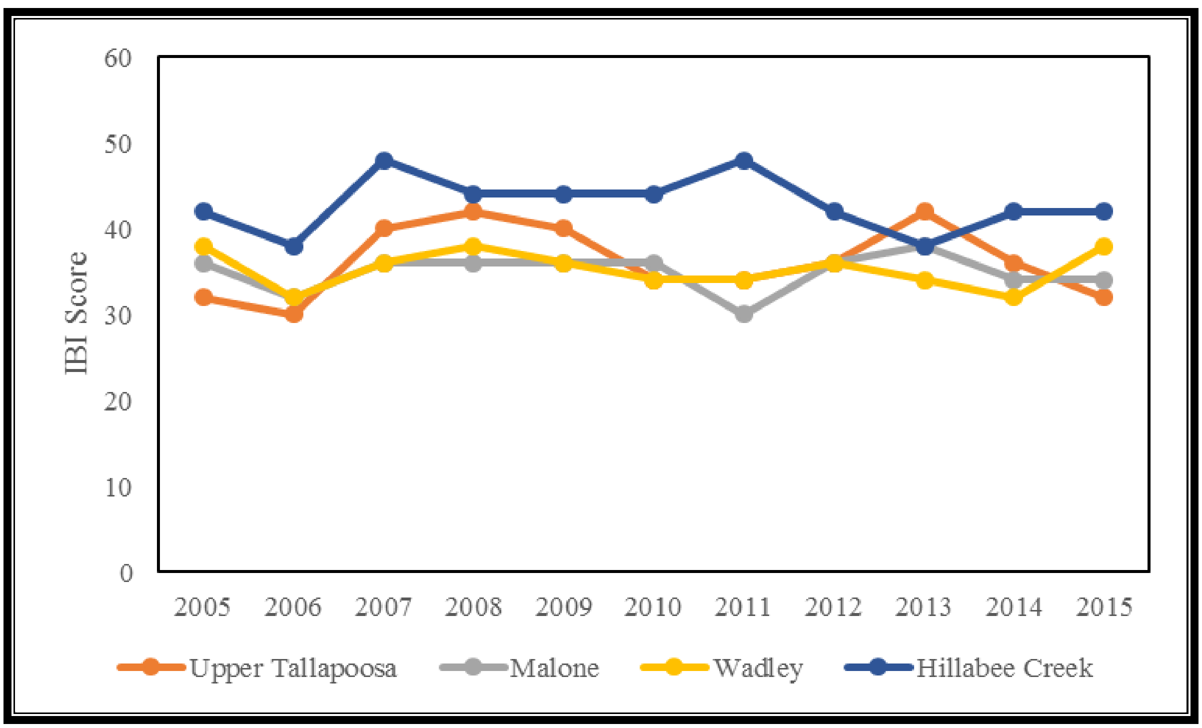


FIGURE 3-3 IBI SCORES FOR 2005-2015 FISH COMMUNITY SAMPLES

3.3 MACROINVERTEBRATE STUDIES

The ACFWRU has sampled benthic macroinvertebrate communities since 2005 at the same 6 sites where fish were sampled. The sites generally consisted of shallow reaches of riffles and shoals. The sites were sampled using a surber sampler, and macroinvertebrates were identified to the lowest practical taxonomic level. In 2017, the ACFWRU reported results from 2005 and 2014 samples for the Heflin (Upper Tallapoosa), Malone, Wadley, and Hillabee Creek sites.

A total of 151 taxa were identified in the 2005 and 2014 samples, 62 of which were from the family Chironomidae. Table 3-3 provides a summary of benthic macroinvertebrate taxa by class and order. In general, more individuals and taxa were collected in 2005 samples versus 2014. Differences in species composition between sites and years were variable. At the unregulated sites (Heflin and Hillabee), Plecoptera (stoneflies) made up a larger percentage of insect order composition in comparison with the regulated sites (Malone and Wadley) (Figure 3-4). The regulated sites appeared to consist of a higher percentage of Ephemeroptera (mayflies) in comparison with the regulated sites. The ACFWRU analysis found few significant differences between sites in the 2005 samples.

Regarding 2014 samples, significant differences in several metrics related to functional feeding groups/habits were noted. Percent scrapers, which are insects that eat algae, detritus, and submerged aquatic vegetation, were higher for the unregulated sites. Percent gatherers, which eat small benthic organic matter, and percent swimmers were higher for the regulated sites (Kosnicki et al. 2017).

TABLE 3-4 NUMBER OF INDIVIDUAL BENTHIC MACROINVERTEBRATES COLLECTED BY TAXON IN 2005 AND 2014

	Heflin		Hillabee		Malone		Wadley	
Taxa	**2005**	**2014**	**2005**	**2014**	**2005**	**2014**	**2005**	**2014**
Arachnida								
Trombidiformes	10		6		16	5	5	2
Bivalvia								
Veneroida	12	3	11	21	72	5	38	12
Clitellata								
Lumbriculida	1	2			37	37	17	16
Tubificida	17	4	12	8	216	28	19	17
Gastropoda								
Basommatophora	16							
Neotaenioglossa	5	27	6	95	1	3	90	14
Insecta								
Coleoptera	14	97	85	170	49	25	15	25
Diptera	331	23	230	87	648	113	109	96
Ephemeroptera	43	9	125	52	111	150	70	228
Megaloptera	1	2	3	1			2	
Odonata	2	1	5			1		1
Plecoptera	55	34	56	59	5		2	4
Trichoptera	53	22	129	19	103	96	56	29
Malacostraca								
Amphipoda					1			
Isopoda					5			
Nematoda	2		4		10		1	1
Turbellaria								
Tricladida					12			2
Total	**562**	**224**	**672**	**512**	**1286**	**463**	**424**	**447**

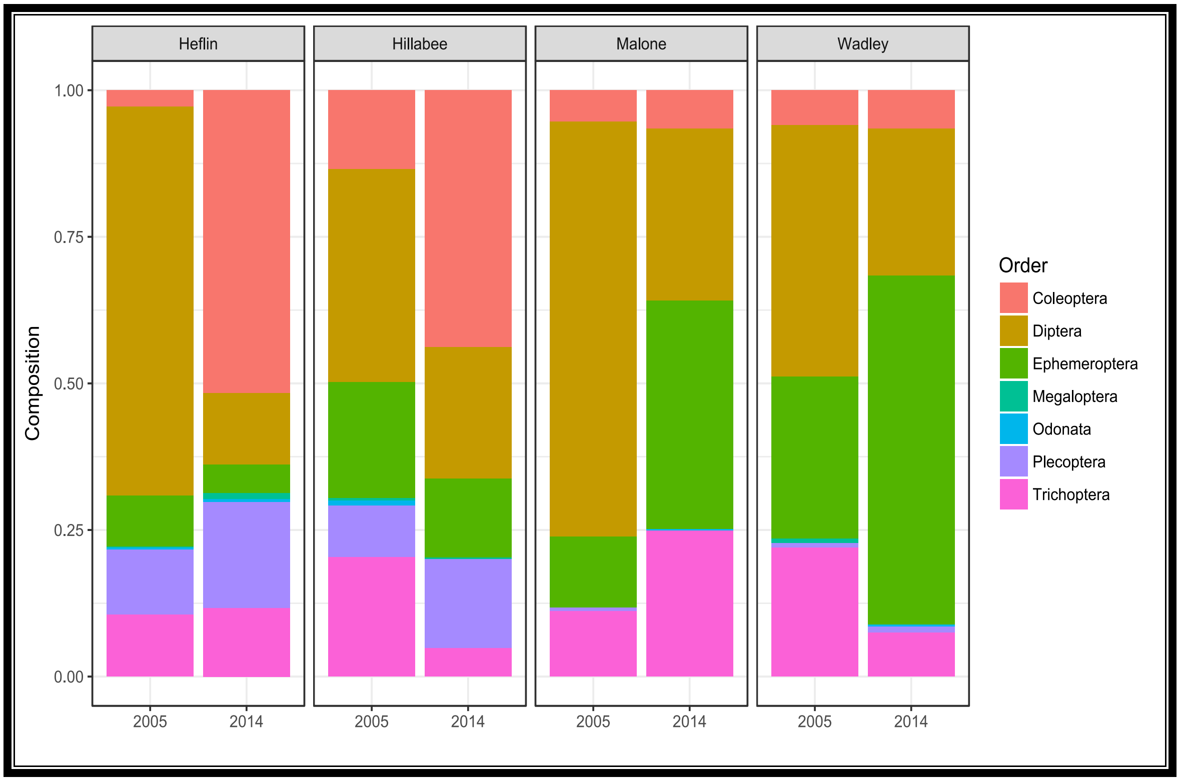


FIGURE 3-4 SUMMARY OF INSECT ORDER COMPOSITION FROM 2005 AND 2014 BENTHIC MACROINVERTEBRATE SAMPLES

3.4 TEMPERATURE STUDIES

Alabama Power has collected water temperature data at the Harris Dam Tailrace and at the Malone and Wadley sites since 2005. Measurements were collected at 1-hour intervals, typically from March through October. Generally, water temperatures were lowest at the tailrace location and highest at Wadley, with the warmest temperatures experienced during the month of August (Table 3-4; Figures 3-5 to 3-7).

TABLE 3-5 SUMMARY OF MEAN MONTHLY WATER TEMPERATURES (°C) IN THE TALLAPOOSA RIVER BELOW HARRIS DAM

Month	Tailrace	Malone	Wadley
March	11.04	11.71	11.89
April	14.73	15.36	16.15
May	17.80	18.99	19.92
June	20.79	22.76	23.80
July	22.66	24.74	25.57
August	24.11	25.72	26.45
September	23.46	24.12	24.73
October	20.50	19.93	20.04

Daily temperature ranges (the difference between the minimum and maximum temperature) were calculated for each site to determine the magnitude and frequency of temperature fluctuations at each site (Figures 3-8 to 3-10). Generally, daily temperature fluctuations ranged from 1 to 5 degrees C.

In 2016 and 2017, Alabama Power performed experimental assessments aimed at optimizing the pulsing scenarios that might result in more desirable temperature ranges for fish spawning. Testing in late March and early April 2017 yielded preliminary results that may be explored further in 2018. Alabama Power also examined the effects of operations on water temperatures and water levels in Crooked Creek and Cornhouse Creek to determine if they represented suitable refugia (Figure 3-11). Generally, there appeared to be few upstream effects on water temperature within the two tributaries. Water levels near the mouth of Crooked Creek showed some effect from pulsing operations due to its proximity to Harris Dam.

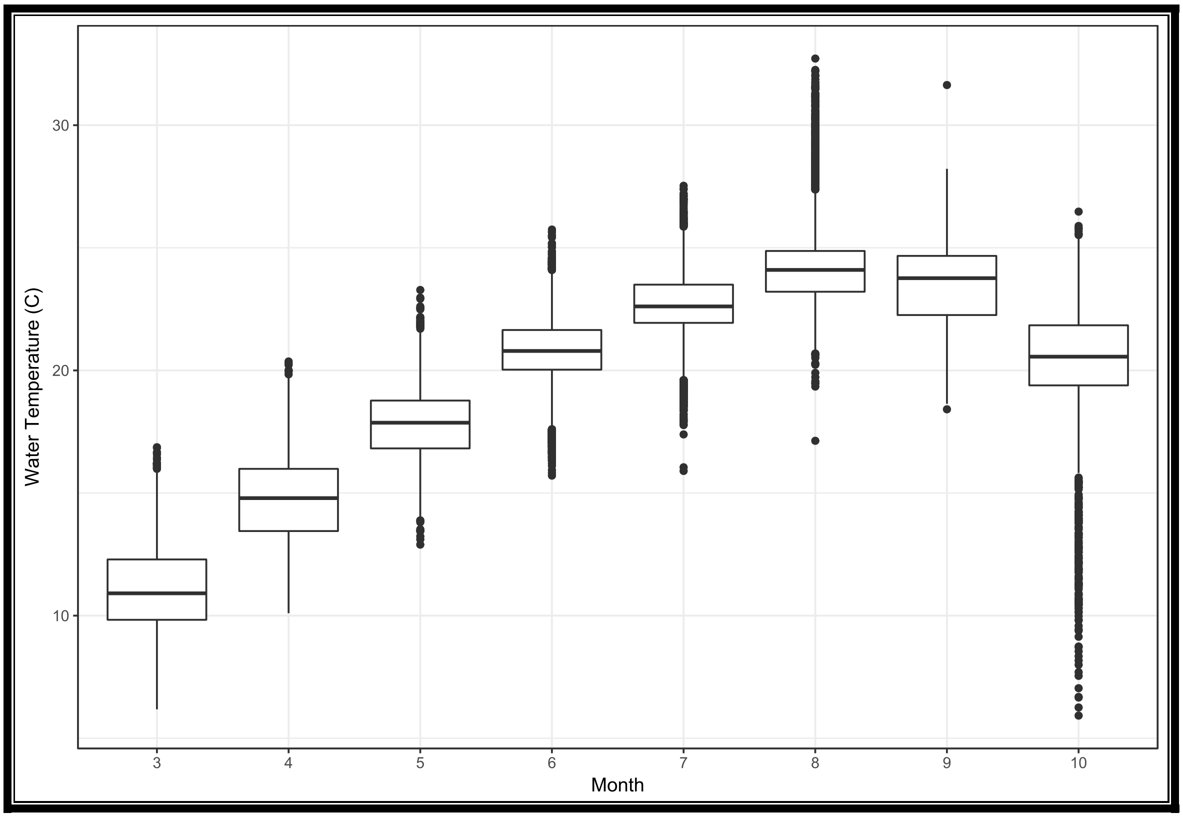


FIGURE 3-5 BOXPLOT OF WATER TEMPERATURE BY MONTH FOR HARRIS DAM TAILRACE (2005 – 2017)

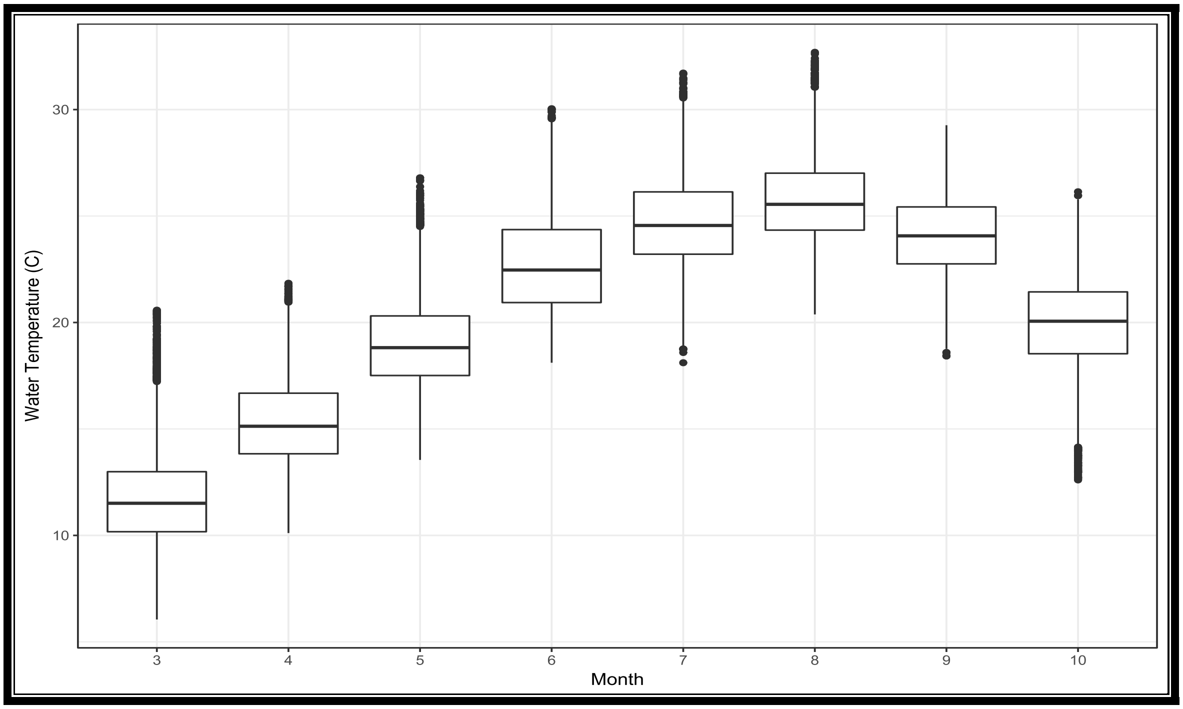


FIGURE 3-6 BOXPLOT OF WATER TEMPERATURE BY MONTH FOR TALLAPOOSA RIVER AT MALONE (2005 – 2017)

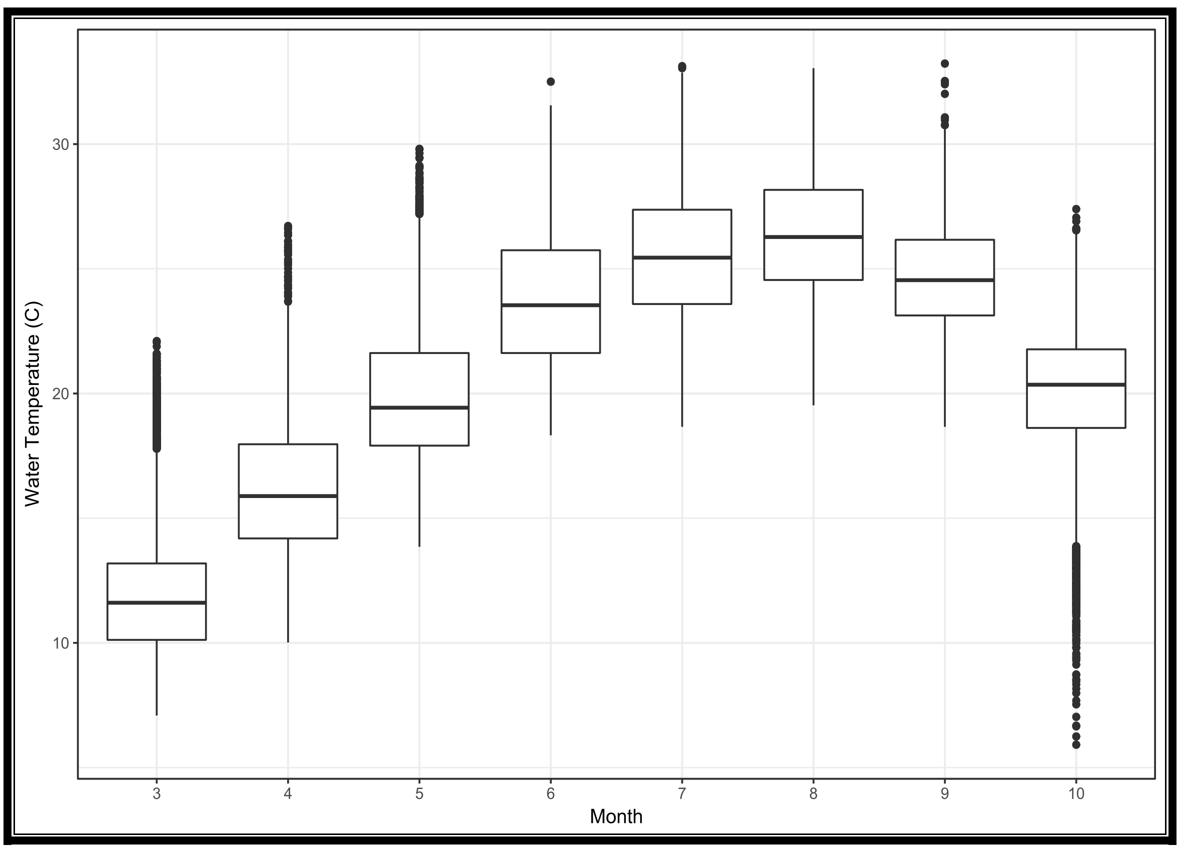


FIGURE 3-7 BOXPLOT OF WATER TEMPERATURE BY MONTH FOR TALLAPOOSA RIVER AT WADLEY (2005 – 2017)

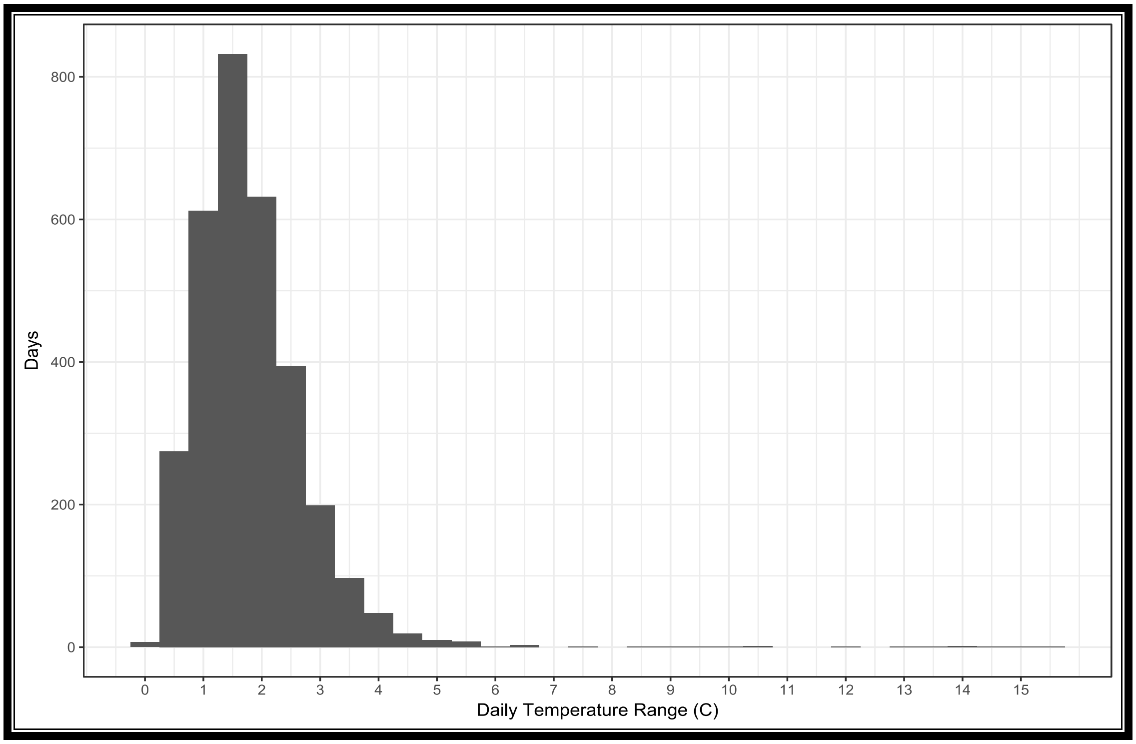


FIGURE 3-8 HISTOGRAM OF DAILY WATER TEMPERATURE RANGE FOR HARRIS DAM TAILRACE FROM 2005 THROUGH 2017

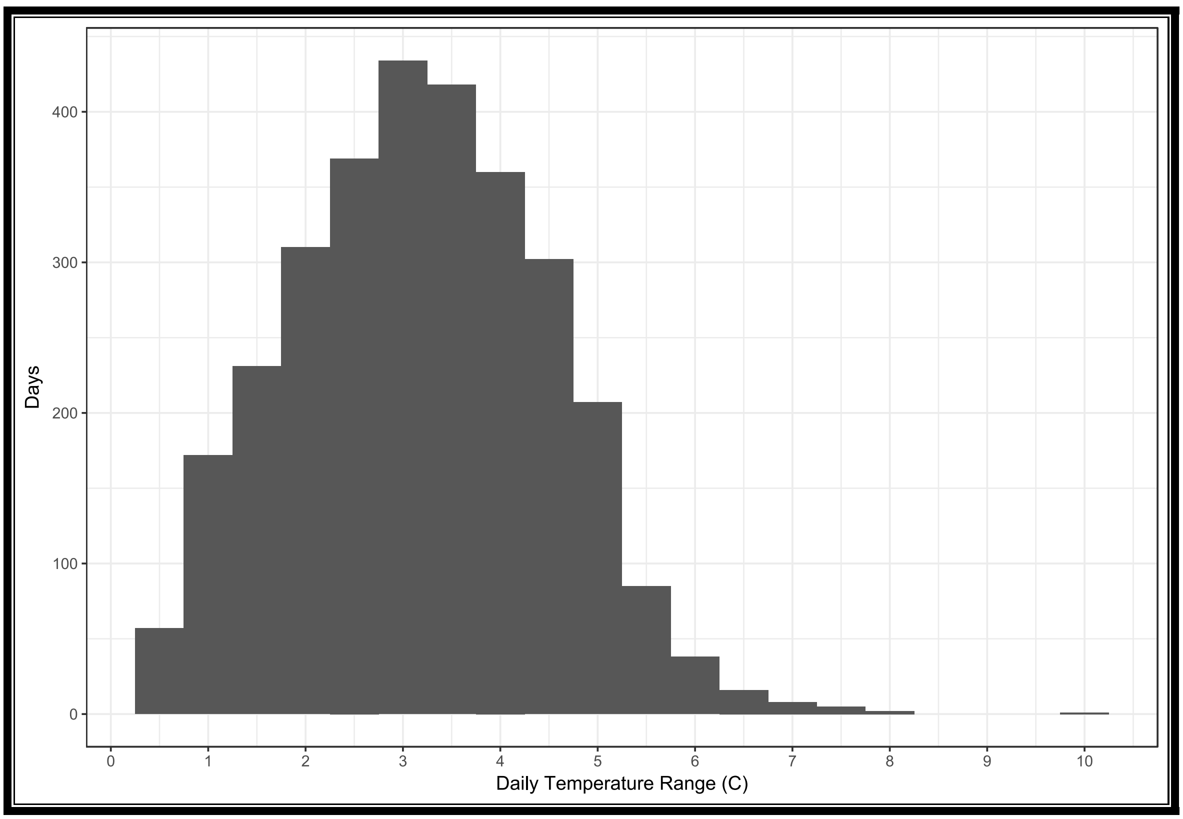


FIGURE 3-9 HISTOGRAM OF DAILY WATER TEMPERATURE RANGE FOR TALLAPOOSA RIVER AT MALONE FROM 2005 THROUGH 2017

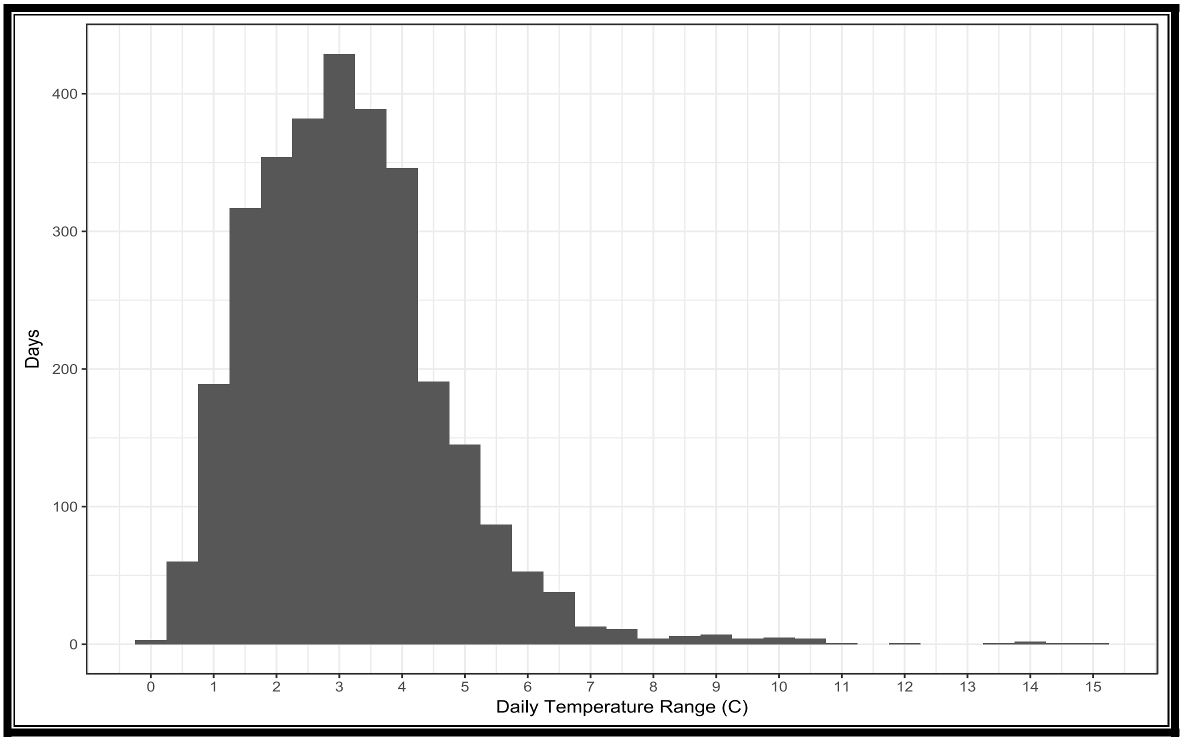
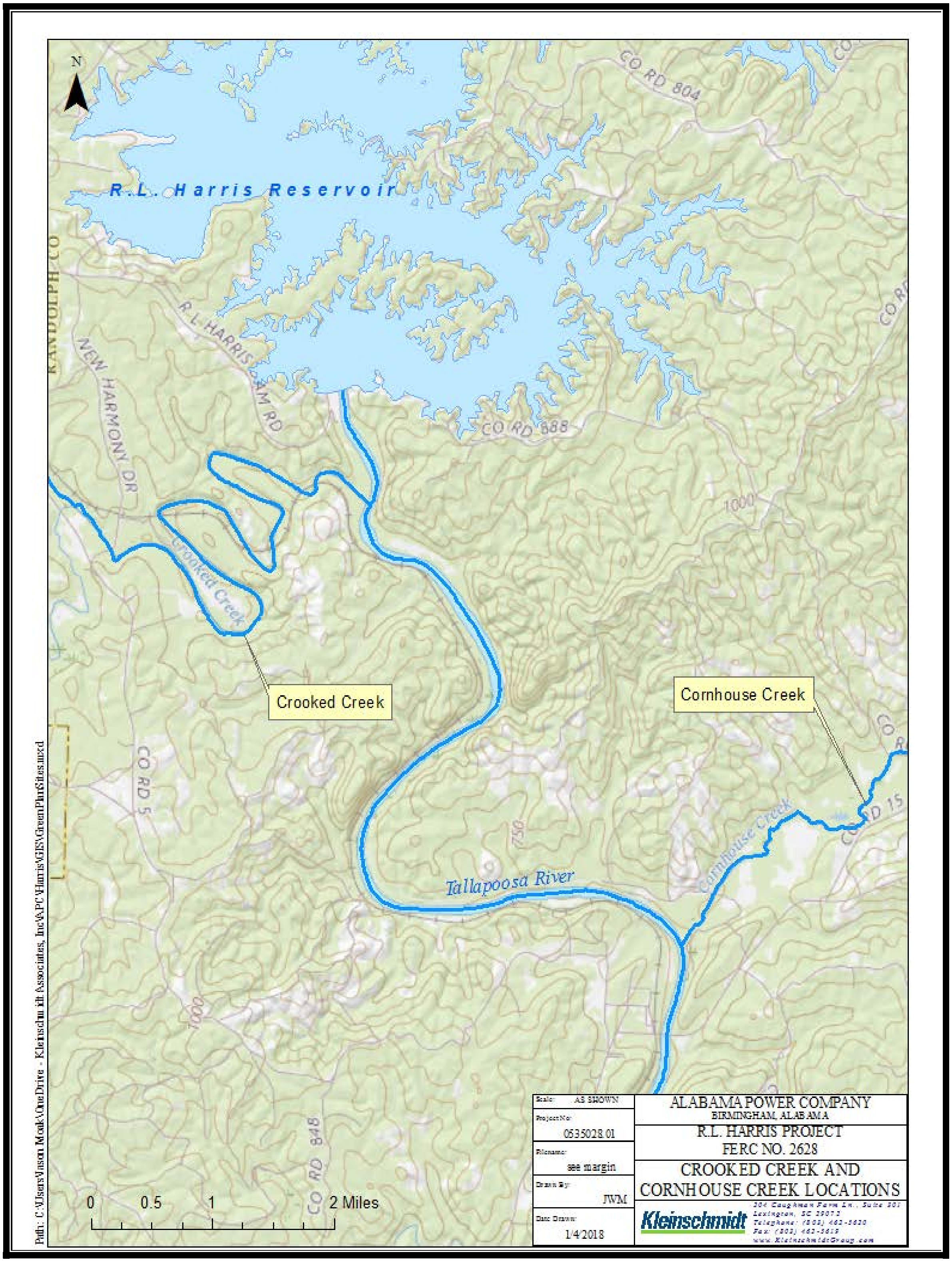


FIGURE 3-10 HISTOGRAM OF DAILY WATER TEMPERATURE RANGE FOR TALLAPOOSA RIVER AT WADLEY FROM 2005 THROUGH 2017



Source: Kleinschmidt, Alabama Power 2018

FIGURE 3-11 CROOKED CREEK AND CORNHOUSE CREEK LOCATIONS

4.0 PUBLICATIONS

This section provides a summary of available publications related to adaptive management of the Tallapoosa River below Harris Dam. These include articles from peer-reviewed technical journals, master's theses, doctoral dissertations, and unpublished reports. The publications are listed in chronological order according to publication date. Some of these abstracts contain spelling and/or grammatical errors; they appear in this text as they were published.

Travnicheck, Vincent H. and M.J. Maceina. 1994. **Comparison of Flow Regulation Effects on Fish Assemblages in Shallow and Deep Water Habitats in the Tallapoosa River**. Journal of Freshwater Ecology, 9(3): 207-216.

ABSTRACT: We measured species richness, diversity, and abundance of fish in both shallow and deep water areas in regulated and unregulated sections of the Tallapoosa River in Alabama from July 1990 through September 1992 to compare the effects of flow regulation on fish assemblages in shallow and deep water habitats. Flow regulation had a greater effect on shallow water fish assemblages than on deep water fish assemblages. Species richness and diversity of shallow water fishes were reduced below two hydroelectric dams compared with unmodified river segments, and we attribute this to a reduction in species adapted to fluvial environments below the two dams. Additionally, the density of fish in shallow water areas of unregulated portions of the river was significantly ($P<0.05$) higher than the density at most of the regulated sites. No reductions in species richness or diversity below the two dams were observed for species inhabiting deep water areas. However, we collected a significantly ($P<0.05$) higher number of catostomid species in the unmodified river sections compared to the flow-regulated sections.

Bowen, Zachary H., M.C. Freeman, and K.D. Bovee. 1998. **Evaluation of Generalized Habitat Criteria for Assessing Impacts of Altered Flow Regimes on Warmwater Fishes**. Transactions of the American Fisheries Society, 127(3): 455-468

ABSTRACT: Assessing potential effects of flow regulation on southeastern warmwater fish assemblages is problematic because of high species richness and poor knowledge of habitat requirements for most species. Our study investigated relationships between availability and temporal persistence of key habitats and fish assemblage structure at regulated and unregulated sites in the Tallapoosa River system. Fish assemblage characteristics at seven sites were quantified based on 1,400 electrofishing samples collected during 1994 and 1995. Physical Habitat Simulation (PHABSIM) programs were used to model availability and persistence of key habitats at regulated and unregulated sites. Associations between fish assemblages and availability or persistence of key habitats were identified via regression and analysis of variance. We found that hydropeaking dam operation reduced the average length of time that shallow-water habitats persisted and also reduced year-to-year variation in the persistence of shallow-water habitats compared with unregulated sites. Across sites and years, proportional representation of catostomids was positively correlated with persistence of shallow and slow-water habitats during spring. Proportion of individuals as cyprinids was positively correlated with median availability of deep–fast habitat whereas proportion of percids was inversely related to median availability of deep–fast habitat. Mean fish density was positively correlated with the persistence of shallow and slow-water habitats. Comparisons of key habitat measures and fish abundances between 1994 and 1995 at each site indicated that higher abundances of percids, catostomids, and cyprinids were associated with increased availability and persistence of shallow and slow-water habitats in 1995. These findings demonstrate that the temporal and spatial availability of key habitats could serve as useful measures of the potential effects of flow alteration on lotic fish assemblages and suggest that both short-term persistence of key habitats as well as annual variation in key-habitat availability are important for maintaining diverse fish assemblages.

Irwin, Elise R. and A. Belcher. 1999. **Assessment of Flathead and Channel Catfish Populations in the Tallapoosa River**. ADCNR – Federal Aid to Fish and Wildlife Restoration, Job Performance Final Report Project F-40, Study 30.

INTRODUCTION: Gathering data on resource use by anglers allows for informed decisions regarding management options. The Tallapoosa River in the 1970's provided quality fishing for black basses (redeye bass *Micropterus coosae*, spotted bass *M. punctulatus*, largemouth bass *M. salmoides*; D. Catchings, personal communication) and catfishes (*Pylodictis olivarus* and *Ictalurus punctatus*; F. Butler, personal communication). In fact, a state record redeye bass was caught in the Tallapoosa River in 1974. More recently, anglers that fish the Tallapoosa River perceived declines in harvest of fish (primarily catfishes). Therefore, a project to assess catfish populations and angler harvest was initiated. To gather information on angler use of fishery resources at the Horseshoe Bend area of the Tallapoosa River, Alabama, a creel station was installed adjacent to the boat ramp in June 1997. The fixed creel station served as an on-site or access point type survey, only lacking the agent or creel clerk to conduct the survey (Pollock et al. 1994). Although a fixed station survey is not representative of most current statistically based survey designs (Van Den Avyle 1986), our survey had the same objectives as traditional creel surveys. Our objective was to gather creel data from the station to determine angler effort and attitudes, harvest rates, and other characteristics of the creel at Horseshoe Bend. To assess temporal changes in the fisheries, we compared angler catch-per-unit effort (CPUE) from the creel station to similar data from angler diaries reported in the 1970's. Angler diaries have proven to provide accurate estimates of fishing effort, harvest rates and other comparative information (Pollock et al. 1994). In addition, we stocked adult flathead catfish in the area in an attempt to monitor their contribution to the creel.

Freeman, Mary C. Z. H. Bowen, K. D. Bovee, and E. R. Irwin. 2001. **Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes**. Ecological Applications, 11(1):179-190.

ABSTRACT: Conserving biological resources native to large river systems increasingly depends on how flow-regulated segments of these rivers are managed. Improving management will require a better understanding of linkages between river biota and temporal variability of flow and instream habitat. However, few studies have quantified responses of native fish populations to multiyear (>2 year) patterns of hydrologic or habitat variability in flow-regulated systems. To provide these data, we quantified young-of-year (YOY) fish abundance during four years in relation to hydrologic and habitat variability in two segments of the Tallapoosa River in the southeastern United States. One segment had an unregulated flow regime, whereas the other was flow-regulated by a peak-load generating hydropower dam. We sampled fishes annually and explored how continuously recorded flow data and physical habitat simulation models (PHABSIM) for spring (April-

June) and summer (July-August) preceding each sample explained fish abundances. Patterns of YOY abundance in relation to habitat availability (median area) and habitat persistence (longest period with habitat area continuously above the long-term median area) differed between unregulated and flow-regulated sites. At the unregulated site, YOY abundances were most frequently correlated with availability of shallow-slow habitat in summer (10 species) and persistence of shallow-slow and shallow-fast habitat in spring (nine species). Additionally, abundances were negatively correlated with 1-h maximum flow in summer (five species). At the flow-regulated site, YOY abundances were more frequently correlated with persistence of shallow-water habitats (four species in spring; six species in summer) than with habitat availability or magnitude of flow extremes. The associations of YOY with habitat persistence at the flow-regulated site corresponded to the effects of flow regulation on habitat patterns. Flow regulation reduced median flows during spring and summer, which resulted in median availability of shallow-water habitats comparable to the unregulated site. However, habitat persistence was severely reduced by flow fluctuations resulting from pulsed water releases for peak-load power generation. Habitat persistence, comparable to levels in the unregulated site, only occurred during summer when low rainfall or other factors occasionally curtailed power generation. As a consequence, summer-spawning species numerically dominated the fish assemblage at the flow-regulated site; five of six spring-spawning species occurring at both study sites were significantly less abundant at the flow-regulated site. Persistence of native fishes in flow-regulated systems depends, in part, on the seasonal occurrence of stable habitat conditions that facilitate reproduction and YOY survival.

Irwin, Elise R. and M.C. Freeman. 2002. **Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, U.S.A**. Conservation Biology, 16(5):1212-1222.

ABSTRACT: Conserving river biota will require innovative approaches that foster and utilize scientific understanding of ecosystem responses to alternative river-management scenarios. We describe ecological and societal issues involved in flow management of a section of the Tallapoosa River (Alabama, U.S.A.) in which a species-rich native fauna is adversely affected by flow alteration by an upstream hydropower dam. We hypothesize that depleted low flows, flow instability, and thermal alteration resulting from pulsed flow releases at the hydropower dam are most responsible for changes in the Tallapoosa River biota. However, existing data are insufficient to prescribe with certainty minimum flow levels or the frequency and duration of stable flow periods that would be necessary or sufficient to protect riverine biotic integrity. Rather than negotiate a specific change in the flow regime, we propose that stakeholders—including management agencies, the power utility, and river advocates—engage in a process of adaptive-flow management. This process would require that stakeholders (1) develop and agree to management objectives; (2) model hypothesized relations between dam operations and management objectives; (3) implement a change in dam operations; and (4) evaluate biological responses and other stakeholder benefits through an externally reviewed monitoring program. Models would be updated with monitoring data and stakeholders would agree to further modify flow regimes as necessary to achieve management objectives. A primary obstacle to adaptive management will be a perceived uncertainty of future costs for the power utility and other stakeholders. However, an adaptive, iterative approach offers the best opportunity for improving flow regimes for native biota while gaining information critical to guiding management decisions in other flow-regulated rivers.

Irwin, Elise R. and K.D. Mickett. 2005. **Development of a monitoring plan for adaptive management below R.L. Harris Dam**. Presented at R.L. Harris Stakeholder Board Meeting, August 23, 2005.

ABSTRACT: Adaptive management requires a scientifically based monitoring plan to assess both cause and effect and status and trends of biological and physical components of the system under management (Walters 1986; Yoccoz et al. 2001). Components of the monitoring plan were developed by the Science Committee after considering goals and objectives out1ined by the Stakeholders. The monitoring plan for the Tallapoosa River below Harris Dam should be implemented immediately to coincide with the beginning of active adaptive flow management of the river. Because adaptive management provides a true experimental context, careful design of monitoring protocols is needed. Shortcomings of many monitoring plans include vague objectives that are often unrelated to management actions, neglect of analysis of underlying mechanisms, lack of a priori hypotheses regarding how management will affect the state and change of variables, and use of methods and or sampling designs that do not incorporate measures of detectability (Yoccoz et al. 2001). With these potential pitfalls illuminated, we propose the following approach for monitoring ecosystem response to adaptive management of the middle Tallapoosa River.

Kennedy, Kathryn M., E.R. Irwin, M.C. Freeman, and J. Peterson. 2006. **Development of Decision Support Tool and Procedures for Evaluating Dam Operation in the Southeastern United States**. Available: <http://www.rivermanagement.org/decision_support_final_report.pdf>.Accessed December 11, 2017.

EXECUTIVE SUMMARY: Riverine systems in the Southeast are highly fragmented and managed for hydropower, navigation, flood control and recreational needs. These multiple-use systems require innovative approaches for management of both natural and water resources for societal needs. Adaptive management has been recommended as a framework for managing complex riverine systems because 1) management goals are often conflicting and 2) system uncertainty is great. Adaptive management is different from other types of management because it includes all stakeholders in the process (versus policy makers only), uses resource optimization techniques by incorporating competing objectives, and recognizes and focuses on the reduction of uncertainty inherent in natural resource systems by attempting to reduce it via knowledge acquisition. Stakeholders negotiate a starting point for management actions, the effects of management are monitored and compared with predicted results, and management strategies are adjusted: then the process is iterative through the "monitor-compare-adjust" routine. State and Federal agencies in the Southeast U.S. region will be involved with the re-licensing of more than 200 dams that are regulated by the Federal Energy Regulatory Commission (FERC) through 2010. Tools are needed to engage stakeholders and develop strategies for defining starting management protocols. Our objectives were to develop a template for incorporating adaptive management and decision support into the FERC re-licensing process.

We conducted a workshop to incorporate stakeholder values and objectives into the template. Participants engaged in an open discussion for building consensus on management objectives and values. Presentations by experts in adaptive management of

natural resources were followed by a professionally facilitated forum. Suggested objectives were judged in an electronic poll by one representative from 23 participating stakeholder groups. Eleven fundamental objectives were developed and discussed by stakeholders; it was agreed that they were complete and representative of all involved parties. It was also agreed that the framework of adaptive management would be adopted for future discussions and management decisions. Objectives were used in the development of a decision support model to assist stakeholders in defining the first flow prescription in the adaptive management process. In addition, the stakeholders developed a governance structure; the R.L. Harris Stakeholders Board.

The study reach (Tallapoosa River below R. L. Harris Dam) represents one of the longest and highest quality segments of Piedmont river habitat remaining in the Mobile River drainage, one of the most biologically diverse river drainages in North America. Extensive areas of shoal habitat, river features that typically support high faunal diversity and that have been replaced by impoundments throughout much of the Southeast, are characteristic along this portion of the river. The native fish assemblage includes at least 57 species, including at least five species endemic to the Tallapoosa River system. The invertebrate fauna is less well-known; however, the fine-lined pocketbook (*Hamiota altilis*), which is listed as Threatened under the Endangered Species Act, and at least two endemic species of crayfishes occur in the piedmont reach.

A decision support model was developed based on fundamental objectives and hypothesized relations between flow and system response. Hypothesized features of flow that affected faunal response in the system were 1) depleted low flows, 2) flow instability, and 3) thermal-regime alteration. We constructed a Bayesian network for use as a decision support model to both quantify uncertainty regarding the response of state variables to management actions and to make hypotheses relative to predicted response. Modeled decisions included four alternative primary flow regimes, the provision of spawning windows (periods during which flows are minimized to allow for hypothesized increased spawning success), and increased weekend flows in October for recreational boating. Relations between flow and system response were modeled using probabilistic dependencies derived from long-term empirical data from multiple projects and expert opinion; whereas, relations between system response and stakeholder satisfaction (i.e., utility values) were modeled using probabilistic dependencies based upon stakeholder opinion. The optimal decision was determined by examining the expected value associated with each alternative decision, which was the sum of the probability-weighted utility values.

The decision support model was comprised of three primary decisions, five stakeholder satisfaction functions, and ten uncertainty nodes. The primary decisions were daily flow operations at dam, provision and timing of stable flows (i.e., “spawning windows”) and provision of enhanced October flows for recreational boaters. Satisfaction functions were included for river boater satisfaction, river landowner satisfaction, reservoir user satisfaction, fish population value, and power generation. The uncertainty nodes were as follows; reservoir inflow, lake levels, boatable days, erosion, shallow-fast habitat, slow-cover habitat, flow-through pools, degree days, small fish abundance, bass recruitment, and redbreast spawning success. The uncertainty nodes (except erosion) were parameters linked directly to fundamental objectives of stakeholders and hypotheses related to system function.

After the model was compiled, sensitivity analysis was conducted and allowed for a better understanding of the influence carried by variables on utility values and the modeled decisions. This analysis also allowed for recommendations relative to allocation of resources for management and monitoring purposes. For example, given the empirical data, periods of stable flows (versus daily flow regime) appear to be most beneficial for the integrity of the fish populations. Therefore, natural resource managers could focus efforts on further defining functional relations between stable flow windows and recruitment of biota.

Freeman et al. (2001) called for flow manipulations in an adaptive management context, coupled with continued biological monitoring to "elucidate how hydrologic variation influences species persistence." This project was successful in developing a template for adaptive management that can be applied to other regulated systems. Active adaptive management began in the study system in spring of 2005 and a monitoring program is in place. The decision support model built and adopted by the stakeholders facilitated decision making and assisted scientists with development of the monitoring plan. Key elements for success were: 1) use of a professional and neutral facilitator to engage stakeholders in objective and value identification; 2) use of a visual decision support model that allowed for stakeholder input and optimization of values associated with various decisions; 3) development of a governance structure for future involvement and ownership in the process; and 4) recognition of a long-term commitment to learning the effects of management through system monitoring and adjustment of management regimes.

Sakaris, Peter C. 2006. **Effects of hydrologic variation on dynamics of channel catfish and flathead catfish populations in regulated and unregulated rivers in the southeast USA** (Ph.D. Dissertation).Available: < https://etd.auburn.edu/bitstream/handle/10415/621/SAKARIS_PETER_47.pdf?sequence=1&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Altered flow regimes resulting from dam construction can have negative impacts on growth and recruitment of fishes in regulated river systems. The effects of hydrologic variation on channel catfish *Ictalurus punctatus* and flathead catfish *Pylodictis olivaris* populations were examined in regulated and unregulated river systems. The objectives of this dissertation were to: 1) develop and validate methods for daily aging age-0 channel catfish, 2) examine the effects of hydrologic variability on growth and hatching success of age-0 channel catfish in regulated and unregulated reaches of the Tallapoosa River Basin, Alabama, and 3) incorporate the effects of variable hydrology on recruitment and variable mortality as stochastic factors influencing the population growth of native and introduced flathead catfish populations from the Coosa (Alabama) and Ocmulgee (Georgia) rivers.

In validation studies, mean daily ring counts from sagittal otoliths and known ages of channel catfish were strongly related, indicating that daily ring deposition occurred in the otoliths of age-0 channel catfish. Daily ring counts were accurate for 107 - 119 days post-hatch. In the Tallapoosa River System, growth of age-0 channel catfish was generally highest among age-0 fish from unregulated sites in the Coastal Plain, intermediate among fish from regulated sites in the Piedmont, and lowest among fish from unregulated sites in the Piedmont. All age-0 fish that hatched in September originated from the regulated site, indicating that fish in the regulated reach had a protracted spawning season. Multiple regression models indicated that positive relations existed between growth of age-0 channel catfish and hydrologic variables including mean discharge, minimum discharge, number of high pulses, and rise rate. In addition, growth was negatively affected by high fall rates. Age-0 channel catfish typically hatched during periods with low and stable flow conditions.

Size classified matrix models were constructed for native and introduced flathead catfish populations from the Coosa (Alabama, USA) and Ocmulgee (Georgia, USA) rivers, respectively. Recruitment of flathead catfish in the Coosa River was positively related to mean spring discharge and November low flow. In the Ocmulgee River, year-class strength was negatively related to mean March discharge and positively related to June low flow. Incorporation of variable hydrology as a stochastic factor in the matrix model had a negative effect on population growth in the Coosa River. In contrast, incorporation of hydrologic variation as a stochastic factor resulted in stable population growth in the Ocmulgee River. By variably decreasing the mortality of flathead catfish with the highest reproductive values, population growth improved over a 50-year period in the Coosa River. Simulation of increased mortality of harvestable sized flathead catfish in the Ocmulgee River resulted in a substantial decline in population size.

Managers are encouraged to use models described in this dissertation as tools in adaptive-flow management programs in the Alabama River System. Specifically, these models can be used to prescribe flow regimes in regulated river systems. Researchers should continually improve models by collecting more data and closely monitoring responses of fish populations to variable flow conditions in regulated river systems.

Martin, Benjamin M. 2008. **Nest survival, nesting behavior, and bioenergetics of redbreast sunfish on the Tallapoosa River, Alabama** (Master's thesis). Available:< https://etd.auburn.edu/bitstream/handle/10415/1458/Martin_Benjamin_10.pdf?sequence=1&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Adaptive management has been implemented in the Tallapoosa River, Alabama; one objective of the process is to determine how discharge and temperature affect redbreast sunfish reproductive success. Nesting male redbreast sunfish *Lepomis auritus* were monitored via snorkeling and video during 2006 and 2007 to estimate nest survival and quantify nesting behavior in a regulated reach of the Tallapoosa River (Alabama) below R.L. Harris Dam. In addition, males were collected during 2007 to determine if metabolic constraints were evident when caloric contents and bioenergetic models from the regulated Tallapoosa River and an unregulated tributary were compared.

A priori hypotheses were constructed relative to how biological and environmental factors might affect nest survival. Nest survival estimates were determined in Program MARK and competing environmental and biological models were evaluated using Akaike's information criterion (AIC). These data allowed for assessment of the functional response of daily survival rate of nests in relation to discharge. One year in the study was an extreme drought year (2007) allowing for nest survival estimates during an atypical water management year. Findings from this study support use of spawning windows (e.g., low flow releases from dam) to increase reproductive success for redbreast sunfish. Spawning window timing could be as early as mid-May, which is earlier than previously

suggested. Spawning flows provided earlier in the year could enhance reproductive success for other fish species.

Video of nesting behavior indicated that male redbreast sunfish primarily exhibited the defend and leave behavior during 'baseflow' (e.g., low flow conditions) observations. During higher discharge events (i.e., one-unit or turbine ~ 200 cms) spawning behaviors (e.g., milt and court) ceased and the defend behavior decreased; whereas, the leave and the clean behaviors increased. Behavior observations indicated that increased flow caused disruption of spawning and nest abandonment. Behavior during two-unit discharge events was only minimally observed because of drought conditions; however, data did indicate detrimental effects of two-unit discharge on nests (i.e., destruction).

Bioenergetic modeling predicted decreased growth, and weight for males during the spawning season at both the regulated and unregulated sites. At the unregulated site consumption rates increased as temperature increased; when the thermal maximum was reached (33ºC), consumption decreased precipitously. In contrast, consumption rates at the regulated site were always positively related to temperature and did not decline when the thermal maxima was reached (28ºC) suggesting that thermal mitigation occurred from hypolimnetic releases from the dam. Reducing uncertainty regarding how biota respond to management actions is a goal of adaptive management and results from this study are applicable to flow management and its subsequent effects on nesting centrarchids.

Martin, Molly Ann Moore. 2010**. Shoal occupancy estimation for 3 lotic crayfish species in the Tallapoosa River basin, Alabama** (Master's thesis). Available: < https://etd.auburn.edu/bitstream/handle/10415/2087/Shoaloccupancyestimationfor3loticcrayfishspecies_Martin_Final.pdf?sequence=2&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: The greatest diversity of crayfishes in the world is in the southeastern United States; however, many species are at risk and lack of information on habitat requirements and the effects of habitat alteration hamper crayfish conservation efforts (Jones and Bergey 2007, Taylor et al. 2007). Two priority level 2 species (P2; ADCNR) of crayfish are endemic to the piedmont region of the Tallapoosa River Basin; *Cambarus englishi*, and closely related *Cambarus halli*, (Schuster et al. 2008). Additionally, widespread priority level 5 (P5) species, *Procambarus spiculifer*, have been documented in the region (Ratcliffe and DeVries 2004). Conservation of native fauna in large rivers is increasingly dependent on flow management therefore native fauna of the middle Tallapoosa are potentially strongly affected by flow management employed by Harris Dam (Irwin and Freeman 2002).

Occupancy was estimated using methods outlined by Mackenzie et al. 2002 for crayfishes as part of adaptive management of the Tallapoosa River to gain understanding on how flow dynamics affect biota. Specific objectives were to determine variables affecting species specific detection probabilities and compare site level occupancy estimates between regulated and unregulated reaches. Additionally, catch data were examined for differences in size structure among sites. Lotic crayfishes were collected from shoals at 3 regulated and 2 unregulated reaches of the Tallapoosa River basin using pre-positioned area electrofishers (PAE). Detection probability and occupancy were modeled from presence- absence data as a function of a priori covariates and estimated in

Program PRESENCE using the custom single-season single-species models. Model selection was based on the principle of parsimony and superfluous models were eliminated. Weighted model-averaged parameter estimates and unconditional sampling variances were calculated (Burnham and Anderson 2002). Multiple PAE's (i.e. spatial replication; n= 5-20) were collected with habitat characters depth, velocity, percent vegetation, and substrate composition recorded and used to model detection. Site level occupancy covariates were based on the a priori hypotheses that occupancy was lower in regulated reaches due to negative impacts of hydropeaking on recruitment and /or occupancy varied along a linear downstream recovery gradient from Harris Dam and one a posteriori hypothesis that occupancy differed among the 5 reaches.

Detection was low for all species in most years which affected precision of occupancy estimates. A few sites consistently had a high number of detections while others consistently had few. Variation in number of detections likely reflected changes in relative underlying populations of crayfishes potentially related to differences in habitat quality, food quality, number of available refuges, or predation risk. At least one individual of *P. spiculifer*, *C. englishi*, and *C. halli* were collected from almost every shoal at least once in the five-year sampling period; however, occupancy estimates varied spatially and temporally. Modeling results suggested occupancy was similar in regulated and unregulated reaches of the basin in a 'wet' year while spatial differences were observed among reaches in all other years. Temporal differences were potentially related to basin hydrology. Data supports occupancy of *P. spiculifer* was close to one ($\Psi \approx 1$) throughout the basin and occupancy of *C. englishi* was higher in the regulated reaches ($\Psi \approx 1$) than unregulated reaches ($\Psi \approx 0.50$ - 0.60) in most years. Extremely low detection due to [sic] (i.e., sparse data) resulted in model uncertainty making estimates for *C. halli* variable and difficult to interpret. Further investigation of distribution and habitat use for *C. halli* is warranted and *C. halli* may be more abundant in tributaries (Ratcliffe and DeVries 2004). Understanding habitat use of endemic species is important for recommending management actions directed towards conservation of crayfishes.

Habitat covariates supported predicted biological responses, were sensitive to annual basin hydrology, and supported evidence of habitat partitioning among species. Vegetation was important for all species demonstrating a positive effect on detection. Depth influenced detection probabilities in 'wet' year and velocity influenced detection in a 'drought' year. Catch data also supported evidence of population level responses to drought including changes in size structure and potential density reductions and variation in recovery time among reaches. No evidence supported that the closely related *Cambarus* species competitively exclude one another; however, size differences were observed between species and *C. halli* may limit their use of shoals in the presence of *C. englishi* which may have resulted in consistently low detection of *C. halli* in our study. In addition, depth having a strong influence on detection of *C. halli* and the observed inverse relation to substrate size between the *C. halli* and *C. englishi* may be evidence of habitat partitioning among these closely related species.

Knight II, John Richard. 2011. **Age, growth, home range, movement, and habitat selection of redeye bass (*Micropterus coosae*) from the middle Tallapoosa River tributaries (Alabama, USA)** (Master's thesis). Available: < https://etd.auburn.edu/bitstream/handle/10415/2473/Knight_john_May_11.pdf?sequence=2&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Redeye bass *Micropterus coosae* is a common, but underutilized sport fish resource in Alabama. This species is the most attractive of all the black basses, and has a reputation as a formidable catch on light tackle. Redeye bass are typically abundant in rivers and streams only navigable by canoes or kayaks. The purpose of this study was to determine age and growth, movement, home range, and habitat selection of redeye bass from the middle Tallapoosa Watershed, in Alabama.

Age and growth was determined using validated hard structures (otoliths). Additionally, alternative non-lethal structures (spines) were also investigated. Results indicated there were minimal differences in age assignment between structures when data were combined; however, variation was observed when individual age classes were examined. Spine aging tended to underestimate actual age, but this structure may be useful to gain a general understanding of age class structure if euthanasia is not desired. Differences in age and growth between tributary and mainstream resident redeye bass were not observed.

Movement, home range, and habitat selection were determined using radio telemetry methods. Proper tagging procedures were determined prior to initiation of this study. Redeye bass generally showed some evidence of site fidelity during hydrologically stable periods, but did not show fidelity during high flow periods. Movement rates were more variable for smaller redeye bass, while larger fish moved less. On average redeye bass moved 705 m during the ten weeks they were monitored.

Home range estimates were difficult to determine due to limited battery life of transmitters. Fifty percent (core) kernel density estimates were similar to what was reported for other black bass species. Ninety-five percent kernel density estimates were calculated, but this research lacked sufficient samples sizes to conclude any valid biological inferences. Future research should focus on tagging larger fish that can be tagged with larger transmitters to gain a better understanding of home range for the species.

Habitat research indicated that there appeared to be some intra-specific competition between redeye bass. Tagged fish were never associated with one another, and juvenile fish appear to occupy sub-optimal habitats. Results from habitat selection analysis indicated that the presence of canopy cover and interactions between specific variables were important predictor variables of redeye bass selection. Some differences were observed between adult and juvenile habitat selection. Adult fish selected locations with an interaction between interactions between relative depth and presence of instream features, interactions between boulders and canopy cover, and presence of instream features reduced distances to shore interactions. Juvenile fish also selected areas with increasing canopy cover, increasing relative depth, interactions between the presence of instream features and depth, and a complex interaction between boulder and sand substratum, that had increased depths. Results from this research will assist managers with gaining a greater understanding of life history requirements of redeye bass, and facilitate management of this potentially valuable fisheries resource.

Irwin, Elise R., K.M. Kennedy, T.C. Goar, B.M. Martin, and M.M. Martin. 2011. **Adaptive management and monitoring for restoration and faunal recolonization of Tallapoosa River shoal habitats**. Alabama Cooperative Fish and Wildlife Research Unit Report 2011-1, 49 pp. Available:< http://www.outdooralabama.com/sites/default/files/Tallapoosa%20Shoals%20Final%20Report.pdf>. Accessed December 11, 2017.

EXECUTIVE SUMMARY: The widespread fragmentation and alteration of riverine habitat by dams require management options that both address restoration and conservation of native aquatic biota and fisheries and increase knowledge of the relations between faunal processes and flow variability. Since 2005, flow management changes from R.L. Harris Dam on the Tallapoosa River, Alabama, have been implemented as part of an adaptive management project to determine optimal flows for multiple competing management objectives. The main objective of the current project was to evaluate the effects of these management flows on the recovery of shoal-dwelling species of greatest conservation need (GCN) and the persistence of functional shoal habitats in the Tallapoosa River.

Faunal sampling was conducted in spring (May-June) and fall (September-November) 2005-2009 using prepositioned area electrofishers (PAEs). Specific microhabitat variables (depth, velocity, percent vegetation, and substrata composition) were measured for each PAE sample. Index of biotic integrity (IBI) was calculated for spring and summer samples in each year for each site. Crayfish catch data were examined for differences in catch per effort, size distribution, and species composition for differences between regulated and unregulated sites using non-parametric K-S tests and paired t-tests.

Estimates of detection, occupancy, extinction, and colonization were calculated for fourteen selected fish species; estimates of detection and occupancy were calculated for all collected crayfish species. These estimates were calculated using maximum likelihood methods and modeled as a function of measured covariates using the logit link function. Competing models of species dynamics were compared using Akaike's information criterion (AIC).

To examine reproductive condition, a random subsample of fish from each shoal in each year were examined for presence of viable reproductive organs. Percent mature females was determined for each of nine species as an indicator of reproductive condition. To assess hatch date of Centrarchid sport fish, young-of-year (YOY) redbreast sunfish, spotted bass, and redeye bass were collected approximately 30, 60, and 90-days after the onset of spawning in 2005 and 2007, and daily ages and hatch dates were estimated from extracted otoliths. Hydrologic data from USGS gage stations were examined against hatch frequencies to determine optimal flow conditions for spawning and subsequent recruitment.

Overall, IBI values were lower among regulated sites; however, IBIs varied widely among sites, within and among river reaches, between seasons, and among years. Nine of the fourteen species examined for species occupancy dynamics had parameters that varied between regulated and unregulated sites. Two of the six GCN fish species, both darters, were apparently unaffected by the impact of Harris Dam; lipstick darter appeared to have a slight positive response to regulation. Occupancy estimates of the remaining three GCN

species suggested that these species are either in decline or absent altogether in the regulated reach below Harris Dam. For all crayfish species, detection was a function of habitat variables; vegetation and velocity affected detection positively, while depth had a negative effect on detection.

Proportion of mature female fish varied among years and sites. No mature largescale stoneroller *Campostoma oligolepis* females were observed at any sites or years. Mature female Tallapoosa shiners *Cyprinella gibbsi* and bullhead minnows *Pimephales vigilax* were observed in the unregulated reaches only. There were no significant differences in total length of YOY Centrarchids found among sites. Hatch dates of YOYs were not correlated to prolonged stable flow periods in 2005, but were correlated in 2007, when the majority of hatches occurred during or up to 3 days after periods of stable, low flows. Stable flow periods may provide for greater availability of suitable spawning and juvenile habitat which allows for recruitment to a stage and size where fish can withstand daily fluctuating discharges.

In general, our results indicated that the Tallapoosa River fish and crayfish assemblage varies considerably, not only between the regulated and unregulated river, but also within the unregulated reaches, both between seasons and among years. These results suggest that there is a natural level of variability that should be expected, and even perhaps managed for. Maximizing conservation potential in free-flowing sections of rivers of Alabama will require, at minimum, clear evidence of effects of regulated flow regimes on river biota. An adaptive management approach holds substantial promise for improving management of regulated rivers by allowing managers and scientists to address the uncertainty in predicting and measuring faunal response to flow alterations.

Early, Laurie Anne. 2012. **Hydro-peaking Impacts on Growth, Movement, Habitat Use and the Stress Response on Alabama Bass and Redeye Bass, in a Regulated Portion of the Tallapoosa River, Alabama** (Master's thesis). Available: < https://etd.auburn.edu/bitstream/handle/10415/3189/Earley_Thesis.pdf?sequence=2&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Altered flow regimes caused by dam construction and operation can affect aquatic organisms in a variety of ways. The Tallapoosa River, in east-central Alabama, has been extensively impounded for flood control, navigation in the Alabama River, hydropower and water supply. None the less, the river still supports an important sport fishery. There has been previous research on the Tallapoosa River studying fish community responses to the altered flow regime. However, there has been minimal work on sportfish, including the black bass found within the river system. The objective of this research was to investigate the impacts of the altered flow regime on growth, movement, habitat use and the stress response on Alabama Bass *Micropterus henshalli* and Redeye Bass *Micropterus coosae*.

Dams and altered flow regimes may impact growth of aquatic organisms. Using incremental growth techniques, annual growth of Alabama Bass and Redeye Bass in the Tallapoosa River was evaluated in response to variation in flow regime. Age was the best explanatory variable that described growth in all models, although flow variables were included in more than half the models. Growth was higher for age-1 fish in years with less flow variation; however, growth was similar among years for age-2 and age-3 fish. Overall growth rates for Alabama Bass and Redeye Bass were higher in the unregulated sites, than either regulated sites. Alabama Bass had higher growth rates than Redeye Bass at the Middle and Lower sites; however, growth was similar between species the upper site. From this study, it appeared that growth was not severely impacted by the altered flow regime.

Little is known about the movement and habitat use of Alabama Bass and Redeye Bass in the Tallapoosa River, specifically below R.L. Harris Dam, which operates as a hydropeaking facility. With the use of radio telemetry both species were tracked over 37 weeks to better understands movement and habitat use of these two species. Movement was strongly associated to season, with both species having the highest movement in the spring. No major difference was observed in movement based on the altered flow regime. However, shifts in habitat use were observed during the altered flows, which may be due to fish relocating to more suitable habitat or for better foraging.

Lastly, stressors, such as alteration in temperature, oxygen or hydrology, can induce acute or chronic stress, which in turn can impact the overall fitness of an organism. Cortisol response is a good indicator of acute stress and additional measurements of stress include leukocyte profiles, with neutrophils increasing and lymphocytes decreasing (N:L). The physiological stress response was studied in both Alabama Bass and Redeye Bass, to determine if the altered flow regime has any impact. Results showed that there is a trend for both baseline cortisol levels and N:L to be higher in the fish found at the disturbed location. Additionally, the percent change of cortisol was higher at the reference site. Results suggest that fish in the treatment site have an altered stress response that may be due to the non-natural flow regime.

Goar, Taconya Piper. 2013. **Effects of hydrologic variation and water temperatures on early growth and survival of selected age-0 fishes in the Tallapoosa River, Alabama** (Ph.D. dissertation). Available: < https://etd.auburn.edu/bitstream/handle/10415/3604/Taconya%20Goar_Dissertation_2013b.pdf?sequence=2&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Altered flow regimes resulting from the construction of hydropower dams can negatively affect aquatic organisms in a variety of ways. The effects of flow and temperature variation on early growth, survival, and hatching success were examined at regulated and unregulated sites in the Tallapoosa River, Alabama. Previous research on the Tallapoosa River has focused on community responses to altered flow regimes in adult populations. However, very little information exists on specific impacts and responses of fish in early life stages. The objectives of this study were to: 1) estimate daily incremental growth rate and back calculate hatch dates of age-0 Redbreast Sunfish *Lepomis auritus* 2) examine relations between average daily incremental growth rate and age, hydrology, temperature, site type (regulated or unregulated) and year; and 3) examine relations between hatch success and frequency and hydrology at regulated and unregulated sites in the Tallapoosa River; and 4) quantify the effects of fluctuating water flow and decreased water temperatures on early daily growth and survival of age-0 Channel Catfish *Ictalurus punctatus* and Alabama Bass *Micropterus henshalli* through a series of laboratory experiments.

Effects of hydrology on early growth and hatching success of age-0 Redbreast Sunfish were examined at regulated and unregulated sites in the Tallapoosa River. Average daily incremental growth techniques were used to back calculate daily incremental growth and estimate hatch dates and predict hatch success. Early growth was impacted by site type and year and hatching success was impacted by flow and temperature variables. Overall daily growth rate and incremental growth rate varied among years and was higher at regulated sites than unregulated sites. Model comparison indicated that the best overall model that described average daily incremental growth included: site type, age, year, the number of hours discharge was greater than 220 cms (FLOW1), the number of cumulative degree days, and the day of year that the growth increment occurred as independent variables. However, overall model fit was poor. Additional models, with flow and temperature variables excluded, were evaluated and compared with Akaike's Information Criterion (AICc). The best overall model included site type, age, and year as independent variables and explained 33% of the variation in average daily incremental growth rate. These results suggest flow and temperature regimes are important predictors of hatching success, and that early growth is impacted more by site type and year. The number of reversals, number of hours discharge was between 0 – 60 cms, number of cumulative degree days, and year were predictors of hatch success. Hatch frequency was higher and occurred earlier in unregulated sites compared to later hatching in regulated sections. Managing instream flows to provide periods of low-stable flows and temperatures should positively affect growth rates, increase hatching success, and increase subsequent recruitment of redbreast sunfish downstream of R. L. Harris Dam.

In experimental studies, results suggest that strong fluctuating flows and decreased water temperatures negatively affected daily growth rates and survival of age 0 Channel Catfish and Alabama Bass. Mortality was highest in treatments with decreased water temperatures. Daily growth rates were lower in treatments with decreased water temperatures. Older fish had higher daily growth rates and decreased mortality, and were not as susceptible to the negative effects of treatments. These data also suggest that growth and survival may be impacted more by fluctuations in temperature ($\Delta 10$ °C) versus flow variation. However, treatments with high flow also exhibited decreased growth and some mortality. Management efforts should consider both flow and temperatures regimes together in an effort to increase growth rates, survival, and increase subsequent recruitment of fish in regulated rivers.

Managers are encouraged to use models and conclusions described in this dissertation as part of their decision-making and objective-setting processes, in an adaptive management framework, to manage flow regimes in regulated rivers. Specifically, we recommend 1) thermal modification technologies at hydropeaking dams be investigated for suitability and feasibility; 2) instream flow management include thermal regimes and variation as part of management objectives; and 3) spawning and rearing windows continue to be employed, with evaluations on an annual basis, as a management tool to increase recruitment of fish in regulated rivers. The models and variables herein described should be continually improved upon and updated as more information is learned and uncertainty reduced. Additional data collection and experimentation is necessary to monitor fish populations and their response to the flow and temperature regimes in regulated rivers.

Sammons, Steven M. L.A. Early, and C.E. McKee. 2013. **Sportfish Dynamics in the Regulated Portion of the Tallapoosa River between Harris Dam and Lake Martin**, Alabama. Report to Alabama Department of Conservation and Natural Resources. F11AF00570 (AL F-40-40) Study 60.

EXECUTIVE SUMMARY: The Tallapoosa River, in east-central Alabama, has been extensively impounded for flood control, navigation in the Alabama River, hydropower and water supply. However, the river still supports an important sport fishery for species such as channel catfish, largemouth bass, redbreast sunfish, redeye bass, and Alabama bass. There has been previous research on the Tallapoosa River studying fish community responses to the altered flow regime, but there has been minimal work on sportfish, especially the black bass found within the river system. This study was conducted in the 79-km portion of the Tallapoosa River regulated by Harris Dam. The target species were the four principal sportfish species found in this section: Alabama bass *Micropterus henshalli*, channel catfish *Ictalurus punctatus*, redbreast sunfish *Lepomis auritus*, and redeye bass *M. coosae*. Our objectives were to (1) describe age and growth of the four target species and determine any impacts on these metrics by the altered flow regime, (2) examine behavior and habitat use of Alabama bass and redeye bass in response to altered flow regimes, (3) describe first-year dynamics of age-0 Alabama bass, redbreast sunfish, and redeye bass and determine influences of flow on hatch-date distribution and growth, and (4) develop a successful standardized sampling protocol for sampling the Tallapoosa River between Lake Martin and Harris Dam that can be used by ADCNR biologists in the future to monitor important sport fish populations.

<u>Age and Growth of the Four Target Species.</u> Anthropogenic factors such as dam construction and hydropower generation can dramatically alter the flow regime of rivers and may impact growth of aquatic organisms. Age and growth of Alabama bass *Micropterus henshalli*, redeye bass *Micropterus coosae*, channel catfish *Ictalurus punctatus*, and redbreast sunfish *Lepomis auritus* were described in the Tallapoosa River, Alabama. Fish were collected from Hillabee Creek and the Tallapoosa River above Harris Dam (unregulated areas) and at two sites downstream of the dam (regulated areas). Using incremental growth techniques and residual analysis, growth and recruitment of these species were evaluated across these areas in response to variation in flow regime. Flow variables were created for each growth year and recruitment year and the best model that described growth and recruitment of each species at each location was chosen using Akaike's Information Criterion. Additionally, growth increments at age 1, 2 and 3 were compared between a less variable flow year and one of a higher variation. Lastly, an analysis of covariance was used to compare growth rates of these species across the three sampling areas. Alabama bass and channel catfish were collected up to age 12, redeye bass up to age 8, and redbreast sunfish only up to age 5 during the study. Annual mortality of these species was relatively low, and approximated likely natural mortality values. Age was the best explanatory variable that described growth in all models, although flow variables were included in more than half the models for black bass. However, flow variation explained < 2% of the variation in growth in every instance. Growth of age-1 Alabama bass and redeye bass was higher in years with less flow variation; however, growth was similar among years for age-2 and age-3 fish. Growth of most species was highest in the middle area, which had the highest hydrologic variation. Recruitment of each species was relatively consistent over the time period examined in each area. Recruitment of Alabama bass and channel catfish was lower in years with high flow

variability in the unregulated portion of the Tallapoosa River, but was not affected by flows in the regulated areas. Recruitment of redeye bass was unaffected by hydrologic variation in any area, but the short lifespan of the species may have obscured any relationships. Overall, this study did not provide strong evidence that growth, mortality, or recruitment of any species was heavily influenced by flow.

Behavior and Habitat Use of Alabama Bass and Redeye Bass. Alabama bass *Micropterus henshalli* and redeye bass *Micropterus coosae*, are two native game fish in the state of Alabama, but little is known about the movement and habitat use of these species, especially in response to altered flow regimes resulting from hydropeaking operation. Therefore, 22 Alabama bass and 20 redeye bass were implanted with radio tags and tracked for 37 weeks, from December 2010 to September 2011 in the Tallapoosa River, Alabama, below R.L. Harris Dam, which operates as a hydropeaking facility. All fish were located regularly to describe seasonal patterns in movement and habitat use. Additionally, 8-9 fish were tracked weekly every 2 h over the course of 10 h to assess the effects of altered flows on movement and habitat use by the two species during different aspects of the hydrograph (base, rising, peak, and falling flows). Movement of both species was strongly associated to season, with the highest movement observed in the spring. Total home range (95%) and core areas (50%) of both species were similar; however, redeye bass total home range size decreased as fish size increased. Alabama bass were typically found in fine sediment substrates but increasingly used more woody debris for cover from winter to summer. Redeye bass were typically found in rocky substrate but less rocky cover and more woody debris in summer months. Both Alabama bass and redeye bass daily movement did not appear to be affected by the altered flow; however, Alabama bass were found closer to shore in vegetated or woody debris habitat during high flows in spring and summer, but farther away in rocky habitat during winter. In contrast, redeye bass showed little lateral movement in the river or change in habitat use in response to higher flows in most seasons, but, similar to Alabama bass, were found in shoreline vegetated habitats more often during high flows in spring. These shifts in habitat during different flows should be further investigated to evaluate possible consequences to overall fitness.

First-year Dynamics of Alabama Bass, Redeye Bass, and Redbreast Sunfish. In 2010-2011, age-0 black bass (309 Alabama bass and 216 redeye bass) and redbreast sunfish (N = 272) were collected from three areas in the Tallapoosa River, Alabama, to describe hatch-date distributions and daily incremental growth rates and determine if relative timing of hatching or growth was affected by altered flow regimes from Harris Dam. Across species and areas, black bass hatch dates ranged from April 5 to June 30 in 2010 and April 24 to June 19 in 2011. Mean hatch dates of these species were generally later in the upper, unregulated area than the lower regulated areas in 2010; timing was more variable among areas in 2011, but mean hatch dates were generally later in the middle area (closest to the dam) than the other areas. Successful hatching of all species generally occurred after water levels stabilized following large spates of water moving through the system; however, some spawning disruption was evident in all species in 2010, especially in the middle area. Flows were lower and more stable in 2011, and hatching distribution of all species was more consistent in all areas. Mean growth rates of black bass ranged from 0.51 to 0.92 mm/d across years and areas during the study; whereas, redbreast sunfish was slower, ranging from 0.40 to 0.62. Growth of Alabama bass was generally greater than redeye bass, and both were greater than redbreast sunfish. Results of this study found little evidence to support the theory that hydropeaking flows cause large spawning disruptions or affect first-year growth of these species; however this study was conducted in two years of below average precipitation and flows. Future research of spawning and recruitment of these species should be conducted in years with higher precipitation to more clearly define the effects of hydropeaking flows on first-year dynamics of sportfish in the Tallapoosa River.

Optimizing a Standardized Sampling Program for Sportfish in the Tallapoosa River. A two-year electrofishing study was initiated in a 79-km section of the Tallapoosa River to identify an optimal standardized sampling program for four principal resident sport fish: Alabama bass *Micropterus henshalli*, channel catfish *Ictalurus punctatus*, redbreast sunfish *Lepomis auritus*, and redeye bass *Micropterus coosae*. Fish were collected from four sites, which were grouped into two areas: Price Island and Wadley (Upper Area) and Germany Ferry and Horseshoe Bend (Lower Area). Samples were conducted in spring (May), summer (July), and fall (October) in 2010 and 2011. Two habitat types were sampled: shoal areas, characterized by large rock substrate and cover, shallow (< 1.5 m) water, and noticeably faster flows, and riverbank area, characterized by variable substrate, lower gradient, and abundant woody debris cover. Riverbank collections consisted of 1-h transects along the shoreline; whereas, shoal habitats were sampled using 2-3, 10-min transects conducted throughout the habitat. Sampling at Horseshoe Bend and Germany Ferry was conducted along two, 1-h riverbank transects and 3, 10-min shoal collections. Sampling at Wadley also consisted of two riverbank transects but only 2, 10-min shoal collections, due to limited habitat. Similarly, sampling at Price Island consisted of only one, 1-h riverbank transect and no shoal collections due to limited accessible habitat. 4 Also, the precision of 10-60-min electrofishing transect durations was evaluated using riverbank transects for estimating relative abundance of Alabama bass, redbreast sunfish, and redeye bass. The goal of this analysis was to optimize transect duration so that catch rates may be estimated precisely and with the least sample effort. A total of 1,240 Alabama bass, 172 channel catfish, 5,257 redbreast sunfish, and 187 redeye bass were collected during this study. Mean CPE across areas, seasons, and habitats ranged from 9.5-33.6 fish/h for Alabama bass, 0.1-8.3 fish/h for channel catfish, 28.7-139.6 fish/h for redbreast sunfish, and 0-2.2 fish/h for redeye bass. Little seasonal differences were observed in catch-per-effort (CPE) or size structure for any species, although few channel catfish were captured in spring. However, flows during both years of this study were low, due to below-average annual precipitation, thus in normal years spring sampling is likely to be less effective due to higher flows. Channel catfish CPE was higher in shoal habitat than riverbank habitat; whereas, the reverse was true for redeye bass. Otherwise, little differences in CPE or size structure were observed among habitats. The CPE of Alabama bass ≥ 300 mm total length (TL) was higher in the upper area than the lower area; whereas, overall CPE of channel catfish was higher in the lower area in summer and fall, which also appeared to have more channel catfish > 400 mm TL. However, overall CPE of all species other channel catfish was similar between areas. Body condition of most species was higher in spring than the other seasons, and was generally similar among areas. Mean CPE of Alabama bass, redbreast sunfish, and redeye bass in riverbank transects was independent of transect duration. The variation in CPE among samples of equal duration increased as CPE and transect duration decreased for all three species, resulting in the need for more samples, especially at higher CPEs. The total effort (i.e., time spent electrofishing and processing fish) needed to estimate a mean CPE with a specified precision was a function of transect duration and CPE. More effort was needed as CPE decreased for most species, but the relation between transect duration and total effort was parabolic, especially at higher CPEs for Alabama bass and lower CPEs for redbreast sunfish. A precision of within 10% of the mean CPE was unattainable for most species due to space and logistic considerations. Based on the results of this study, it appears that fall is the optimal time to sample this section of the Tallapoosa River, which is historically the time of the lowest flows in southeastern rivers. Based on the results of the sample size portion of this study, the optimal transect duration for monitoring mean CPE of Alabama bass, redbreast sunfish, and redeye bass is likely 10 min. At a precision level of 20% of the mean, the number of 10-min transects required ranged from 5-40, with a total sample time for each individual species of 0.82-7.16 h. However, because all species would likely be collected simultaneously, the overall sample protocol should likely be a maximum of 40 riverbank transects of 10 min duration. This will result in an estimated total sample time on the water of approximately 12 h. Shoal habitat may be omitted from standardized sampling due to the limited amount of this habitat, and the lack of differences observed in population metrics between habitats. Likewise, channel catfish CPE and size structure is unlikely to be reliably estimated using this protocol, due to the low CPE and specific habitat preferences of this species.

Gerken, Clark N. 2015. **A Hook and Line Assessment and Angler Survey of the Tallapoosa River Fishery (Alabama, USA)** (Master's thesis). Available: < https://etd.auburn.edu/bitstream/handle/10415/4925/GerkenThesisThree.pdf?sequence=2&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Angler satisfaction is one of many fundamental objectives in the adaptive evaluation of flow prescriptions below R. L. Harris Dam on the Tallapoosa River in Alabama. We have collected fishery specific information to inform future management decisions related to flow regimes. Quantification of the fishery resource below R.L. Harris Dam was conducted using hook and line sampling from canoes and kayaks by multiple anglers during several seasons and three years and over a range of flow conditions. This allowed for an assessment of conditions that may have influenced angler catch statistics in the river. Regulated and unregulated reaches of the river were fished by 2-4 anglers during three different seasons: spring, summer and fall (2013 and 2014). Angling was conducted during different water conditions including river hydrology, water temperature, and weather conditions. Small spinner baits were trolled behind the boats in an attempt to present lures to most species of sport fish (i.e., *Micropterus spp*., *Lepomis spp*., *Morone spp*. and *Ictalurus punctatus*). We recorded each capture encounter in the river during each sampling trip; individual fish were weighed and measured and harvest-per-unit-effort (# fish/angler hour) was calculated by species and by angler. Water temperature was recorded at beginning of sampling trips using a thermometer. Hydrologic data were collected from USGS gages and various metrics were summarized for the angling days. Stepwise multiple regression models were constructed to evaluate impacts of environmental and physical variables on angler catch. Results indicated that water temperature was positively correlated with harvest-per-unit-effort at all study sites and discharge was negatively correlated. The unregulated reach above the dam had the most diverse catch consisting of eight species. Catch rates varied among seasons and river reach; highest catch rates were observed in the spring in the middle reach below Harris Dam (4.21 fish/h); whereas, the lowest catch rates were also observed in the spring at the site most downstream from the dam (0.38 fish/h).

A mail survey was used to quantify Tallapoosa River angler demographics, preferences and desired fishing conditions. The mail survey was sent to 2000 fishing license holders in counties surrounding the Tallapoosa River between the Georgia state line and Lake Martin, Alabama. An online survey was also available for those anglers who did not receive a mail survey. Signs were posted at access points along the river with instructions for anglers to take the online survey.

Surveyed anglers targeted catfishes and black basses; 55% of the survey respondents were satisfied with the catch rates that averaged 2.04 fish per hour. The average angler was an older white male. Anglers would like to have more days where the river was more suitable to boating. Fishing the Tallapoosa River was an important tradition to the participants in the survey; they do it to be outdoors, to enjoy nature, and for relaxation. Time, lack of access, and unknown water flow conditions were top reasons for not fishing on the Tallapoosa River.

The results of both the fishery independent and angler survey for this river will help inform decisions related to management of the fishery and toward maintaining or increasing angler satisfaction. The models constructed can assist anglers to decide the river conditions and seasons for targeting certain species. Results from this study indicate that temperature and flow from R.L. Harris dam may influence recreation and angler satisfaction on the river.

Kennedy, Kathryn Dawn Mickett. 2015. **Quantitative methods for integrating instream biological monitoring data into aquatic natural resource management decision making** (Ph.D. dissertation). Available: < https://etd.auburn.edu/bitstream/handle/10415/4496/Kennedy_Dissertation_final.pdf?sequence=2&isAllowed=y>. Accessed December 11, 2017.

ABSTRACT: Freshwater aquatic resource management is fraught with challenges, as managers of multiple-use, highly diverse systems must frequently make management decisions with limitations including unclear management objectives and inadequate knowledge of system state and response. In this dissertation, I present three different freshwater aquatic resource management problems and examine the application of quantitative methods to address specific limitations in each.

The first management context was a small wildlife refuge faced with making land use decisions that consider impacts to aquatic resource objectives. I examined hypotheses relating fish species occupancy to land use using multiple model comparison. Four species – striped shiner *Luxilus chrysocephalus*, redbreast sunfish *Lepomis auritus*, orangespotted sunfish *L. humilis*, and longear sunfish *L. megalotis* – had strong support for land use as a predictor of occupancy. However, only orangespotted sunfish had an estimated occupancy probability that was predicted to decrease with increasing urban and agricultural land use. Results suggest both the dominance of a mainstem reservoir in defining patterns of fish species distribution and the tolerance to urban and agricultural land use of most encountered species.

The second management context was a hydropower-regulated river in which an adaptive management program has been initiated. Also using multiple model comparison, I examined patterns of fish species occupancy to evaluate the potential response to an

implemented management action and to inform the next adaptive management iteration. Nine of 13 fish species had distributions that reflected downstream impacts of the hydropower dam. Model results for three species – two minnows and one darter – indicated a potential positive response to management action, whereas up to five species – largescale stoneroller *Campostoma oligolepis*, Alabama hogsucker *Hypentelium etowanum*, speckled madtom *Noturus leptacanthus*, redbreast sunfish Lepomis auritus, and muscadine darter *Percina smithvanizi* – demonstrated potential negative responses. I hypothesize that an altered thermal regime may be inhibiting occupancy of several fish species, and recommend that the next iteration of adaptive management focus on thermal restoration.

The final management context considered statewide management of aquatic resources. In many states, established biomonitoring programs are expected to inform decision making. However, use of these data is often restricted to site classification decisions. To facilitate broader use, I provide a general framework to incorporate the index of biotic integrity (IBI), a widely used multi-metric index, into aquatic resource management decision making. I demonstrate use of the framework for a specific decision context wherein the IBI provides a basis for informing the selection of instream flow management alternatives that meet defined objectives of a state resource agency.

Data collected as part of a freshwater monitoring program may be used to inform and support management decision making by adding to our knowledge of system state and of system response to management actions. However, the most successful freshwater aquatic resource management program will include explicit definition of management objectives and hypotheses of system response, a monitoring plan linked directly these objectives and hypotheses, and a flexible management framework, such as adaptive management, that allows for the integration of monitoring data to update hypotheses and improve future management decision making.

Irwin, E.R. and T.P. Goar. 2015. **Spatial and temporal variation in recruitment and growth of Channel Catfish Alabama bass and Tallapoosa Bass in the Tallapoosa River and associated tributaries**. U.S. Department of Interior, Fish and Wildlife Service, Cooperator Science Series FWS/CSS -116, Washington, D.C.

ABSTRACT: Effects of hydrology on growth and hatching success of age-0 black basses and Channel Catfish were examined in regulated and unregulated reaches of the Tallapoosa River, Alabama. Species of the family Centrarchidae, *Ictalurus punctatus* Channel Catfish and *Pylodictis olivaris* Flathead Catfish were also collected from multiple tributaries in the basin. Fish were collected from 2010-2014 and were assigned daily ages using otoliths. Hatch dates of individuals of three species (*Micropterus henshalli* Alabama Bass, *M. tallapoosae* Tallapoosa Bass and Channel Catfish) were back calculated, and growth histories were estimated every 5 d post hatch from otolith sections using incremental growth analysis. Hatch dates and incremental growth were related to hydrologic and temperature metrics from environmental data collected during the same time periods. Hatch dates at the regulated sites were related to and typically occurred during periods with low and stable flow conditions; however, no clear relations between hatch and thermal or flow metrics were evident for the unregulated sites. Some fish hatched during unsuitable thermal conditions at the regulated site suggesting that some fish may recruit from unregulated tributaries. Ages and growth rates of age-0 black basses ranged from 105 to 131 d and 0.53 to 1.33 mm/day at the regulated sites and 44 to 128 d and 0.44

to 0.96 mm/d at the unregulated sites. In general, growth was highest among age-0 fish from the regulated sites, consistent with findings of other studies. Mortality of age-0 to age-1 fish was also variable among years and between sites and with the exception of one year, was lower at regulated sites. Multiple and single regression models of incremental growth versus age, discharge, and temperature metrics were evaluated with Akaike's Information Criterion (AICc) to assess models that best described growth parameters. Of the models evaluated, the best overall models predicted that daily incremental growth was positively related to low flow parameters and negatively related to the number of times the hydrograph changed direction (e.g., reversals). These results suggest that specific flow and temperature criteria provided from the dam could potentially enhance growth and hatch success of these important sport fish species.

Kosnicki, Ely, K. Ouellette, C. Lloyd, and E. Irwin. 2017. **Harris AMP Invertebrate Analysis Summary Report 2016**. Unpublished Report by Alabama Cooperative Fish and Wildlife Research Unit.

INTRODUCTION: Benthic macroinvertebrates are excellent biological monitoring units because they are diverse, easy to sample, their taxonomy and life-histories traits are well known, and they respond to a wide range of environmental impacts and disturbances (Metcalfe 1989; Barbour et al. 1999; Wright et al. 2000; Poff et al. 2006; Merritt et al. 2008). As the term "benthic" implies, they are generally relegated to the stream bottom from which they are sampled and although mobility exists in the form of drifting downstream, few species have significant dispersal capabilities in their immature phases. Thus, benthic macroinvertebrates communities are affected by acute as well as chronic disturbances, opposed to fishes which have the ability to swim to a refuge and return after an acute disturbance has subsided.

Macroinvertebrate life histories are directly linked to temperature thresholds (Vannote and Sweeney, 1980; Sweeney, 1984; Ward, 1992; Williams and Feltmate, 1992; Kosnicki and Burian 2003; Kosnicki and Sites 2011). Furthermore, community structures are greatly influenced by hydrological regimes (McElravy et al., 1989; Power et al. 1995; Hart and Finelli 1999; Bunn and Arthington 2002). Therefore, macroinvertebrate communities should show profound demarcations between regulated and non-regulated reaches in the Tallapoosa River basin.

The objective of this analysis is to explore the utility of using macroinvertebrate community characterization from regulated and unregulated reaches in the Tallapoosa River basin to provide 1) inference regarding the impacts of river regulation on macroinvertebrate assemblages and 2) identify measurable attributes (e.g., community similarity indices; presence-absence of specific taxa) that could be useful in determining "success" of prescribed flow and temperature changes at the dam. Surber samples taken from reaches of the Harris Dam project and provide some recommendations for research going forward. To meet project goals we needed to: 1) provide a standard operating procedure for efficiently processing Surber samples; 2) characterize the taxonomic assemblages from regulated and non-regulated reaches; 3) identify a suitable number of Surber samples necessary to quantify macroinvertebrate communities; 4) examine the utility of a suite of macroinvertebrate metrics for identifying differences between regulated and non-regulated reaches; 5) perform gradient analysis of metrics with distance from dam; and 6) give some recommendations for processing and analysis of the remaining samples.

Lloyd, M. Clint, Q. Lai, S. Sammons, and E. Irwin. 2017. **Experimental stocking of sport fish in the regulated Tallapoosa River to determine critical periods for recruitment**. U.S. Department of Interior, Fish and Wildlife Service, Cooperator Science Series FWS/CSS-128-2017, Washington, D.C.

ABSTRACT: The stocking of fish in riverine systems to re-establish stocks for conservation and management appears limited to a few species and often occurs in reaches impacted by impoundments. Stocking of sport fish species such as centrarchids and ictalurids is often restricted to lentic environments, although stocking in lotic environments is feasible with variable success. R. L. Harris Dam on the Tallapoosa River, Alabama is the newest and uppermost dam facility on the river (operating since 1983); flows from the dam have been managed adaptively for multiple stakeholder objectives since 2005. One of the stakeholders' primary objectives is to provide quality sport fisheries in the Tallapoosa River in the managed area below the dam. Historically, ictalurids and cyprinids dominated the river above Lake Martin. However, investigations after Harris Dam closed have detected a shift in community structure to domination by centrarchids. Flow management (termed the Green Plan) has been occurring since March 2005; however, sport fish populations as measured by recruitment of age-1 sport fishes below the dam has not responded adequately to flow management. The objectives of this research were to: (1) determine if stocking Channel Catfish *Ictalurus punctatus* and Redbreast Sunfish *Lepomis auritus* influences year-class strength; (2) estimate vital rates (i.e. growth, mortality, and recruitment) for Channel Catfish populations for use in an age-based population model; and (3) identify age-specific survivorship and fecundity rates contributing to Channel Catfish population stability. No marked Redbreast Sunfish were recaptured due to poor marking efficacy and therefore no further analysis was conducted with this species. Stocked Channel Catfish, similarly, were not recaptured, leaving reasons for non-recapture unknown. Matrix models exploring vital rates illustrated survival to age-1 for Channel Catfish to be less than 0.03% and that survival through ages 2 – 4 had equal contribution to overall population growth, indicating recruitment limitation may impact population size and stability. Results from this study indicate stock enhancement of sport fish populations below Harris Dam may not be an effective management technique at this time.

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Appendix A

Green Plan

R L HARRIS RELEASE CRITERIA – *Effective March 1, 2005*

1. Daily Release Schedule
    a. The required Daily Volume Release will be at least 75% of the prior day's flow at the USGS Heflin Gauge.
    b. In the event that the Heflin Gauge is not in service, the required Daily Volume Release will be at least one-fourth of the previous day's inflow into R L Harris Reservoir.
    c. The Daily Volume Release will not to be below 100 DSF.
    d. Operations to ensure that flows at Wadley remain above the 45 cfs minimum mark shall continue.
    e. The required Daily Volume Release will be suspended if R L Harris is engaged in flood control operations.
    f. The required Daily Volume Release will be suspended if it jeopardizes the ability to fill R L Harris.
2. Hourly Release Schedule
    a. If less than two machine hours are scheduled for a given day, then the generation will be scheduled as follows:
        i. One-fourth of the generation will be scheduled at 6 AM.
        ii. One-fourth of the generation will be scheduled at 12 Noon.
        iii. One-half of the generation will be scheduled for the peak load.
        iv. If the peak load is during the morning, one-fourth of the generation will be scheduled at 6 PM.
    b. If two to four machine hours are scheduled for a given day, then generation will be scheduled as follows:
        i. Thirty minutes of generation will be scheduled at 6 AM.
        ii. Thirty minutes of generation will be scheduled at 12 Noon.
        iii. The remaining generation will be scheduled for the peak load.
        iv. If the peak load is during the morning, thirty minutes of the generation will be scheduled at 6 PM.
3. Two Unit Operation
    a. On the average, there will be more than 30 minutes between the start times between the two units.
    b. Two units may come online with less than 30 minute difference in their start times if there is a system emergency need.
4. Spawning Windows

    Spring and Fall spawning windows will scheduled as conditions permit. The operational criteria during spawning windows will supersede the above criteria.

R L Harris Release Criteria – *Effective March 1, 2005*

1. Daily Release Schedule

   a. The required Daily Volume Release will be at least 75% of the prior day's flow at the USGS Heflin Gauge.

   b. In the event that the Heflin Gauge is not in service, the required Daily Volume Release will be at least one-fourth of the previous day's inflow into R L Harris Reservoir.

   c. The Daily Volume Release will not to be below 100 DSF.

   d. Operations to ensure that flows at Wadley remain above the 45 cfs minimum mark shall continue.

   e. The required Daily Volume Release will be suspended if R L Harris is engaged in flood control operations.

   f. The required Daily Volume Release will be suspended if it jeopardizes the ability to fill R L Harris.

Drought 2007-2008 R L Harris Release Criteria

a. If the flows at Wadley are at or above 100 cfs, there will be one pulse per day, which will result in a Daily Volume Release of approximately 50 DSF.

b. The flows at Wadley will not be lower than the flows at Heflin.

R L HARRIS MINIMUM FLOW PROCEDURE

STEP 1: CREATE SCHEDULE BASED ON PRIOR DAY'S HEFLIN FLOW

Prior Day's Heflin Flow (DSF)	Generation At 6 AM	Generation At 12 Noon	Generation As System Needs	Total Machine Time	R L Harris Total Disch (DSF)
0 < HEFLIN Q < 150	10 MIN	10 MIN	10 MIN	30 MIN	133
150 < HEFLIN Q < 300	15 MIN	15 MIN	30 MIN	1 HR	267
300 < HEFLIN Q < 600	30 MIN	30 MIN	1 HR	2 HRS	533
600 < HEFLIN Q < 900	30 MIN	30 MIN	2 HRS	3 HRS	800
900 < HEFLIN Q	30 MIN	30 MIN	3 HRS	4 HRS	1,067

STEP 2: ADD ADDITIONAL PEAK GENERATION AS NEEDED

STEP 3: ADJUST SCHEDULE IF NECESSARY

TOTAL SCH GENERATION	Generation At 6 AM	Generation At 12 Noon	Generation As System Needs	Total Machine Time	R L Harris Total Disch (DSF)
IF GENERATION = 1 MACH HR	15 MIN	15 MIN	30 MIN	1 HR	267
IF GENERATION = 2 MACH HRS	30 MIN	30 MIN	1 HR	2 HRS	533
IF GENERATION = 3 MACH HRS	30 MIN	30 MIN	2 HRS	3 HRS	800
IF GENERATION = 4 MACH HRS	30 MIN	30 MIN	3 HRS	4 HRS	1,067
IF GENERATION = 5+ MACH HRS			ALL		

NOTES

1. SCHEDULING OF GENERATION DOES NOT PRECLUDE THE ADDITION OF GENERATION AT ANY TIME.
2. ALL START TIMES ARE APPROXIMATE.
3. WHEN PULSING, IF THE SYSTEM DOES NOT DICTATE GENERATION DURING THE PM, A PULSE WILL BE SCHEDULED AT 6 PM.
4. R L HARRIS MIN FLOW PROCEDURE WILL BE SUSPENDED DURING ANY OF THE FOLLOWING CONDITIONS:
   - A) TALLAPOOSA RIVER HAS BEEN PLACED UNDER FLOOD CONTROL OPERATIONS.
   - B) FISH SPAWNING OPERATIONS HAVE BEEN SCHEDULED.
   - C) APC HAS DECLARED THAT CONDITIONS EXIST THAT THREATEN THE SPRING FILLING OF R L HARRIS RESERVOIR.

Appendix B

January 31, 2018 Presentation
Adaptive Management of Downstream Flows

Appendix E

R.L. Harris Dam Relicensing
FERC No. 2628

Adaptive Management of Downstream Flows

January 31, 2018
Stakeholder Informational Meeting

Agenda

- Harris Project Overview
- Harris Original License History
- Harris Adaptive Management Timeline

R.L. Harris Project Overview

Alabama Power

Alabama Power Company's Hydroelectric Developments

14 Developments

Warrior River

Coosa River

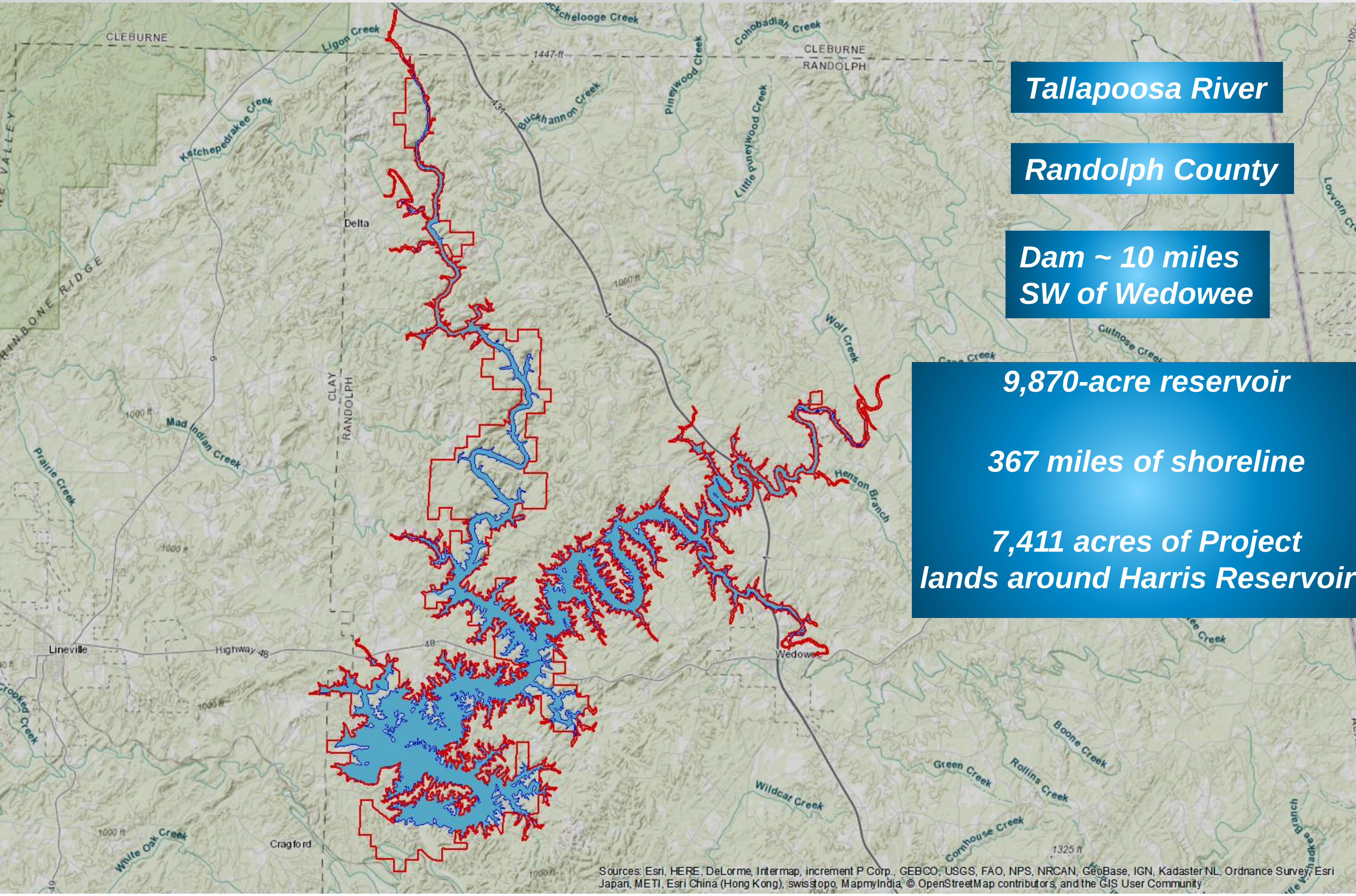
Tallapoosa River

Generation – 1,600 MW
Project Waters – 155,700 Acres
Project Lands – 119,500 Acres
Shoreline – 3,100 Miles
River Miles – 430 Miles
*All numbers approximate

Harris Project Overview

HARRIS DAM RELICENSING

Appendix E



Tallapoosa River

Randolph County

Dam ~ 10 miles SW of Wedowee

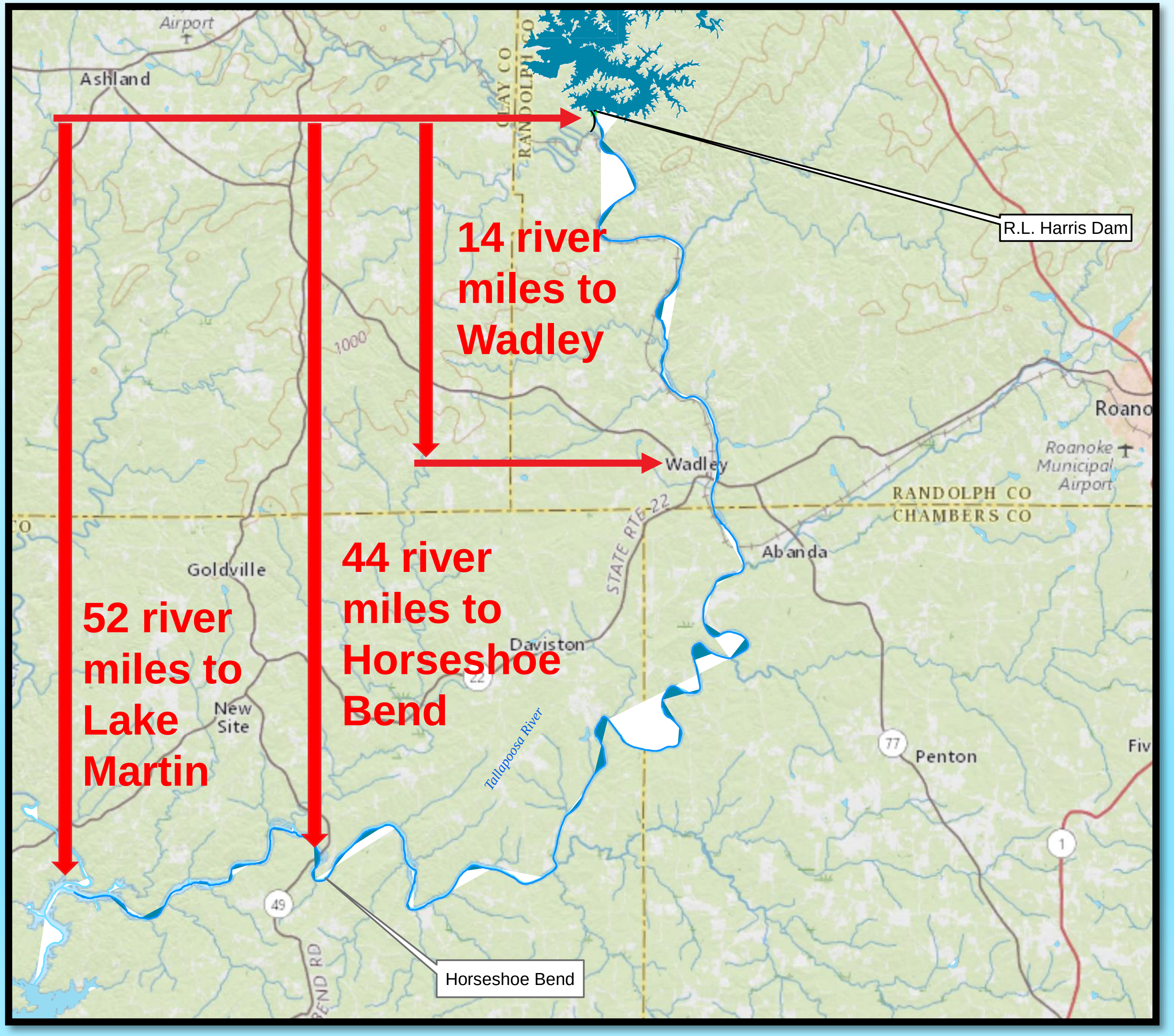
9,870-acre reservoir

367 miles of shoreline

7,411 acres of Project lands around Harris Reservoir

Distances

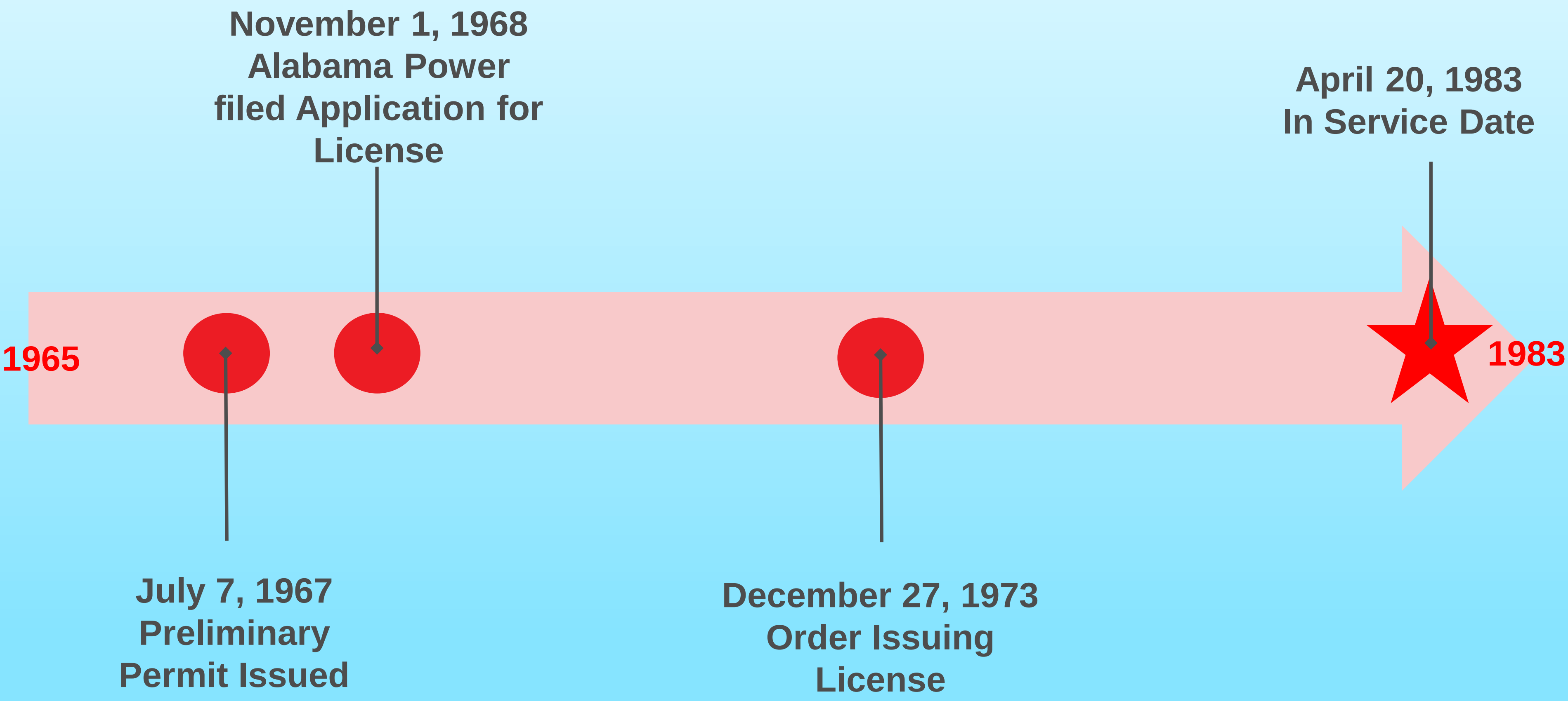
Appendix E



License Timeline

Harris Original License Timeline

Appendix E



Order Issuing License – December 27, 1973

Appendix E

In another issue relating to reservoir operating procedures, three agencies, the Environmental Protection Agency, the Alabama Department of Conservation and Natural Resources, and the U.S. Army Corps of Engineers, in letters to the Commission made inquiries and recommendations concerning the need to maintain adequate river flows. In addition, the Alabama Water Improvement Commission (AWIC) requested certain license conditions to insure that the construction and operation of the project would not contravene State water standards and recommended that a minimum continuous flow in the Tallapoosa River at the Wadley Gage be not less than 45 cfs. The AWIC water quality certificate issued to the Company included a provision for maintenance of this amount of flow. The Company has agreed to a minimum continuous flow of 45 cfs. We are requiring a minimum continuous flow of 45 cfs as measured at the Wadley Gage located several miles below the proposed dam.

Revised Exhibit S

1973 – 1980
Filing Extensions

March 1980
Alabama Power filed Revised Exhibit S

March 1981
Agency Comments filed

October 1981
FPC requests Alabama Power file revision

April 1982
Alabama Power submits for approval of a revised Exhibit S

September 1984
FPC issues order conditionally approving Revised Exhibit S

Adaptive Management Timeline 1998 - 2004

Alabama Power

Timeline: 1998 - 2004

Appendix E

Talks Begin

ADCNR and Alabama Power begin discussions about downstream flows

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

Timeline: 1998 - 2004

Appendix E

Talks Begin
ADCNR and Alabama Power begin discussions about downstream flows

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

USFWS Letter
Lays out perspective on outstanding minimum flow issues

Initial Discussions

- Re-regulation dams
- Geotubes
- House turbine
- Spillway gate modifications
- Pulsing operations

Timeline: 1998 - 2004

Talks Begin
ADCNR and Alabama Power begin discussions about downstream flows

Wadley Meeting
Over 100 attendees

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

USFWS Letter
Lays out perspective on outstanding minimum flow issues

Public Meeting on August 8, 2000

Appendix E

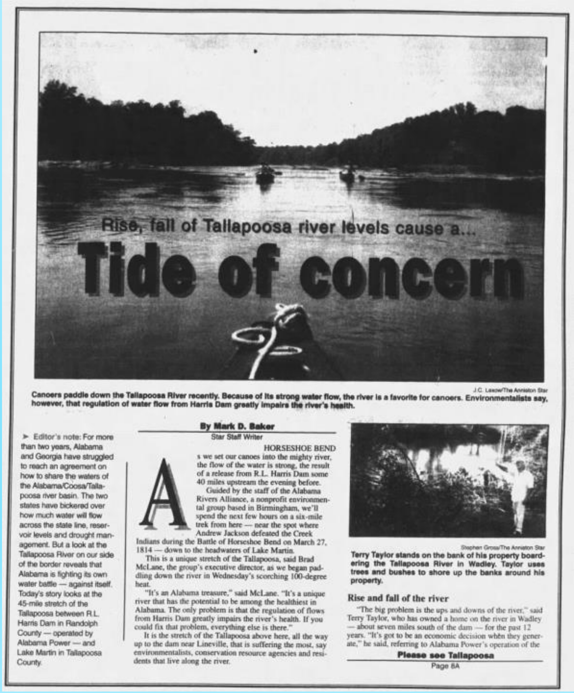
- Organized and facilitated by ADCNR
- FERC attended – encouraged collaboration
- Elise Irwin (ALCFWRU) presented Adaptive Flow Management concept.
- APC presented proposal for building a re-regulation dam within a seven-mile stretch below Harris Dam.

PUBLIC NOTICE OF
TALLAPOOSA RIVER FLOW MEETING

A public meeting concerning flows in the Tallapoosa River below R. L. Harris Dam will be held on August 8th, 2000 at 7:00 p.m. in the Braseal Auditorium on the campus of Southern Union Community College, Wadley, Alabama. Representatives from the Alabama Department of Conservation and Natural Resources, Alabama Power Company and the United States Fish and Wildlife Service will be present to discuss Tallapoosa River flow issues below R. L. Harris Dam and the process that will be used to resolve these issues. All interested stakeholders are invited and will be given an opportunity to express their concerns.

For further information contact
The District II Fisheries Office at 256-831-6860.

Anniston Star August 20, 2000



J.C. Leeow/The Anniston Star

Canoers paddle down the Tallapoosa River recently. Because of its strong water flow, the river is a favorite for canoers. Environmentalists say, however, that regulation of water flow from Harris Dam greatly impairs the river's health.

➤ Editor's note: For more than two years, Alabama and Georgia have struggled to reach an agreement on how to share the waters of the Alabama/Coosa/Tallapoosa river basin. The two states have bickered over how much water will flow across the state line, reservoir levels and drought management. But a look at the Tallapoosa River on our side of the border reveals that Alabama is fighting its own water battle — against itself. Today's story looks at the 45-mile stretch of the Tallapoosa between R.L. Harris Dam in Randolph County — operated by Alabama Power — and Lake Martin in Tallapoosa County.

By Mark D. Baker
Star Staff Writer

HORSESHOE BEND

As we set our canoes into the mighty river, the flow of the water is strong, the result of a release from R.L. Harris Dam some 40 miles upstream the evening before.

Guided by the staff of the Alabama Rivers Alliance, a nonprofit environmental group based in Birmingham, we'll spend the next few hours on a six-mile trek from here — near the spot where Andrew Jackson defeated the Creek Indians during the Battle of Horseshoe Bend on March 27, 1814 — down to the headwaters of Lake Martin.

This is a unique stretch of the Tallapoosa, said Brad McLane, the group's executive director, as we began paddling down the river in Wednesday's scorching 100-degree heat.

"It's an Alabama treasure," said McLane. "It's a unique river that has the potential to be among the healthiest in Alabama. The only problem is that the regulation of flows from Harris Dam greatly impairs the river's health. If you could fix that problem, everything else is there."

It is the stretch of the Tallapoosa above here, all the way up to the dam near Lineville, that is suffering the most, say environmentalists, conservation resource agencies and residents that live along the river.

Stephen Gross/The Anniston Star

Terry Taylor stands on the bank of his property boardering the Tallapoosa River in Wadley. Taylor uses trees and bushes to shore up the banks around his property.

Rise and fall of the river

"The big problem is the ups and downs of the river," said Terry Taylor, who has owned a home on the river in Wadley — about seven miles south of the dam — for the past 12 years. "It's got to be an economic decision when they generate," he said, referring to Alabama Power's operation of the

Please see Tallapoosa
Page 8A

Timeline: 1998 - 2004

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

Talks Begin (1998)
ADCNR and Alabama Power begin discussions about downstream flows

USFWS Letter (1999)
Lays out perspective on outstanding minimum flow issues

Wadley Meeting (2000)
Over 100 attendees

Journal Article (2002)
Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, U.S.A

Conservation Biology – February 2002 (Vol. 11, No. 1)

Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, U.S.A.

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†Patuxent Wildlife Research Center, U.S. Geological Survey, University of Georgia, Athens, GA 30602, U.S.A.

- Low fish abundance and diversity
- Low mussel species richness
- Caused by
  - Depleted low flow – limits habitat suitability
  - Flow instability – reduces reproductive success and recruitment
  - Thermal regime alteration – delays spawning, reduces hatching success and slows larval development

Adaptive Management Process

1. Develop and agree to management objectives

2. Model hypothesized relations between dam operations and management objectives

3. Implement changes in dam operations

4. Evaluate biological responses and other stakeholder benefits

Timeline: 1998 - 2005

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

Talks Begin (1998)
ADCNR and Alabama Power begin discussions about downstream flows

USFWS Letter (1999)
Lays out perspective on outstanding minimum flow issues

Wadley Meeting (2000)
Over 100 attendees

Journal Article (2002)
Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, U.S.A

Auburn Workshop (2003)
44 individuals from 21 organizations

2003 Workshop Participants

AL Dept. Conservation & Natural Resources

AL Coop. Fish and Wildlife Research Unit

Alabama Power Company

Alabama Rivers Alliance

Coalition of Associations at Lake Martin

Conservation Unlimited

Emerald Triangle Commission

Environmental Insight

Federal Energy Regulatory Commission

GA Coop. Fish and Wildlife Research Unit

GA Department of Natural Resources

Lake Wedowee Property Owners Association

Mobile Bay Watch

Mobile Register

OK Coop. Fish and Wildlife Research Unit

Randolph County Commission

Tennessee Valley Authority

University of Georgia

Upper Tallapoosa Watershed Committee

United States Fish and Wildlife Service

United States Geological Survey

2003 Workshop Topics

Maximize

- Economic development
- Diversity of flora and fauna
- Reservoir water levels
- Water quality in reservoir and downstream
- Boating and angling opportunities
- Operational flexibility

Minimize

- Downstream bank erosion
- River fragmentation
- Cost to APC
- Consumptive uses

Timeline: 1998 - 2005

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

1998 – Talks Begin
ADCNR and Alabama Power begin discussions about downstream flows

1999 – USFWS Letter
Lays out perspective on outstanding minimum flow issues

2000 – Wadley Meeting
Over 100 attendees

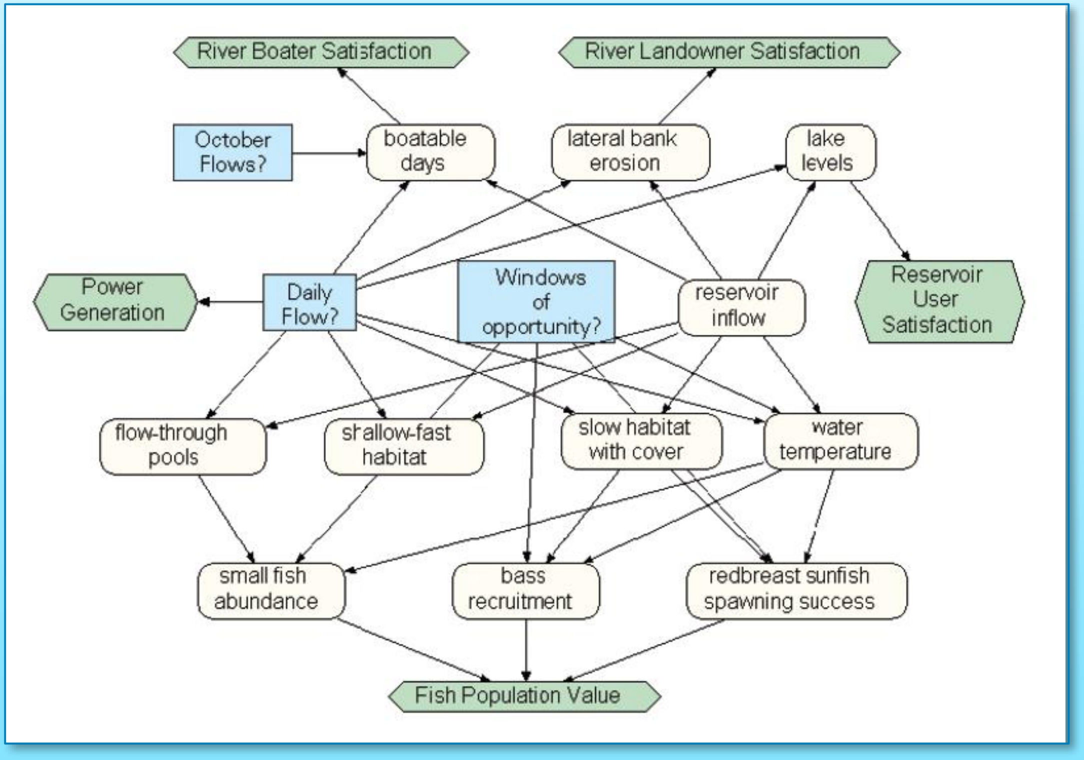
2002 – Journal Article
Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, U.S.A

2003 – Auburn Workshop
44 individuals from 21 organizations

Stakeholder Meetings
May, June, August, & November

2003 Stakeholder Meetings

- Continuous Minimum flows
- Re-regulation Dams
- Geotubes
- House Turbine
- Models/NETICA
- Model components



Timeline: 1998 - 2005

1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004

Talks Begin (1998)
ADCNR and Alabama Power begin discussions about downstream flows

USFWS Letter (1999)
Lays out perspective on outstanding minimum flow issues

Wadley Meeting (2000)
Over 100 attendees

Journal Article (2002)
Proposal for Adaptive Management to Conserve Biotic Integrity in a Regulated Segment of the Tallapoosa River, Alabama, U.S.A

Auburn Workshop (2003)
44 individuals from 21 organizations

Stakeholder Meetings
May, June, August, & November

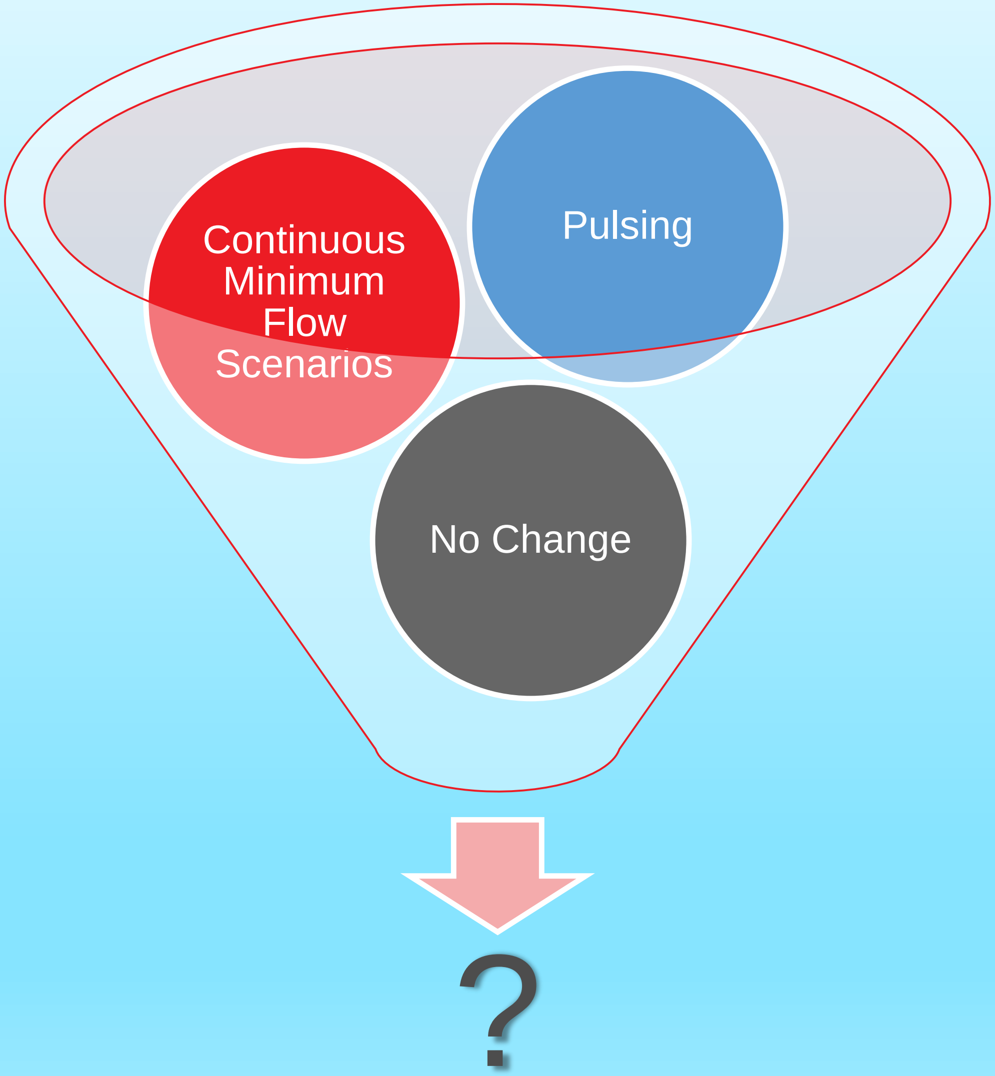
Stakeholder Meeting (2004)
December

December 2004 Stakeholder Meeting

- Alabama Power presents activities since November 1, 2003

Item Evaluated	Outcome
Trash Gate Modifications	Not capable of passing less than 500 cfs
Penstock Drain System	Insufficient space for piping and valves.
Penetration Through Headworks Structure	Not possible due to location of concrete piers and construction joints.
East Non-Overflow Structure Siphon	Not possible to west. Possible to east. Could deliver 150 cfs via 4-ft pipe; but had significant financial implications
Geotubes & Re-regulation dam(s)	Ruled out due to stakeholder opposition and lack of benefits to resources

Ongoing Discussions



Adaptive Management Timeline 2005 - 2010

Alabama Power

Timeline

Appendix E

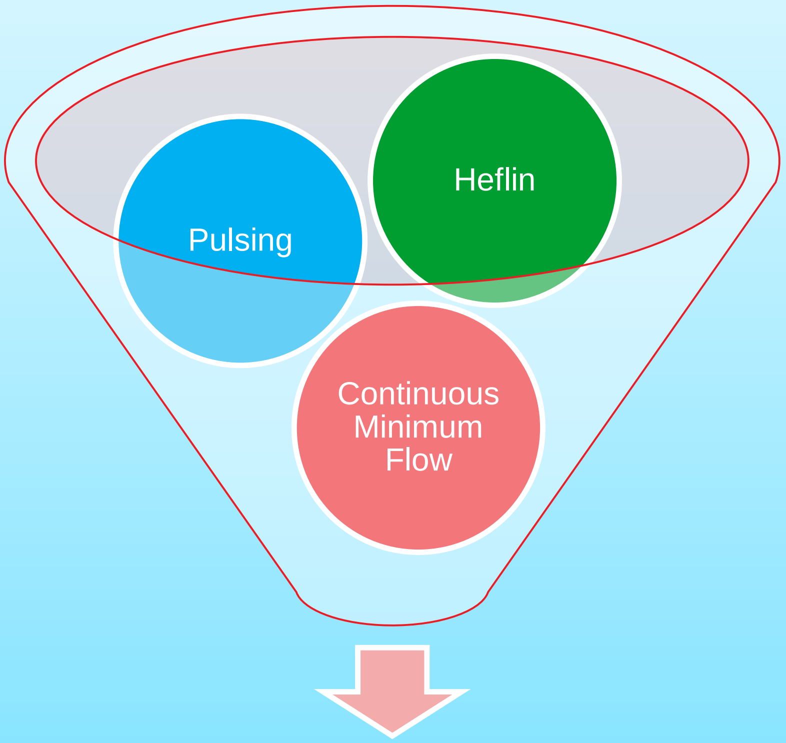
Stakeholder Meetings

January & August

2005 → 2006 → 2007 → 2008 → 2009 → 2010

2005 Meetings

- Decision Model presented
- Technical Committee formed*
- Green Plan selected
- Draft monitoring plan discussed
- Funding discussed



Pulsing based on Heflin

*ACFWRU, ADCNR, USFWS, Alabama Power

Timeline

Appendix E

Stakeholder Meetings
January & August

Green Plan Implemented
March

2005 | 2006 | 2007 | 2008 | 2009 | 2010

The Green Plan – Daily Release Schedule

Prior Day's Heflin Flow (DSF)	Generation @ 6 AM	Generation @ 12 PM	Generation as needed	Total Machine Time	Total Harris Discharge (DSF)
0 – 150	10 min	10 min	10 min	30 min	133
150 – 300	15 min	15 min	30 min	1 hr	267
300 – 600	30 min	30 min	1 hr	2 hrs	533
600 – 900	30 min	30 min	2 hrs	3 hrs	800
>900	30 min	30 min	3 hrs	4 hrs	1,067

DSF = day second feet

The **volume** of water represented by a flow of 1 cubic foot per second for 24 hours; equal to 86,400 cubic feet and approximately 2 acre feet.

The Green Plan – Hourly Release Schedule

Appendix E

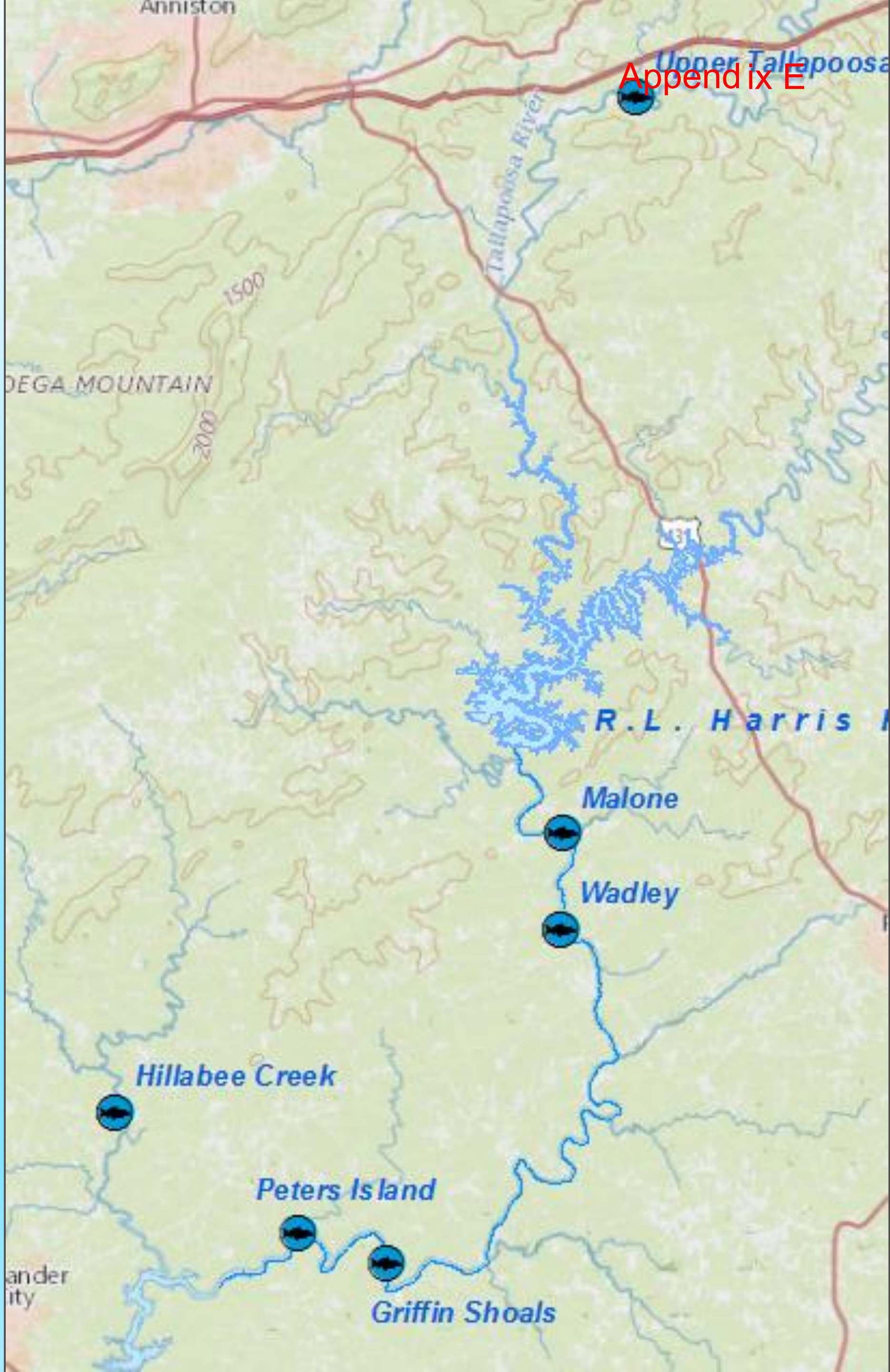
Total Scheduled Generation	Generation @ 6 AM	Generation @ 12 PM	Generation as needed	Total Machine Time	Total Harris Discharge (DSF)
1 machine hr	15 min	15 min	30 min	1 hr	267
2 machine hrs	30 min	30 min	1 hr	2 hrs	533
3 machine hrs	30 min	30 min	2 hrs	3 hrs	800
4 machine hrs	30 min	30 min	3 hrs	4 hrs	1067
5+ machine hrs			all		

Study Reaches

- Upper Tallapoosa @ Heflin
- Malone
- Wadley
- Griffin Shoals
- Peters Island
- Hillabee Creek

Study Components

- Spring and Fall fish sampling
- Fall benthic macroinvertebrate sampling
- Habitat measurements (substrate, depth, velocity, temperature, etc.)



Timeline: 2005 - 2010

Appendix E

Stakeholder Meetings
January & August

Green Plan Implemented
March

2005 | 2006 | 2007 | 2008 | 2009 | 2010

Stakeholder Meeting
Some preliminary results presented

August 2007 – Stakeholder Meeting

Append ix E

Results of 2005 Monitoring
for Adaptive Management of the Tallapoosa River below R.L. Harris Dam

Elise Irwin
USGS

Kathryn Mickett Kennedy
Alabama Cooperative Fish and Wildlife Research Unit

Alabama Power Company's
Review of the RL Harris 'Green Plan'

R L Harris Adaptive Management Meeting
Alexander City, AL
August 2, 2007

Timeline: 2005 - 2010

Stakeholder Meetings
January & August

Green Plan Implemented
March

Report
2002 - 2009

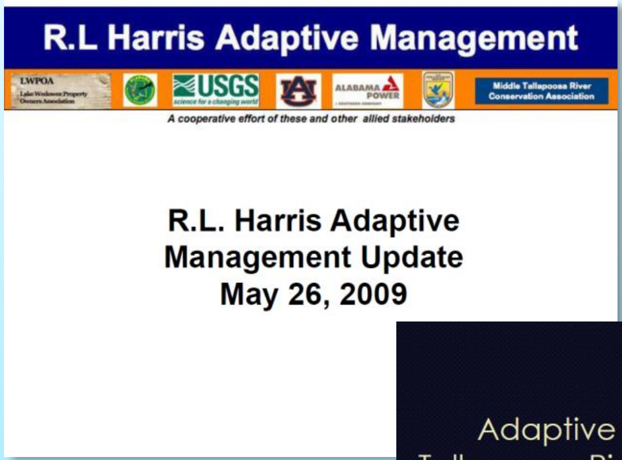
Stakeholder Meeting
May

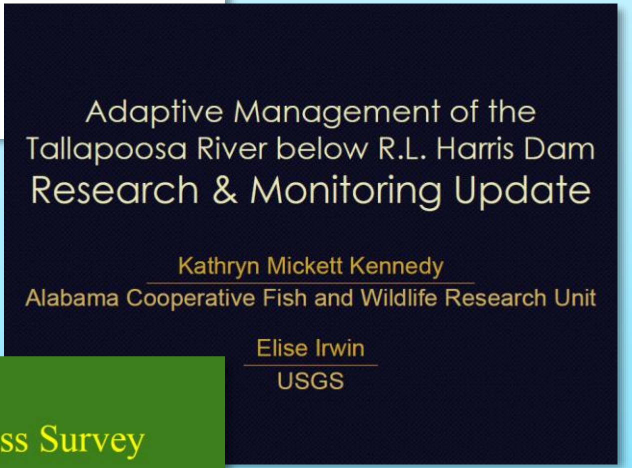
2005 | 2006 | 2007 | 2008 | 2009 | 2010

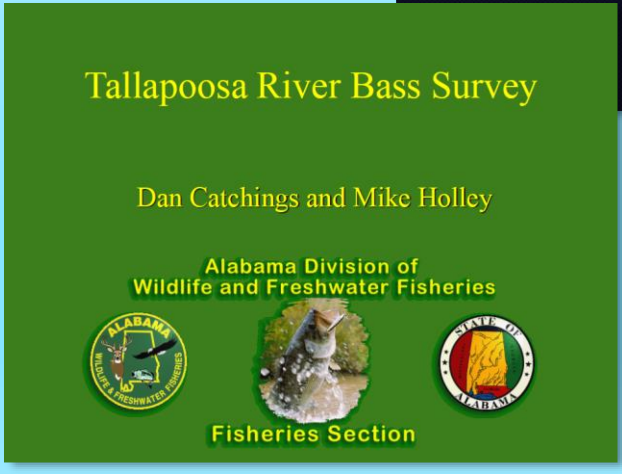
Stakeholder Meeting
Some preliminary results

May 2009 Stakeholder Meeting

- Alabama Power provided update on flow management
- ADCNR summarized results of the Tallapoosa sport fish study
- ALCFWRU presented a research and monitoring update







Appendix E

Adaptive Management Timeline 2011 - 2017

Alabama Power

Timeline: 2011 - 2017

Report

Report on 2005-2010

2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017

2011 Report

Adaptive management and monitoring for restoration and faunal recolonization of Tallapoosa River shoal habitats.

Prepared by:

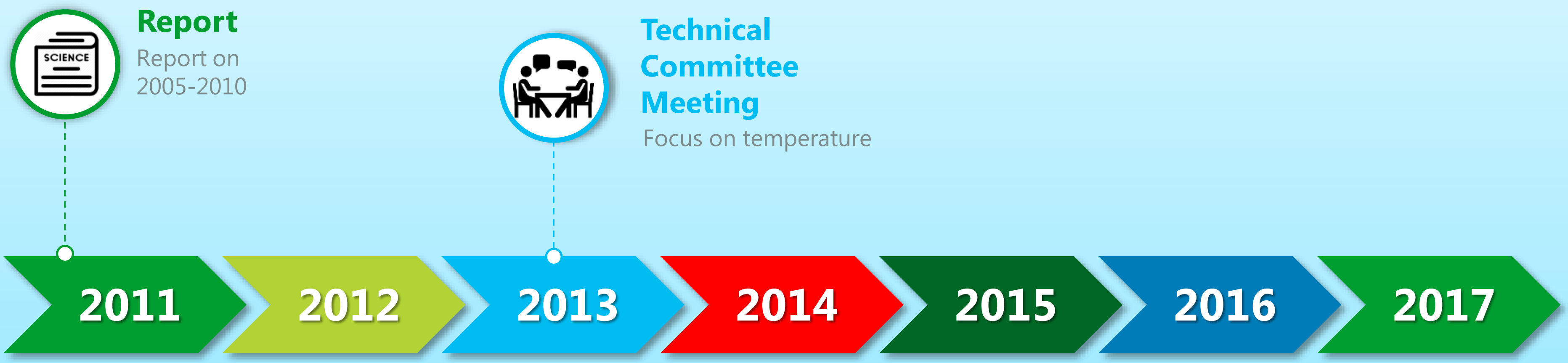
Elise Irwin, Kathryn Mickett Kennedy,
Taconya Piper Goar, Benjamin Martin, and Molly Moore Martin
Alabama Cooperative Fish and Wildlife Research Unit

- IBI scores lower at regulated sites, but varied widely
- Fish assemblages vary considerably, in regulated and unregulated reaches
- Stable flows may enhance spawning

Lipstick Darter (*Etheostoma chuckwachatte)*

Timeline

Appendix E



2013 Technical Committee Meeting

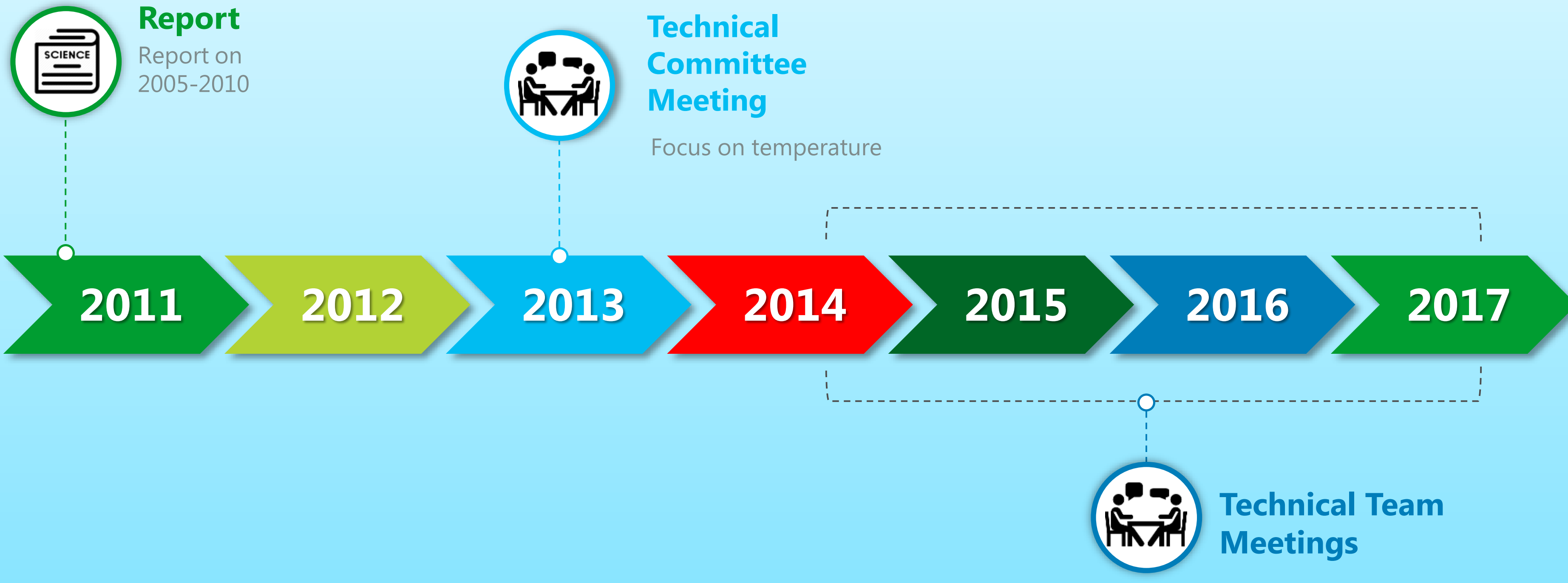
Increased habitat diversity and positive ecosystem response to Green Plan

Temperatures can be “too cold” for certain fish

Formation of technical team – modelers and biologists

Reconvene when technical committee formulates proposal for addressing temperature issue

Timeline


Report
Report on 2005-2010
Technical Committee Meeting
Focus on temperature
2011
2012
2013
2014
2015
2016
2017
Technical Team Meetings

2013 - 2017 Technical Meetings

- Focused on temperature below dam
- Participants note that Green Plan has improved habitat
- Proposed and discussed variations to pulse timing and effects on temperature
- Macroinvertebrate processing and analysis
- Alabama Power samples fish via 30+2 methodology
- Discussion of potential future creel studies

Alabama Shiner (*Cyprinella callistia)*

Largescale Stoneroller
(*Campostoma oligolepis)*

Bronze Darter (*Percina palmaris)*

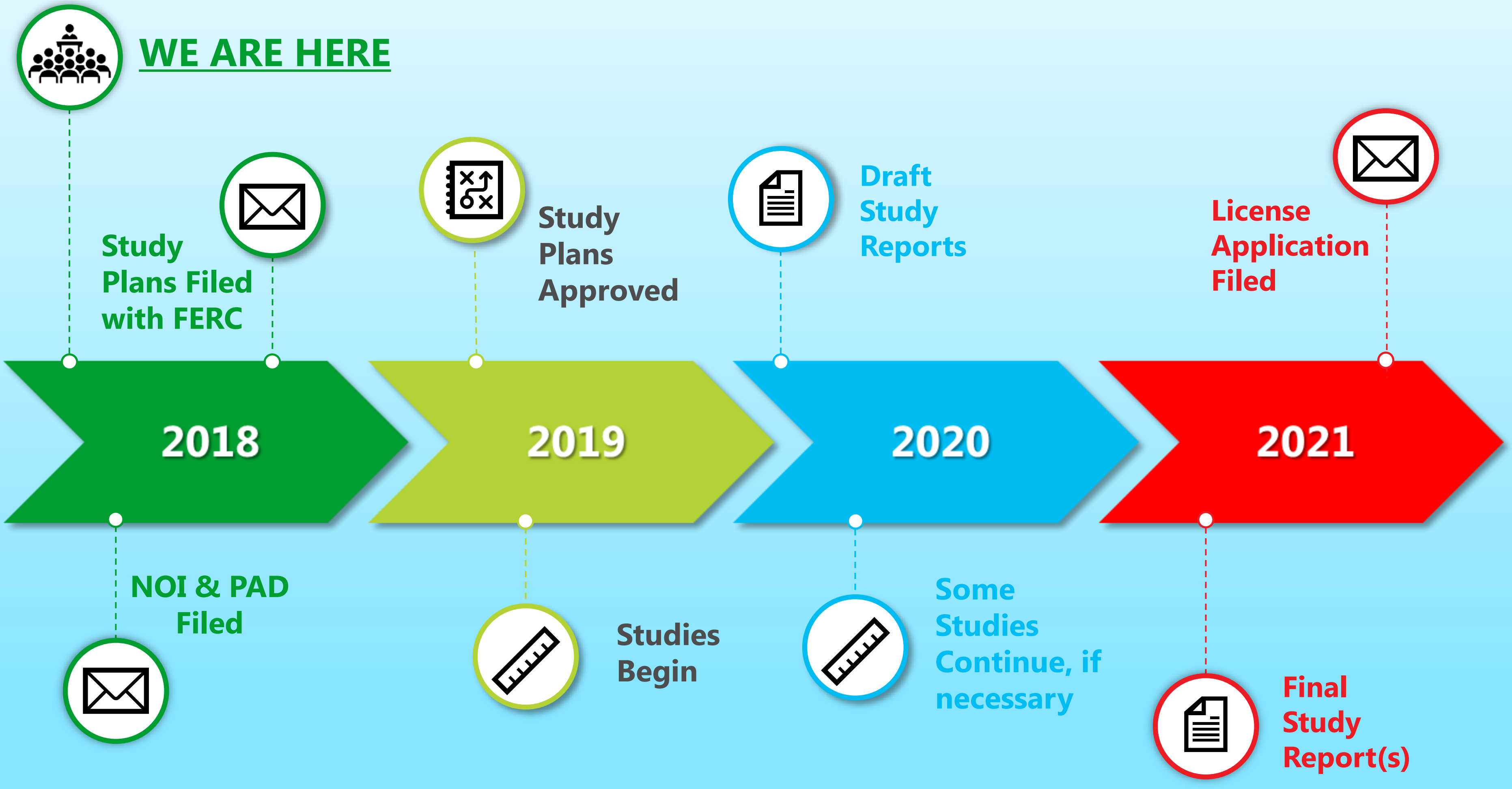
Summary

Append ix E

- 20+ years of collaboration
- 13 years of implementation, research, monitoring, & evaluation

HARRIS DAM
RELICENSING

2018 – 2021: Relicensing Process



Appendix F
Current R.L. Harris Project License Requirements

HARRIS DAM LICENSE

FERC NO. 2628

ISSUED DECEMBER 27, 1973, AS MODIFIED BY SUBSEQUENT ORDERS

NOTE: The following license articles and exhibits represent current license requirements and reflect known revisions and amendments ordered/approved by FERC since the original license was issued on December 27, 1973. The edits included in this document are based on searches of Alabama Power files and eLibrary and may not reflect the entirety of all revisions to the original license. Some articles, as noted, no longer apply to the Harris Project because they were for original construction. FERC Cites are given, where available.

The Commission orders:

(A) This license is hereby issued to the Alabama Power Company (Licensee) of Birmingham, Alabama, under Section 4(e) of the Federal Power Act (Act) for a period of 50 years commencing on the first day of the month in which the license is issued, for the construction, operation, and maintenance of the Crooked Creek Project No. 2628, located on the Tallapoosa River in Clay and Randolph Counties, Alabama, and which occupies approximately 58 acres of the lands of the United States, and further would be constructed and operated upon a navigable waterway of the United States, subject to the terms and conditions of the Act, which is incorporated herein by reference as a part of this license and subject to such rules and regulations as the Commission has issued or prescribed under the provisions of the Act.

(B) The Crooked Creek Project No. 2628 consists of:

(i) all lands constituting the project area and enclosed by the project boundary, the limits of which are otherwise defined, and/or interests in such lands necessary or appropriate for the purposes of the project, whether such lands or interests therein are owned or held by the Applicant or by the United States; such project area and project boundary being shown and described by certain exhibits which form part of the application for license and which are designated and described as follows:

NOTE: The following Exhibit J and Exhibit K Drawings were superseded in an order dated August 15, 1984 (28FERC¶62,214).

Exhibits	FPC No. 2628	Showing
J	-3	General Map of Project Area
K-3	-4	Project Area Map
K-4	-5	
K-5	-6	"
K-6	-7	"
K-7	-8	"
K-8	-9	"
K-9	-10	"
K-10	-11	"
K-11	-12	"
K-12	-13	"
K-13	-14	"

NOTE: The following Exhibits G-2 through G-4 and G-8 through G-9 were superseded in an order dated June 29, 1990 (51FERC¶62,344). Exhibit G-10 was added in this same order. Exhibits G-1 and G-5 through G-7 were superseded in an order dated February 17, 1999 (86FERC¶62,137).

Exhibit	FERC No. 2628-	Title	Superseding FERC No. 2628-
G-1 (Sheet 3)	47	Project Area Map	4
G-2 (Sheet 4)	48	Project Area Map	5
G-3 (Sheet 6)	49	Project Area Map	7
G-4 (Sheet 7)	50	Project Area Map	8
G-5 (Sheet 9)	51	Project Area Map	10
G-6 (Sheet 10)	52	Project Area Map	11
G-7 (Sheet 11)	53	Project Area Map	12
G-8 (Sheet 12)	54	Project Area Map	13
G-9 (Sheet 13)	55	Project Area Map	14

NOTE: The following Exhibits G-1 through G-9 were superseded in an order dated February 17, 1999 (86FERC¶62,137) and Exhibit G-10 was superseded in an order dated May 26, 2010 (131FERC¶62,185).

Exhibit	FERC No.	Drawing Title	Superseding
G-1 (Sheet 3)	2628-47	Project Area Map	47
G-2 (Sheet 4)	2628-79	Project Area Map	48
G-3 (Sheet 6)	2628-80	Project Area Map	49

~~G-4 (Sheet 7)~~	~~2628-81~~	~~Project Area Map~~	~~50~~
~~G-5 (Sheet 9)~~	~~2628-51~~	~~Project Area Map~~	~~10~~
~~G-6 (Sheet 10)~~	~~2628-52~~	~~Project Area Map~~	~~11~~
~~G-7 (Sheet 11)~~	~~2628-53~~	~~Project Area Map~~	~~12~~
~~G-8 (Sheet 12)~~	~~2628-82~~	~~Project Area Map~~	~~13~~
~~G-9 (Sheet 13)~~	~~2628-83~~	~~Project Area Map~~	~~14~~
~~G-10~~	~~2628-84~~	~~Project Area Map, Additional Project Lands~~	~~None~~

NOTE: The following Exhibit G Drawings were superseded in an order dated May 26, 2010 (131FERC¶62,185).

~~EXHIBIT~~	~~FERC DRAWING NO. 2628-~~	~~TITLE~~	~~SUPERSEDING DRAWING NO. 2628-~~
~~G-1~~	~~85~~	~~Project Area Map~~	~~47~~
~~G-2~~	~~86~~	~~Project Area Map~~	~~79~~
~~G-3~~	~~87~~	~~Project Area Map~~	~~80~~
~~G-4~~	~~88~~	~~Project Area Map~~	~~81~~
~~G-5~~	~~89~~	~~Project Area Map~~	~~51~~
~~G-6~~	~~90~~	~~Project Area Map~~	~~52~~
~~G-7~~	~~91~~	~~Project Area Map~~	~~53~~
~~G-8~~	~~92~~	~~Project Area Map~~	~~82~~
~~G-9~~	~~93~~	~~Project Area Map~~	~~83~~

NOTE: The following Exhibit G-19 was superseded in an order dated February 3, 2017 (158FERC¶62,074).

Exhibit	FERC No.	Superseding	Licensee's Drawing No.	Title
G-11	2628-94	2628-84	Sheet 1	Project Area map
G-12	2628-95	2628-84	Sheet 2	Project Area map
G-13	2628-96	2628-84	Sheet 3	Project Area map
G-14	2628-97	2628-84	Sheet 4	Project Area map
G-15	2628-98	2628-84	Sheet 5	Project Area map
G-16	2628-99	2628-85	Sheet 6	Project Area map
G-17	2628-100	2628-85, 86	Sheet 7	Project Area map
G-18	2628-101	2628-86, 87, 88	Sheet 8	Project Area map
~~G-19~~	~~2628-102~~	~~2628-88~~	~~Sheet 9~~	~~Project Area map~~
G-19	2628-106	2628-102		Project Area Map
G-20	2628-103	2628-87, 88, 89, 90	Sheet 10	Project Area map
G-21	2628-104	2628-88, 90, 91	Sheet 11	Project Area map
G-22	2628-105	2628-89, 90, 92, 93	Sheet 12	Project Area map

NOTE: The Project description was revised on July 12, 1984 (28FERC¶62,017).

~~(ii) project works including: (1) a concrete gravity dam about 150 feet high and 956 long, including a 310 foot long gated spillway section, a 391 foot long non-overflow section containing the headworks for the powerhouse and a 255-foot long non-overflow section; (2) an earth and rock fill dike section extending from each abutment of the concrete dam; (3) a 10,661-acre, 24-mile long reservoir at normal high water elevation 793 msl; (4) a powerhouse, integral with the dam, containing two generators each rated at 67,500 kw; (5) the generator leads, 13.1/115 kv transformers and appurtenant 115 kv facilities to connect to the 115 kv bus in the proposed substation; and (6) other appurtenant facilities: --the location, nature and character of which are more specifically shown and described by the exhibits hereinbefore cited and by certain other exhibits which also form part of the application for license and which are designated and described as follows:~~

(ii) project works including: (1) a concrete gravity dam about 150 feet high and 956 feet long, including an 310 foot long gated spillway section, a 391-foot long non-overflow section containing the headworks for the powerhouse and a 255-foot long non-overflow section; (2) an earth and rock filled dike section extending from each abutment of the concrete dam; (3) a 10,661-acre, 24-mile long reservoir at normal high water elevation 793 msl; (4) a powerhouse integral with the dam, containing two vertical generators each rated 71,740 Kva at .90 plant factor driven by two vertical Frances turbines rated at 95,000 h.p. each; (5) the generator leads, 13.8/115 kv transformers and appurtenant 115 kv facilities to connect to the 115 kv bus in the proposed substation; and (6) other appurtenant facilities: the location, nature and character of which are more specifically shown and described by the exhibits herein-before cited and by certain other exhibits which also form part of the application for license and which are designated and described as follows:

NOTE: The following Exhibit L Drawings was superseded in an order dated July 21, 1977.

~~Exhibit~~	~~FPC No. 2628~~	~~Showing~~
~~L-1~~	~~-15~~	~~General Plan – Downstream Elevation Earth Dike Section~~
~~L-2~~	~~-16~~	~~Powerhouse and Spillway Sections~~
~~L-3~~	~~-17~~	~~Powerhouse Floor Plans~~

NOTE: The following Exhibit L Drawings was superseded in an order dated July 12, 1984 (28FERC¶62,017).

~~Exhibit L~~	~~FPC No. 2628~~	~~Showing~~	~~Superseding FPC No. 2628-~~
~~1~~	~~-32~~	~~General Plan~~	~~-15~~
~~2A~~	~~-33~~	~~Transverse Section Thru Powerhouse~~	~~-16~~
~~2B~~	~~-34~~	~~Longitudinal Section Thru Powerhouse~~	~~-16~~
~~2C~~	~~-35~~	~~Transverse Section Thru Spillway~~	~~-16~~
~~3A~~	~~-36~~	~~Powerhouse Floor Elevation 714’-0”~~	~~-17~~
~~3B~~	~~-37~~	~~Powerhouse Floor Elevation 697’-9”~~	~~-17~~
~~3C~~	~~-38~~	~~Powerhouse Floor Elevation 683’-4-1/2”~~	~~-17~~
~~3D~~	~~-39~~	~~Powerhouse Floor Elevation664’-0”~~	
~~3E~~	~~-40~~	~~Powerhouse Floor Elevation647’-9”~~	~~-17~~
~~4A~~	~~-41~~	~~Stability Analysis of Concrete Structures~~	~~-18~~
~~4B~~	~~-42~~	~~Stability Analysis of Earth Dikes~~	~~-18~~
~~5~~	~~-43~~	~~Geology~~	~~-19~~

NOTE: The FERC exhibit numbers were revised in an errata notice dated September 28, 1984.

Exhibit	FERC No. 2628-	Showing	Superseded No. 2628-
F-1	~~44~~ 68	General Plan	32
F-2A	~~45~~ 69	Transverse Section Thru Powerhouse	33
F-2B	~~46~~ 70	Longitudinal Section Thru Powerhouse	34
F-2C	~~47~~ 71	Transverse Section Thru Spillway	35
F-3A	~~48~~ 72	Powerhouse Floor Elevation 714’-0”	36
F-3B	~~49~~ 73	Powerhouse Floor Elevation 697’-9”	37
F-3C	~~50~~ 74	Powerhouse Floor Elevation 683’-4-1/2”	38

F-3D	~~51~~ 75	Powerhouse Floor Elevation664'-0"	39
F-3E	~~52~~ 76	Powerhouse Floor Elevation647'-9"	40
F-4A	~~53~~ 77	Stability Analysis of Concrete Structures	41
F-4B	78	Stability Analysis of Earth Dams and Saddle Dam	42

NOTE: Exhibit M was superseded by Exhibit A in a July 12, 1984 order (28FERC¶62,017).

~~Exhibit M: Consisting of 3 typewritten pages entitled, "General Description of Mechanical, Electrical, and Transmission Equipment," filed with the Commission on November 5, 1968,~~

Exhibit A: General Description of Mechanical, Electrical and Transmission Equipment

NOTE: The original Exhibit R (consisting of 10 pages of typewritten text and two drawings) was revised in a September 24, 1984 order (28FERC¶62,428), and then subsequently revised in orders dated September 22, 1998 (84FERC¶62,263) and May 26, 2010 (131FERC¶62,185). Current recreation requirements are contained in the "1995 Land Use Plan for the R.L. Harris Project" filed on June 30, 2008.

Exhibit R: ~~Consisting of 10 pages of typewritten text and two drawings (FPC Nos. 2628-20 and 21).~~

~~(1) six pages of text and Table A,~~

~~(2) ten road-end facility maps - FERC Nos. 2628-56 thru 2~28-65, and (3) two revised Exhibit R Drawings, which delineate project lands reserved for public hunting:~~

~~Title~~	~~Sheet~~	~~Number~~	~~FERC No.~~
~~Public Hunting Area Map~~	~~1 of 2~~	~~D360410~~	~~2628-66~~
~~Public Hunting Area Map~~	~~2 of 2~~	~~D360410~~	~~2628-67~~

~~and a supplemental filing on August 28, 1984, consisting of three pages of text,~~

(iii) all of the structures, fixtures, equipment or facilities used or useful in the maintenance and operation of the project and located on the project area, including such portable property as may be used or useful in connection with the project or any part thereof, whether located on or off the project area, if and to the extent that the inclusion of such property as part of the project is approved or acquiesced in by the Commission; also, all riparian or other rights, the use or possession of which is necessary or appropriate in the maintenance or operation of the project.

(C) This license is also subject to the following terms and conditions:

Article 1. The entire project, as described in this order of the Commission, shall be subject to all of the provisions, terms, and conditions of the license.

Article 2. No substantial change shall be made in the maps, plans, specifications, and statements described and designated as exhibits and approved by the Commission in its order as a part of the license until such change shall have been approved by the Commission: Provided, however: That if the Licensee or the Commission deems it necessary or desirable that said approved exhibits, or any of them, be changed, there shall be submitted to the Commission for approval amended, or additional exhibit or exhibits covering the proposed changes which, upon approval by the Commission, shall become a part of the license and shall supersede, in whole or in part, such exhibit or exhibits theretofore made a part of the license as may be specified by the Commission.

Article 3. The project works shall be constructed in substantial conformity with the approved exhibits referred to in Article 2 herein or as changed in accordance with the provisions of said article. Except when emergency shall require for the protection of navigation, life, health, or property, there shall not be made without prior approval of the Commission any substantial alteration or addition not in conformity with the approved plans to any dam or other project works under the license or any non-project use of project property; and any emergency alteration, addition, or use so made shall thereafter be subject to such modification and change as the Commission may direct. Minor changes in project works, or divergence from such approved exhibits may be made if such changes will not result in a decrease in efficiency, in a material increase in cost, in an adverse environmental impact, or in impairment of the general scheme of development; but any of such minor changes made without the prior approval of the Commission, which in its judgment have produced or will produce any of such results, shall be subject to such alteration as the Commission may direct. Upon completion of the project, or at such other time as the Commission may direct, the Licensee shall submit to the Commission for approval revised exhibits insofar as necessary to show any divergence from or variations in the project area and project boundary as finally located or in the project works as actually constructed when compared with the area and boundary shown and the works described in the license or in the exhibits approved by the Commission, together with a statement in writing setting forth the reasons which in the opinion of the Licensee necessitated or justified variations in or divergence from the approved exhibits. Such revised exhibits shall, if and when approved by the Commission, be made a part of the license under the provisions of Article 2 hereof.

Article 4. The construction, operation and maintenance of the project and any work incident to additions or alterations shall be subject to the inspection and supervision of the Regional Engineer, Federal Power Commission, in the region wherein the project is located, or of such other officer or agent as the Commission may designate, who shall be the authorized representative of the Commission for such purposes. The Licensee shall cooperate fully with said representative and shall furnish him a detailed program of inspection by the Licensee that will provide for an adequate and qualified inspection force for construction of the project. Construction of the project works or any feature thereof shall not be initiated until the program of inspection of the project or any such feature thereof has been approved by said representative. The Licensee shall also furnish to said representative such further information as he may require concerning the construction, operation, and maintenance of the project, and of any alteration thereof, and shall notify him of the date upon which work will begin, as far in advance thereof as said representative may reasonably specify, and shall notify him promptly in writing of any suspension of work for a period of more than one week, and of its resumption and completion. The Licensee shall allow him and other officers or employees of the United States, showing proper credentials, free and unrestricted access to, through, and across the project lands and project works in the performance of their official duties. The Licensee shall comply with such rules and regulations of general or special applicability as the Commission may from time to time prescribe for the protection of life, health, or property.

Article 5. The Licensee, within five years from the date of issuance of the license, shall acquire title in fee or the right to use in perpetuity all lands, other than lands of the United States, necessary or appropriate for the construction, maintenance, and operation of the project. The Licensee, its successors and assigns shall, during the period of the license, retain the possession of all project property covered by the license as issued or as later amended, including the project area, the project works, and all franchises, easements, water rights, and rights of occupancy and use; and none of such properties shall be voluntarily sold, leased, transferred, abandoned, or otherwise disposed of without the prior written approval of the Commission, except that the Licensee may lease or otherwise dispose of interests in project lands or property without specific written approval of the Commission pursuant to the then current regulations of the Commission. The provisions of this article are not intended to prevent the abandonment or the retirement from service of structures, equipment, or other project works in connection with replacements thereof when they become obsolete, inadequate, or inefficient for further service due to wear and tear; and mortgage or trust deeds or judicial sales made thereunder, or tax sales, shall not be deemed voluntary transfers within the meaning of this article.

Article 6. In the event the project is taken over by the United States upon the termination of the license, as provided in Section 14 of the Act, or is transferred to a new licensee or to a non-power licensee under the provisions of Section 15 of the Act, the Licensee, its successors and assigns will be responsible for, and will make good any defect of title to, or of right of occupancy and use in any of such project property which is necessary or appropriate or valuable and serviceable in the maintenance and operation of the project, and will pay and discharge, or will assume responsibility for payment and discharge of, all liens or encumbrances upon the project or project property created by the Licensee or created or incurred after the issuance of the license: Provided, That the provisions of this article are not intended to require the Licensee, for the purpose of transferring the project to the United States or to a new Licensee, to acquire any different title to, or right of occupancy and use in, any of such project property than was necessary to acquire for its own purposes as the Licensee.

Article 7. The actual legitimate original cost of the project, and of any addition thereto or betterment thereof, shall be determined by the Commission in accordance with the Act and the Commission's rules and regulations thereunder.

Article 8. [THIS ARTICLE WAS REVISED BY ADDING THE LAST SENTENCE ON 08/24/1976] After the first 20 years of operation of the project under the license, six percent per annum shall be the specified rate of return on the net investment in the project for determining surplus earnings of the project for the establishment and maintenance of amortization reserves, pursuant to Section 10(d) of the Act; one-half of the project surplus earnings, if any, accumulated after the first 20 years of operation under the license, in excess of six percent per annum on the net investment, shall be set aside in a project amortization reserve account as of the end of each fiscal year: Provided, that, if and to the extent that there is a deficiency of project earnings below six percent per annum for any fiscal year or years after the first 20 years of operation under the license, the amount of such deficiency shall be deducted from the amount of any surplus earnings accumulated thereafter until absorbed, and one-half of the remaining surplus earnings, if any thus cumulatively computed, shall be set aside in the project amortization reserve account; and the amounts thus established in the project amortization reserve account shall be maintained therein until further order of the Commission. This article is effective through June 23, 1976.

Article 9. For the purpose of determining the stage and flow of the stream or streams on which the project is located the amount of water held in the withdrawn from storage, and the effective head on the turbines, the Licensee shall install and thereafter maintain such gages and stream-gaging stations as the Commission may deem necessary and best adapted to the requirements; and shall provide for the required readings of such gages and for the adequate rating of such stations. The Licensee shall also install and maintain standard meters adequate for the determination of the amount of electric energy generated by said project works. The number, character, and location of gages, meters, or other measuring devices, and the method of operation thereof, shall at all times be satisfactory to the Commission and may be altered from time to time if necessary to secure adequate determinations, but such alteration shall not be made except with the approval of the Commission or upon the specific direction of the Commission. The installation of gages, the ratings of said stream or streams, and the determination of the flow thereof, shall be under the supervision of, or in cooperation with, the District Engineer of the United States Geological Survey having charge of stream-gaging operations in the region of said project, and the Licensee shall advance to the United States Geological Survey the amount of funds estimated to be necessary for such supervision or cooperation for such periods as may be mutually agreed upon. The Licensee shall keep accurate and sufficient record of the foregoing determinations to the satisfaction of the Commission, and shall make return of such records annually at such time and in such form as the Commission may prescribe.

Article 10. The Licensee shall install additional capacity or make other changes in the project as directed by the Commission, to the extent that it is economically sound and in the public interest to do so, after notice and opportunity for hearing.

Article 11. The Licensee shall, after notice and opportunity for hearing, coordinate the operation of the project, electrically and hydraulically, with such other projects or power systems and in such manner as the Commission any direct in the interest of power and other beneficial public uses of water resources, and on such conditions concerning the equitable sharing of benefits by the Licensee as the Commission may order.

Article 12. Whenever the Licensee is directly benefited by the construction work of another licensee, a permittee, or the United States of a storage reservoir or other headwater improvement, the Licensee shall reimburse the owner of the headwater improvement for such part of the annual charges for interest, maintenance, and depreciation thereon as the Commission shall determine to be equitable, and shall pay to the United States the cost of making such determination as fixed by the Commission. For benefits provided by a storage reservoir or other headwater improvements of the United States, the Licensee shall pay to the Commission the amounts for which it is billed from time to time for such headwater benefits and for the costs of making the determinations pursuant to the then current Commission Regulations under the Federal Power Act.

Article 13. The United States specifically retains and safeguards the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the Commission my prescribe for the protection of life, health, and property, and in the interest of the fullest practicable conservation and utilization of such waters for power purposes and for other beneficial public uses, including recreational purposes, and the Licensee shall release water from the project reservoir at such rate in cubic feet per second, or such volume in acre-feet per specified period of time, as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinbefore mentioned. Pending further order by the Commission on its own motion or at the request of others, after notice and opportunity for hearing, the Licensee shall:

(a) In the interest of protecting and developing the downstream aquatic habitat, release water from the project to provide a minimum flow of 45 cfs, as measured at the Wadley gage;

(b) In the interest of recreation, flood control and other public uses, and consistent with power needs, maintain the reservoir as reasonably as possible at normal full pool elevation of 793 feet from May 1 to September 30 of each year and maintain the reservoir from October 1 to April 30, of each year at elevations as high as is consistent with flood control and system power needs and in no event lower than elevation 768 feet; and

(c) Operate the reservoir for flood control in accord with the agreement between the Chief of Engineers, Department of the Army, and the Licensee filed with the Commission October 11, 1972, provided that the Commission shall be furnished copies of any future adjustment thereto, and provided further that in the absence of agreement to an adjustment proposed by either party the matter shall be referred promptly to the Commission.

Article 14. On the application of any person, association, corporation, Federal agency, State or municipality, the Licensee shall, after notice and opportunity for hearing, permit such reasonable use of its reservoir or other project properties, including works, lands and water rights, or parts thereof, as may be ordered by the Commission in the interest of comprehensive development of the waterway or waterways involved and the conservation and utilization of the water resources of the region, for water supply, or for the purposes of steam-electric, irrigation, industrial, municipal or similar uses. The Licensee shall receive reasonable compensation, at least full reimbursement for any damages or expenses which the joint use causes him to incur, for use of its reservoir or other project properties or parts thereof for such purposes, any such compensation to be fixed by the Commission either by approval of an agreement between the Licensee and the party or parties benefiting or after notice and opportunity for hearing. Applications shall contain information in sufficient detail to afford a full understanding of the proposed use, including satisfactory evidence that the applicant possesses necessary water rights pursuant to applicable State law, or a showing of cause why such evidence cannot be concurrently submitted, and a statement as to the relationship of the proposed use to any State or municipal plans or orders which may have been adopted with respect to the use of such waters.

Article 15. In the construction or maintenance of the project works, the Licensee shall place and maintain suitable structures and devices to reduce to a reasonable degree the liability of contact between its transmission lines and telegraph, telephone and other signal wires or power transmission lines constructed prior to its transmission lines and not owned by the Licensee, and shall also place and maintain suitable structures and devices to reduce to a reasonable degree the liability of any structures or wires falling or obstructing traffic or endangering life. None of the provisions of this article are intended to relieve the Licensee from any responsibility or requirement which may be imposed by any other lawful authority for avoiding or eliminating inductive interference.

Article 16. The Licensee shall, for the conservation and development of fish and wildlife resources, construct, maintain, and operate, or arrange for the construction, maintenance, and operation of such reasonable facilities, and comply with such reasonable modifications of the project structures and operation, as may be ordered by the Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any State in which the project or a part thereof is located, after notice and opportunity for hearing.

Article 17. Whenever the United States shall desire, in connection with the project, to construct fish and wildlife facilities or to improve the existing fish and wildlife facilities at its own expense, the Licensee shall permit the United States or its designated agency to use, free of cost, such of the Licensee's lands and interests in lands, reservoirs, waterways and project works as may be reasonably required to complete such facilities or such improvements thereof. In addition, after notice and opportunity for hearing, the Licensee shall modify the project operation as may be reasonably prescribed by the Commission in order to permit the maintenance and operation of the fish and wildlife facilities constructed or improved by the United States under the provisions of this article. This article shall not be interpreted to place any obligation on the United States to construct or improve fish and wildlife facilities or to relieve the Licensee of any obligation under this license.

Article 18. The Licensee shall construct, maintain, and operate, or shall arrange for the construction, maintenance, and operation of such reasonable recreational facilities, including modifications thereto, such as access roads, wharves, launching ramps, beaches, picnic and camping areas, sanitary facilities, and utilities, and shall comply with such reasonable modifications of the project structures and operations as may be prescribed hereafter by the Commission during the term of this license upon its own motion or upon the recommendation of the Secretary of the Interior or other interested Federal or State agencies, after notice and opportunity for hearing.

Article 19. So far as is consistent with proper operation of the project, the Licensee shall allow the public free access, to a reasonable extent, to project waters and adjacent project lands owned by the Licensee for the purpose of full public utilization of such lands and waters for navigation and for outdoor recreational purposes, including fishing and hunting: Provided, That the Licensee may reserve from public access such portions of the project waters, adjacent lands, and project facilities as may be necessary for the protection of life, health, and property. Licensee, in the interests of promoting optimum recreational use and protecting the scenic values of project lands and waters, may to a reasonable extent grant permits to individuals or groups of individuals for landscape plantings on project lands, or for the construction of access roads, wharves, landings, and other similar facilities, the occupancy of which may, under appropriate circumstances, be subject to the payment of rent in a reasonable amount; Provided, that Licensee, in granting such permits, shall require that permittees provide for multiple occupancy and use of such facilities, where feasible, and shall ensure that such facilities are constructed and maintained in such a manner so as to be consistent with shoreline aesthetic values; provided further, that the Licensee, prior to the granting of said permits and construction of such facilities, shall file for Commission approval as part of its Exhibit R a master plan for the entire project showing the location and typical design of such facilities and the use of project lands adjacent thereto. The master plan shall be prepared in compliance with the requirements of Section 4.41 – Exhibit R of the Commission's Regulations under the Federal Power Act.

Article 20. The Licensee shall be responsible for, and shall take reasonable measures to prevent, soil erosion on lands adjacent to stream(s) and to prevent stream siltation or other forms of water or air pollution resulting from construction, operation or maintenance of the project. The Commission, upon request or upon its own motion, may order the Licensee to take such measures as the Commission may find to be necessary for these purposes, after notice and opportunity for hearing.

Article 21. The Licensee shall consult with the appropriate State and Federal agencies and within one year of the date of issuance of this license shall submit for Commission approval a plan for clearing the reservoir area. Further, Licensee shall clear and keep clear to an adequate width lands along open conduits and shall dispose of all temporary structures, unused timber, brush, refuse, or other material resulting from the clearing of lands or from the maintenance or alteration of the project works. In addition, all trees along the periphery of reservoirs which may die during operations of the project shall be removed. Upon approval of the clearing plan all clearing of the lands and disposal of the material shall be done with due diligence and to the satisfaction of the authorized representative of the Commission and in accordance with appropriate Federal, State, and local statutes and regulations.

Article 22. Insofar as any material is dredged or excavated in the prosecution of work authorized under the license; or in the maintenance of the project, such material shall be removed and deposited in such manner that it will reasonably preserve the project environmental values and so it will not interfere with traffic, both land and water. Dredging and filling in a navigable water of the United States will be done to the satisfaction of the District Engineer, Department of the Army, in charge of the locality.

Article 23. Whenever the United States shall desire to construct, complete, or improve navigation facilities in connection with the project, the Licensee shall convey to the United States, free of cost, such of its lands and rights-of-way and such right-of-passage through its dams or other structures, and permit such control of pools, as may be required to complete and maintain such navigation facilities.

Article 24. The operation of any navigation facilities which may be constructed as a part of, or in connection with, any dam or diversion structure constituting a part of the project works shall at all times be controlled by such reasonable rules and regulations in the interest of navigation, including control of the level of the pool caused by such dam or diversion structure, as may be made from time to time by the Secretary of the Army.

Article 25. The Licensee shall furnish power free of cost to the United States power for the operation and maintenance of navigation facilities at the voltage and frequency required by such facilities and at a point adjacent thereto, whether said facilities are constructed by the Licensee or by the United States.

Article 26. The Licensee shall for the protection of navigation, construct, maintain, and operate at its own expense such lights and other signals on fixed structures in or over navigable of the United States as may be directed by the Secretary of the Department in which the Coast Guard is operating.

Article 27. Timber on lands of the United States cut, used, or destroyed in the construction and maintenance of the project works, or in the clearing of said lands, shall be paid for, and the resulting slash and debris disposed of, in accordance with the requirement of the agency of the United States having jurisdiction over said lands. Payment for merchantable timber will be at current stumpage rates, and payment for young growth timber below merchantable size shall be at current damage appraisal values. However, the agency of the United States having jurisdiction may sell or dispose of the merchantable timber to others than the Licensee, with the provision that timber so sold or disposed of will be cut and removed from the area prior to, or without undue interference with, clearing operations of the Licensee and in coordination with his project construction schedules. Such sale or disposal to others will not relieve the Licensee of the responsibility for the clearing and disposal of all slash and debris from project lands.

Article 28. The Licensee shall do everything reasonably within its power, and shall require its employees, contractors, and employees of contractors to do everything reasonably within their power, both independently and upon the request of officers of the agency concerned, to prevent, make advance preparations for suppression, and suppress fires on the lands to be occupied or used under the license. The Licensee shall be liable for and shall pay the costs incurred by the United States in suppressing fires caused from the construction, operation, or maintenance of the project works or of the work appurtenant or accessory thereto under the license.

Article 29. The Licensee shall interpose no objection to, and shall in no way prevent, the use by the agency of the United States having jurisdiction over the lands of the United States affected, or by persons or corporations occupying lands of the United States under permit, of water for fire suppression from any stream, conduit, or body of water, natural or artificial, used by the Licensee in the operation of the project works covered by the license, or the use by said parties of water for sanitary and domestic purposes from any stream, conduit, or body of water, natural or artificial, used by the Licensee in the operation of the project works covered by the license.

Article 30. The Licensee shall be liable for injury to, or destruction of, any buildings, bridges, roads, trails, lands, or other property of the United States, occasioned by the construction, maintenance, or operation of the project works or of the works appurtenant or accessory thereto under the license. Arrangements to meet such liability, either by compensation for such injury or destruction, or by reconstruction or repair of damaged property, or otherwise, shall be made with the appropriate department or agency of the United States.

Article 31. The Licensee shall allow any agency of the United States, without charge, to construct or permit to be constructed on, through, and across those project lands which are lands of the United States such conduits, chutes, ditches, railroads, roads, trails, telephone and power lines, and other means of transportation and communication not inconsistent with the enjoyment of said lands by the Licensee for the purposes of the license. This license shall not be construed as conferring upon the Licensee any right of use, occupancy, or enjoyment of the lands of the United States other than for the construction, operation, and maintenance of the project as stated in the license.

Article 32. In the construction and maintenance of the project, the location and standards of roads and trails on lands of the United States and other uses of lands of the United States, including the location and condition of quarries, borrow pits, and spoil disposal areas, and sanitary facilities, shall be subject to the approval of the department or agency of the United States having supervision over the lands involved.

Article 33. The Licensee shall make provision, or shall bear the reasonable cost, as determined by the agency of the United States affected, of making provision for avoiding inductive interference between any project transmission line or other project facility constructed, operated, or maintained under the license, and any radio installation, telephone line, or other communication facility installed or constructed before or after construction of such project transmission line or other project facility and owned, operated, or used by such agency of the United States in administering the lands under its jurisdiction.

Article 34. The Licensee shall make use of the Commission's guidelines as issued in Order No. 414 and other recognized guidelines for treatment of transmission line rights-of-way, and shall clear such portions of transmission line rights-of-way across lands of the United States as are designated by the officer of the United States in charge of the lands; shall keep the areas so designated clear of new growth, all refuse, and inflammable material to the satisfaction of such officer; shall trim all branches of trees in contact with or liable to contact the transmission lines; shall cut and remove all dead or leaning trees which might fall in contact with the transmission lines; and shall take such other precautions against fire as may be required by such officer. No fires for the burning of waste material shall be set except with the prior written consent of the officer of the United States in charge of the lands as to time and place.

Article 35. The Licensee shall cooperate with the United States in the disposal by the United States of mineral and vegetative materials, under the Act of July 31, 1947, 61 Stat. 681 as amended, (30 U.S.C. 601, et seq.) from lands of the United States occupied by the project or any part thereof: Provided, That such disposal has been authorized by the Commission and that it does not unreasonably interfere with the occupancy of such lands by the Licensee for the purposes of the license and provided further that in the event of disagreement, any question of unreasonable interference shall be determined by the Commission after notice and opportunity for hearing.

Article 36. If the Licensee shall cause or suffer essential project property to be removed or destroyed or to become unfit for use, without adequate replacement, or shall abandon or discontinue good faith operation of the project for a period years, or refuse or neglect to comply with the terms of the license and the lawful orders of the Commission mailed to the record address of the Licensee or its agent, the Commission will deem it to be the intent of the Licensee to surrender the license, and not less than 90 days after public notice may in its discretion terminate the licensee.

Article 37. Upon abandonment of the project or retirement of all power facilities, the Commission may require the Licensee to remove any or all structures, equipment and power lines within the project boundary and take any such other action necessary to restore the project stream(s) and property to a condition satisfactory to the United States agency having jurisdiction over its lands or the Commission's authorized representative, as appropriate, or to provide for the continued operation and maintenance of non-power facilities and fulfill such other obligations under the license as the Commission may prescribe.

Article 38. The right of the Licensee and of its transferees and successors to use or occupy waters over which the United States has jurisdiction, or lands of the United States under the license, for the purpose of maintaining the project works or otherwise, shall absolutely cease at the end of the license period, unless Licensee has obtained a new license pursuant to the then existing laws and regulations, or an annual license under the terms and conditions of this license.

Article 39. The Licensee shall cooperate with the appropriate State and local agencies in the identification of historical structures, if any, within the project area and, if necessary, cooperate in developing a plan for protection or relocation of such structures.

Article 40. The Licensee shall retain a board of three or more qualified independent consultants to review the design, specifications, and construction of the project for safety and adequacy. Among other things, the board shall assess the geology of the project site and surroundings; the proposed design, specifications, and construction of the dam, powerhouse, electrical and mechanical equipment involved in water control, and emergency power supply; the construction inspection program; construction procedures and progress, instrumentation and plans for surveillance during initial filling of the reservoir. The Licensee shall submit copies of the Board's report on each meeting. Reports reviewing each portion of the project shall be submitted prior to or simultaneously with the submission of the corresponding Exhibit L final design drawings. The Licensee shall also submit a final report of the board upon completion of the project.

Article 41. The Licensee shall install appropriate instrumentation and other devices to monitor seepage, uplift, and performance of the project structures and reservoir slopes. A plan of instrumentation and a schedule of recording instrument readings shall be furnished to the Commission prior to initial filling of the reservoir. The Licensee shall furnish periodically to the Commission, as may be requested by the Commission or its appropriate Regional Engineer, a report and analysis of the instrument readings.

Article 42. The Licensee shall submit in accordance with the Commission's Rules and Regulations revised Exhibit L drawings showing final designs of the project works, and the Licensee shall not begin construction of any such project structures until the Commission has approved the Exhibit.

Article 43. The Licensee shall, to the satisfaction of the Regional Engineer, install and operate such signs, lights, sirens or other devices below the powerhouse to warn the public of fluctuations in flow of the project, and shall install such signs, lights and other safety devices in the project reservoir, such as log booms above the spillway and powerhouse intakes, as may be reasonably needed to protect the public in its recreational use of project lands and waters.

Article 44. The Licensee shall, prior to relocation or reconstruction of any roads, bridges, or transmission lines within the project boundary, (other than transmission facilities which are to be part of the project) in connection with construction of the project, consult with appropriate Federal, State, and local agencies and shall prior to construction submit to the Commission plans showing the proposed relocation or reconstruction, including vertical clearance of bridges and transmission lines, and plans for the preservation and enhancement of the environment as it may be affected by such relocation or reconstruction. These plans shall give appropriate consideration to the guidelines issued in the Commission's Order No. 414, issued November 27, 1970. The Commission reserves the right after notice and opportunity for hearing to prescribe any changes in the plans as the public interest may warrant.

Article 45. The Licensee shall avoid or minimize any disturbance caused by construction and maintenance of the project works to the natural, scenic, historical and recreational values of the area, blending project works with the natural view, and revegetating, stabilizing and landscaping any construction areas located outside the area of the project reservoir. Within one year from issuance of this license, the Licensee shall submit for Commission approval its detailed plan to avoid or minimize any disturbance to such values of the area caused by construction and maintenance of the project works; this plan, including an architectural rendering for the major project features including project transmission facilities, shall be prepared after consultation with a professional land use planner and appropriate Federal, State and local agencies; and this plan shall give due consideration to the provisions of the Commission's Order No. 414, issued November 27, 1970.

Article 46. Licensee shall consult and cooperate with Federal, State, and local recreation agencies in protecting and developing the recreation resources of the project area and shall file for Commission approval within one year from the date of issuance of the license (1) site development costs, and schedules for those recreational facilities shown on Sheet 2, Exhibit R drawing (FPC 2628-2); and (2) site development plans, costs and schedules for: (a) the overlook area at the east side of the dam and (b) a public fishing facility at the tailrace area. Furthermore, in consultation with the above agencies, the Licensee shall file for Commission approval within one year after commencement of operation of the project, site development plans for those road-ends which are to be developed for public use as turnaround areas and for parking and boat-launching purposes.

Article 47. Licensee shall, in cooperation with the U.S. Bureau of Outdoor Recreation of the Department of the Interior and the Alabama Department of Conservation and Natural Resources, within one year after the commencement of operation of the project, file for Commission approval functional plans for the development of those areas in the Exhibit R proposed for future recreational use. In the preparation of these plans the Licensee shall give consideration to future needs for public recreation at the project including the possibility of meeting those needs by developing as general public recreational areas a portion of those lands proposed for future recreational cottage sites.

Article 48. Licensee, in cooperation with the Alabama Department of Conservation and Natural Resources, shall select project lands to be reserved for public hunting areas. These lands, which may include those areas now designated on Exhibit R maps for public hunting, shall be selected within one year after the commencement of operation of the project and shall be shown on a map of the project area which shall be filed for Commission approval as a revised Exhibit R drawing.

Article 49. Licensee, within one year from the date of issuance of the license and in consultation with the Bureau of Outdoor Recreation of the U.S. Department of the Interior and the Alabama Department of Conservation and Natural Resources, shall file with the Commission the results of a study of the feasibility of utilizing a residential clustering concept (as opposed to linear development) in those areas proposed for both initial and future recreation cottage site development, and if such concept is feasible, shall thereafter file for Commission approval, design plans for such concept.

Article 50. Licensee shall purchase in fee and place within the project boundary all lands necessary for project operations including lands for recreational use and shoreline control. The lands encompassed by the project boundary shall include, inter alia:

1. All islands formed by the 793 foot contour, and

2. Shoreline lands up to the 800 foot contour, or up to a 50-foot horizontal measure from the 793 foot contour that in no event shall the project boundary be established at less than the induced surcharge storage elevation at the 795 foot contour.

Licensee shall file a revised Exhibit F and, for Commission approval, a revised K within one year after commencement of operation of the project.

[THE FOLLOWING SECTION WAS ADDED ON 07/24/1980] The Licensee may, in lieu of purchasing fee title to the foregoing project boundary lands, purchase easements over those lands, provided, that such easements contain covenants running with the land sufficient to ensure that the following specifications are met and that the Licensee controls the easement lands according to the specifications. The specifications are:

(1) The owner of the fee title to the land subject to the easement may not clear significant trees (over three-inch caliper) or shrubs (over 4 feet high) from or undertake any permanent or temporary construction or improvement, including roads and landscaping, on project lands except as the Commission has permitted the Licensee to authorize or, in any other instance, as specifically approved by the Commission.

(2) The owner of the fee title to the land subject to the easement shall allow the public free access, to a reasonable extent, to project waters and adjacent project lands for the purpose of public utilization of such lands and waters for navigation and outdoor recreational purposes. This condition does not require the owner of fee title to the land subject to the easement to allow the public free access to or passage across any land not within the easement.

(3) The owner of the fee title to the land subject to the easement shall ensure, to the satisfaction of the Licensee, that all authorized clearing, construction, and improvements on project lands and waters are consistent with shoreline aesthetic values and that all authorized construction and improvements on those lands and waters: (a) are maintained in a good state of repair, (b) comply with State and local health and safety regulations, and (c) are consistent with overall project recreational use.

(4) If authorized clearing, construction, or improvement fails to comply with the conditions of the easement, or with any reasonable conditions imposed by the Licensee for the protection of the environmental quality of project lands and waters, the Licensee may take appropriate action to correct the violations including, if necessary, cancellation of the authorization and removal of any non-complying plantings, structures, or facilities. The Licensee's consent to any authorized construction or improvement shall

not, without its express agreement, place upon the Licensee any obligation to construct or maintain any associated facilities.

In administering any project lands for which it has obtained easements under this article, the Licensee:

(a) May authorize, without further Commission approval, clearing of significant trees (over three-inch caliper) or shrubs (over four-feet high), landscape plantings, and construction, operation, and maintenance of access roads, power and telephone distribution lines, piers, landings, boat docks, or similar structures and facilities, and embankments, bulkheads, retaining walls, or similar structures for erosion control to protect the existing shoreline.

(b) Shall, before authorizing any construction of embankments, bulkheads, retaining walls, or other erosion control structures: (i) inspect the site of the proposed construction, (ii) consider whether planting of vegetation or use of riprap would be adequate to control erosion at the site, and (iii) determine that the proposed construction is needed.

(c) Shall ensure that all authorized clearing of significant trees or shrubs, landscape plantings, and construction or improvements by the owner of the fee title to the land subject to the easement are consistent with shoreline aesthetic values and comply with the conditions of the easement and with any reasonable conditions imposed by the Licensee for the protection of the environmental quality of project lands and waters and that all authorized construction and improvements are maintained in good state of repair and comply with State and local health and safety regulations, and shall take appropriate action to correct any violations, including, if necessary, cancellation of any authorization and removal of any non-complying plantings, structures or facilities.

Article 51. Licensee, in cooperation with the Alabama Water Improvement Commission and the United States Environmental Protection Agency, shall review its heat budget analysis of the reservoir for optimum design and placement of the project intake structures to permit withdrawal of water from selected levels of the reservoir to control the water quality of the discharges from the powerhouse. The design and placement of the intake structures shall be shown on the Exhibit L drawings to be filed for Commission approval prior to the commencement of construction as specified in Article 42 herein.

Article 52. Licensee, within four years from date of issuance of the license, shall file for Commission approval a revised Exhibit S, prepared in accordance with the Commission's Rules and Regulations, and shall include (1) plans for a study of the potential fishery resources of the reservoir to be conducted in cooperation with the appropriate State and Federal fishery agencies; and (2) a description of measures being taken to maintain or change the water quality of the Tallapoosa River downstream from the project.

Article 53. The Licensee shall, prior to commencement of construction, consult with the University of Alabama to determine the extent of any archeological survey and salvage excavations that may be necessary prior to any construction activities and provide funds in a reasonable amount for any needed surveys or salvage excavations to be conducted and completed prior to construction and/or flooding, whichever is applicable.

Article 54. Licensee shall take such measures as may be necessary for control of vectors at the project and shall seek, in this regard, the recommendations of the State of Alabama's Public Health Department. In the event of Licensee's failure to undertake effective control measures, the Commission reserves the right to order, after notice and opportunity for hearing, Licensee to take appropriate measures for the control of vectors at the project.

Article 55. Licensee shall consult and cooperate with the Alabama State Department of Public Health in complying with State and local regulations in planning and providing for the collection, storage, and disposal of solid wastes generated through public access and use of project lands and waters and, within one year after the commencement of operation of the project, shall file with the Commission a solid waste management plan which has been approved by the Alabama Department of Public Health. This plan shall provide, (a) the location of solid waste receptacles to be provided at public areas including campgrounds, picnicking areas, and boat access areas; (b) schedules of collection for the above receptacles; (c) provisions for including in the subject plan any public use areas as they are developed; and (d) disposal sites and methods of disposal.

Article 56. [THE ORIGINAL LICENSE ARTICLE WAS REVISED ON 01/24/1979 AND FURTHER AMENDED ON 10/10/1980] ~~The Licensee shall commence construction of the project within one year from the effective date of the license and shall thereafter in good faith and with due diligence prosecute such construction and shall complete construction of such project works within five years from the effective date of the license.~~

~~The Licensee shall commence construction of the project within one year from the effective date of the license and shall thereafter in good faith and with due diligence prosecute such construction and shall complete construction of such project works within seven years from the effective date of the license.~~

The Licensee shall commence construction of the project on or before November 30, 1974, and shall thereafter in good faith and with due diligence prosecute such construction and shall complete construction of such project works on or before July 31, 1983.

Article 57. [THE FIRST PART CONCERNING THE INSTALLED CAPACITY WAS REVISED 07/12/1984 (28FERC¶62,017) AND THE ENTIRE ARTICLE WAS REVISED ON 02/03/2017 (158FERC¶62,074)] ~~The Licensee shall pay the United States the following annual charge, effective as of the first day of the month in which this license is issued.~~

~~(i) For the purpose of reimbursing the United States for the cost of administration of Part I of the Act, a reasonable annual charge as determined by the Commission in accordance with the provisions of its regulations, in effect from time to time. The authorized installed capacity for such purposes is 180,000 horsepower.~~

~~For the purpose of reimbursing the United States for the cost of administration of Part I of the Act, a reasonable annual charge as determined by the Commission in accordance with the provisions of its regulations, in effect from time to time. The authorized installed capacity for such purposes is 190,000 horsepower.~~

~~(ii) For the purpose of recompensing the United States for the use, occupancy, and enjoyment of 58.2 acres of its lands: $139.68.~~

The licensee shall pay the United States the following annual charge, effective the issuance date of this order.

(i) For the purpose of reimbursing the United States for the cost of administration of Part I of the Act, a reasonable annual charge as determined by the Commission in accordance with the provisions of its regulations, in effect from time to time. The authorized installed capacity for such purposes is 190,000 horsepower.

(ii) For the purpose of recompensing the United States for the use, occupancy, and enjoyment of 4.90 acres of its lands, such amount as may be determined from time to time pursuant to the Commission's regulations.

Article 58. The terms and conditions expressly set forth in the license shall not be construed as impairing any terms and conditions of the Federal Power Act which are not expressly set forth herein.

Article 59. [THIS ARTICLE WAS ADDED ON 08/24/1976] Pursuant to Section 10(d) of the Act, after the first 20 years of operation of the project under the license, a specified reasonable rate of return upon the net investment in the project shall be used for determining surplus earnings of the project for the establishment and maintenance of amortization reserves. One half of the project surplus earnings, if any, accumulated after the first 20 years of operation under the license, in excess of the specified rate of return per annum on the net investment, shall be set aside in a project amortization reserve account as of the end of each fiscal year: Provided, that, if and to the extent that there is a deficiency of project earnings below the specified rate of return per annum for any fiscal year or years after the first 20 years of operation under the license, the amount of such deficiency shall be deducted from the amount of any surplus earnings accumulated thereafter until absorbed, and one-half of the remaining surplus earnings, if any, thus cumulatively computed, shall be set aside in the project amortization reserve account; and the amounts thus established in the project amortization reserve account shall be maintained until further order of the Commission.

The annual specified reasonable rate of return shall be the sum of the weighted cost components of long-term debt, preferred stock, and the cost of common equity, as defined herein. The weighted cost component for each element of the reasonable rate of return is the product of its capital ratios and cost rate. The current capital ratios for each of the above elements of the rate of return shall be calculated annually based on an average of 13 monthly balances of amounts properly includable in the Licensee's long-term debt and proprietary capital accounts as listed in the Commission's Uniform System of Accounts. The cost rates for such ratios shall be the weighted average cost of long-term debt and preferred stock for the year, and the cost of common equity shall be the interest rate on 10-year government bonds (reported as the Treasury Department's10 year constant maturity series) computed on the monthly average for the year in question plus four percentage points (400 basis points).

Article 60. [THIS ARTICLE WAS ADDED ON 08/05/1976 AND THEN RENUMBERED AND REVISED ON 10/06/1976] ~~License shall, by January 31, 1977, file for Commission approval a site plan for the permanent overlook area showing its location on the west side of the reservoir, as determined after consultation with the Bureau of Outdoor Recreation of the U.S. Department of the Interior and the State of Alabama Department of Conservation and Natural Resources.~~

Licensee shall, by January 31, 1977, file for Commission approval a site plan for the permanent overlook area showing its location on the west side or the east side of the reservoir, as determined after consultation with the Bureau of Outdoor Recreation of the U.S. Department of the Interior and the State of Alabama Department of Conservation and Natural Resources.

Article 61. [THIS ARTICLE WAS ADDED ON 05/07/1981] (a) In accordance with the provisions of this article, the Licensee shall have the authority to grant permission for certain types of use and occupancy of project lands and waters and to convey certain interests in project lands and waters for certain other types of use and occupancy, without prior Commission approval. The Licensee may exercise the authority only if the proposed use and occupancy is consistent with the purposes of protecting and enhancing the scenic, recreational, and other environmental values of the project. For those purposes, the Licensee shall also have continuing responsibility to supervise and control the use and occupancies for which it grants permission, and to monitor the use of, and ensure compliance with the covenants of the instrument of conveyance for, and interests that it has conveyed, under this article. If a permitted use and occupancy violates any condition of this article or any other condition imposed by the Licensee for protection and enhancement of the project's scenic, recreational, or other environmental values, of if a covenant of a conveyance made under the authority of this article is violated, the Licensee shall take any lawful action necessary to correct the violation. For a permitted use or occupancy, that action includes, if necessary, cancelling the permission to use and occupy the project lands and waters and requiring the removal of any non-complying structures and facilities.

(b) The types of use and occupancy of project lands and waters for which the Licensee may grant permission without prior Commission approval are: (1) landscape plantings; (2) non-commercial piers, landings, boat docks, or similar structures and facilities; and (3) embankments, bulkheads, retaining walls, or similar structures for erosion control to protect the existing shoreline. To the extent feasible and desirable to protect and enhance the project's scenic, recreational and other environmental values, the Licensee shall require multiple use and occupancy of facilities for access to project lands or waters. The Licensee shall also ensure, to the satisfaction of the Commission's authorized representative, that the uses and occupancies for which it grants permission are maintained in good repair and comply with applicable State and local health and safety requirements. Before granting permission for construction of bulkheads or retaining walls, the Licensee shall: (1) inspect the site of the proposed construction, (2) consider whether the planting of vegetation or the use of riprap would be adequate to control erosion at the site, and (3) determine that the proposed construction is needed and would not change the basic contour of the reservoir shoreline. To implement this paragraph (b), the Licensee may, among other things, establish a program for issuing permits for the specified types of use and occupancy of project lands and waters, which may be subject to the payment of a reasonable fee to cover the Licensee's costs of administering the permit program. The Commission reserves the right to require the Licensee to file a description of its standards, guidelines, and procedures for implementing this paragraph (b) and to require modification of those standards, guidelines, or procedures.

(c) The Licensee may convey easements or rights-of-way across, or leases of, project lands for: (1) replacement, expansion, realignment, or maintenance of bridges and roads for which all necessary State and Federal approvals have been obtained; (2) storm drains and water mains; (3) sewers that do not discharge into project waters; (4) minor access roads; (5) telephone, gas, and electric utility distribution lines; (6) non-project overhead electric transmission lines that do not require erection of support structures within the project boundary; (7) submarine, overhead, or underground major telephone distribution cables or major electric distribution lines (69 kV or less); and (8) water intake or pumping facilities that do not extract more than one million gallons per day from a project reservoir. No later than January 31 of each year, the Licensee shall file three copies of a report briefly describing for each conveyance made under this paragraph (c) during the prior calendar year, the type of interest conveyed, the location of the lands subject to the conveyance, and the nature of the use for which the interest was conveyed.

(d) The Licensee may convey fee title to , easements or rights-of-way across, or leases or project lands for: (1) construction of new bridges or roads for which all necessary State and Federal approvals have been obtained; (2) sewer or effluent lines that discharge into project waters, for which all necessary Federal and State water quality certificates or permits have been obtained; (3) other pipelines that cross project lands or waters but do not discharge into project waters; (4) non-project overhead electric transmission lines that require erection of support structures within the project boundary, for which all necessary Federal and State approvals have been obtained; (5) private or public marinas that can accommodate no more than 10 watercraft at a time and are located at least one-half mile from any other private or public marina; (6) recreational development consistent with an approved Exhibit R or approved report on recreational resources of an Exhibit E; and (7) other uses, if: (i) the amount of land conveyed for a particular use is five acres or less; (ii) all of the land conveyed is located at least 75 feet, measured horizontally, from the edge of the project reservoir at normal maximum surface elevation; and (iii) no more than 50 total acres of project lands for each project development are conveyed under this clause (d)(7) in any calendar year. At least 45 days before conveying any interest in project lands under this paragraph (d), the Licensee must file a letter to the Director, Office of Electric Power Regulation, stating its intent to convey the interest and briefly describing the type of interest and location of the lands to be conveyed (a marked Exhibit G or K map may be used), the nature of the proposed use, the identity of any Federal or State agency official consulted, and any Federal or State approvals required for the proposed use. Unless the Director, within 45 days from the filing date, requires the Licensee to file an application for prior approval, the Licensee may convey the intended interest at the end of that period.

(e) The following additional conditions apply to any intended conveyance under paragraphs (c) or (d) of this article:

(1) Before conveying the interest, the Licensee shall consult with Federal and State fish and wildlife or recreation agencies, as appropriate, and the State Historic Preservation Officer.

(2) Before conveying the interest, the Licensee shall determine that the proposed use of the lands to be conveyed is not inconsistent with any approved Exhibit R or approved report on recreational resources of an Exhibit E; or, if the project does not have an approved Exhibit R or approved report on recreational resources, that the lands to be conveyed do not have recreational value.

(3) The instrument of conveyance must include covenants running with the land adequate to ensure that: (i) the use of the lands conveyed shall not endanger health, create a nuisance, or otherwise be incompatible with overall project recreational use; and (ii)The grantee shall take all reasonable precautions to ensure that the construction, operation, and maintenance of structures or facilities on the conveyed lands will occur in a manner that will protect the scenic, recreational, and environmental values of the project.

(4) The Commission reserves the right to require the Licensee to take reasonable remedial action to correct any violation of the terms and conditions of this article, for the protection and enhancement of the project’s scenic, recreational, and other environmental values.

(f) The conveyance of an interest in project lands under this article does not in itself change the project boundaries. The project boundaries may be changed to exclude land conveyed under this article only upon approval of revised Exhibit G or R drawings (project boundary maps) reflecting exclusion of that land. Lands conveyed under this article will be excluded from the project only upon a determination that the lands are not necessary for project purposes, such as operation and maintenance, flowage, recreation, public access, protection of environmental resources, and shoreline control, including shoreline aesthetic values. Absent extraordinary circumstances, proposals to exclude lands conveyed under this article from the project shall be consolidated for consideration when revised Exhibit G or K drawings would be filed for approval for other purposes.

<u>Article 62.</u> [THIS ARTICLE WAS ADDED ON 09/21/1984 (28FERC¶61,370)] Licensee shall, prior to commencement of any future construction at the project, consult with the Alabama State Historic Preservation Officer (SHPO) about the need for any cultural resource survey to salvage work. The Licensee shall make available funds in a reasonable amount for any such work as required.

If any previously unrecorded archeological or historical sites are discovered during the course of construction or development of any project works or other facilities at the project, construction activity in the vicinity shall be halted, a qualified archeologist shall be consulted to determine the significance of the sites, and the Licensee shall consult with the SHPO to develop a mitigative plan for the protection of significant archeological or historical resources. If the Licensee and the SHPO cannot agree on the amount of money to be expended on archeological or historical work related to the project, the Commission reserves the right to require the Licensee to conduct, at its own expense, any such work found necessary.

If the Licensee authorizes other persons to undertake any construction or development on project lands, the Licensee shall ensure that such construction or development is carried out in compliance with the provisions of this article.

<u>Article 63.</u> [THIS ARTICLE WAS ADDED ON 09/21/1984 (28FERC¶61,370) AND REVISED ON 12/20/1984] ~~Licensee shall, after consultation with the U.S. Fish and Wildlife Service and the Alabama Department of Conservation and Natural Resources,~~

~~and within 1 year from the date of this order, file for Commission approval, a wildlife mitigative plan for the R.L. Harris Project. The plan shall include the management of project land for wildlife enhancement, the designation and management of additional lands for wildlife enhancement, and an implementation schedule and cost estimates for these actions. Agency comments on the plan shall be included in the filing. The Commission reserves the right to require any appropriate changes in the plan.~~

Licensee shall, after consultation with the U.S. Fish and Wildlife Service and the Alabama Department of Conservation and Natural Resources, and within 1 year from the date of this order, file for Commission approval, a wildlife mitigative plan for the R.L. Harris Project. The plan shall include the management of project land for wildlife enhancement, if necessary the designation and management of additional non-project lands for wildlife enhancement, and an implementation schedule and cost estimates for these actions. Agency comments on the plan shall be included in the filing. The Commission reserves the right to require any appropriate changes in the plan.

Article 64. [THIS ARTICLE WAS ADDED ON 05/21/1985 (81FERC¶62,237)] The Licensee shall, after consultation with the Alabama Department of Conservation and Natural Resources and the National Park Service, file for Commission approval within 6 months of the publication date of the 1985-1990 Alabama Statewide Comprehensive Outdoor Recreation Plan, or by June 30, 1986, whichever comes first, a revised public park recreational development schedule and a nature trail development schedule for the R.L. Harris Project. Comments received from the above-mentioned agencies shall be included in the filing.

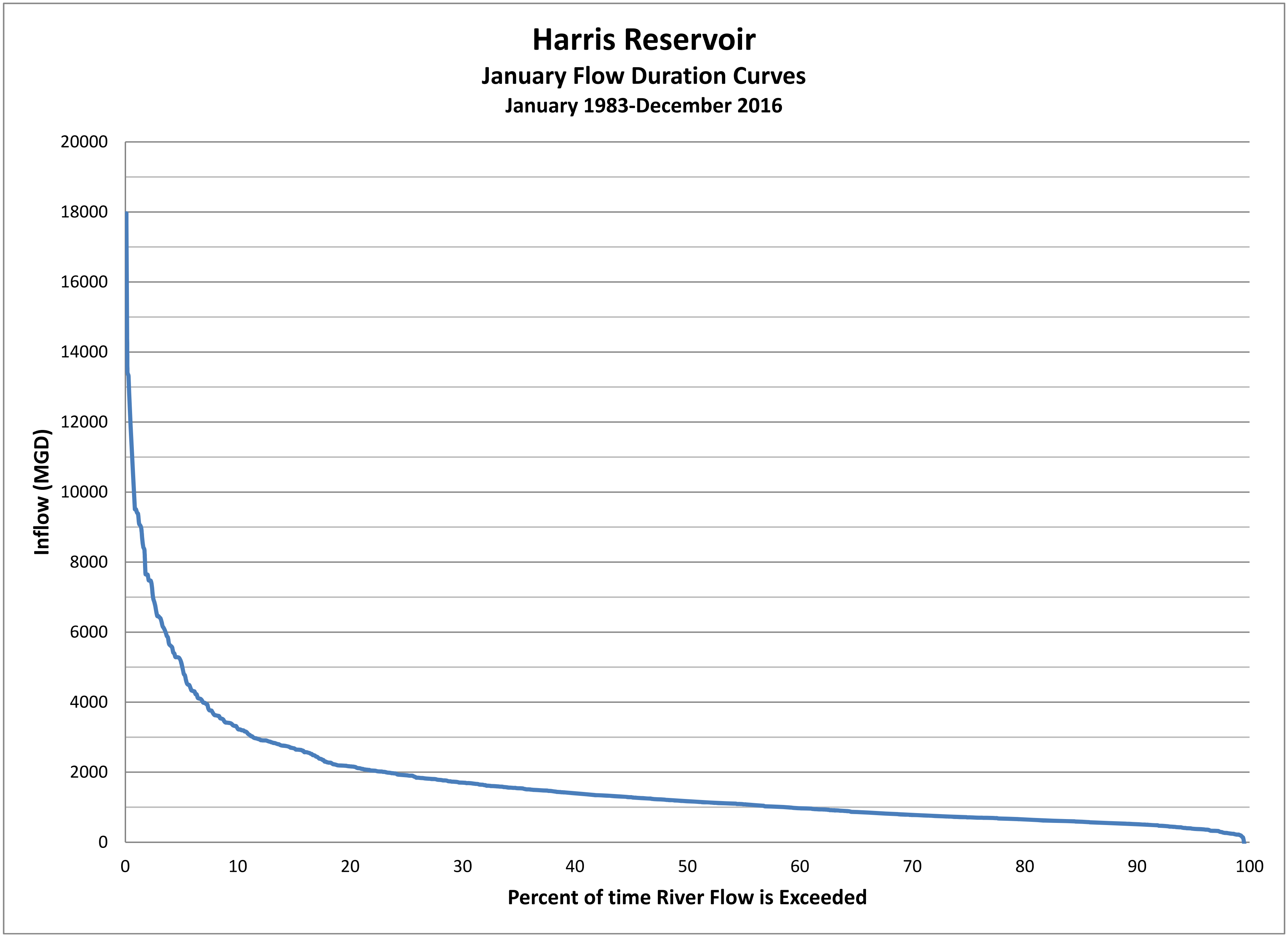
Article 65. [THIS ARTICLE WAS ADDED ON 12/02/1987] The Licensee, within 2 years from the issuance date of this order, shall consult with the Alabama Department of Conservation and Natural Resources and the National Park Service, to determine the final location of the backpacking/hiking and nature trails to be constructed between 1990-1994. In addition, the Licensee shall file for Commission approval a map showing the type, location and length of these trails. Documentation of agency consultation shall be included in the filing.

(D) The Exhibits designated and described in Paragraph (B) above are hereby approved and made a part of this license, except the items designated as R-3 and R-4 in Exhibit R are not approved.

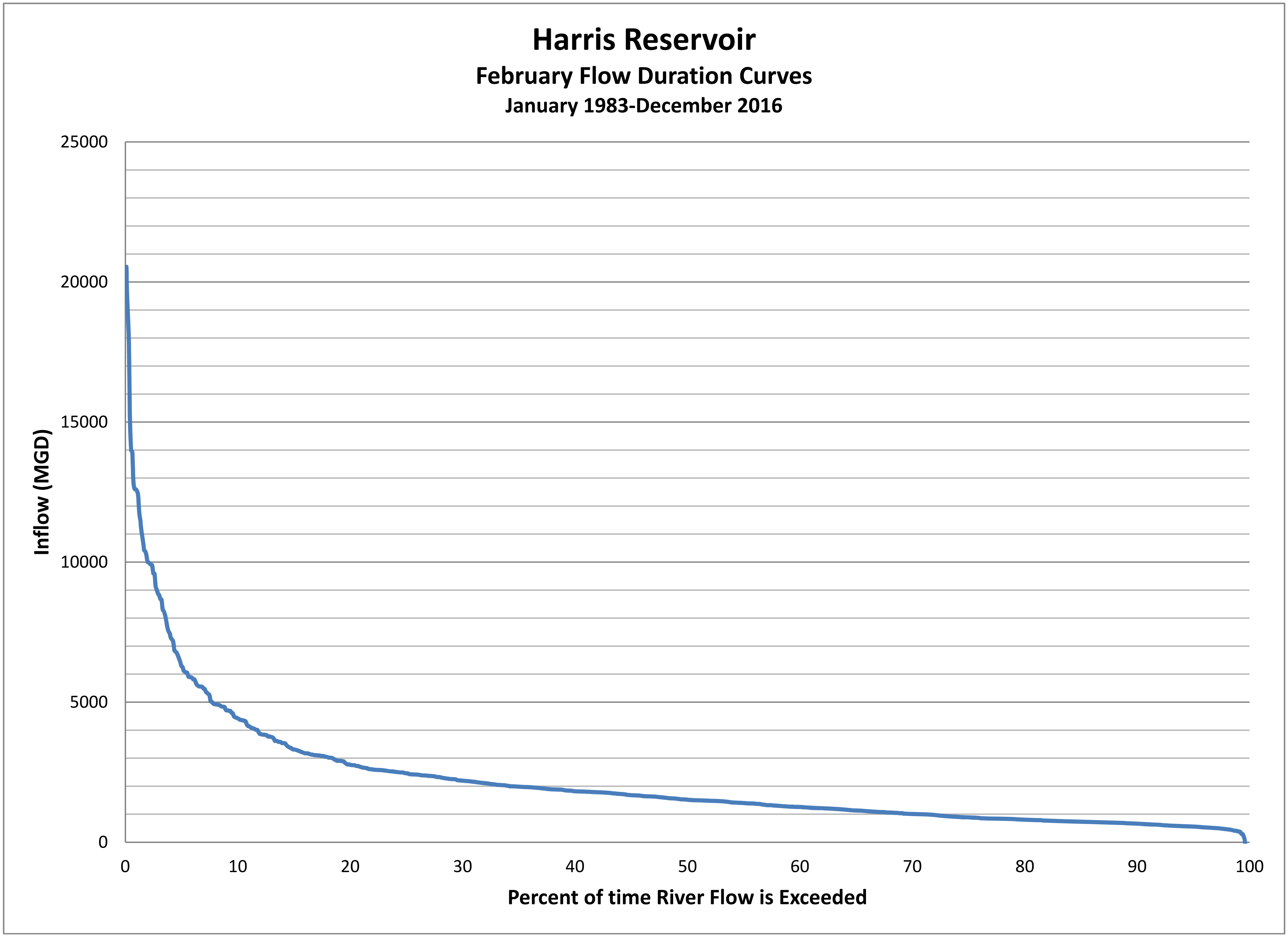
(E) This order shall become final 30 days from the date of its issuance unless application for rehearing shall be filed as provided in Section 313(a) of the Act, and failure to file such an application shall constitute acceptance of this license. In acknowledgement of the acceptance of this license it shall be signed for the Licensee and returned to the Commission within 60 days from the date of issuance of this order.

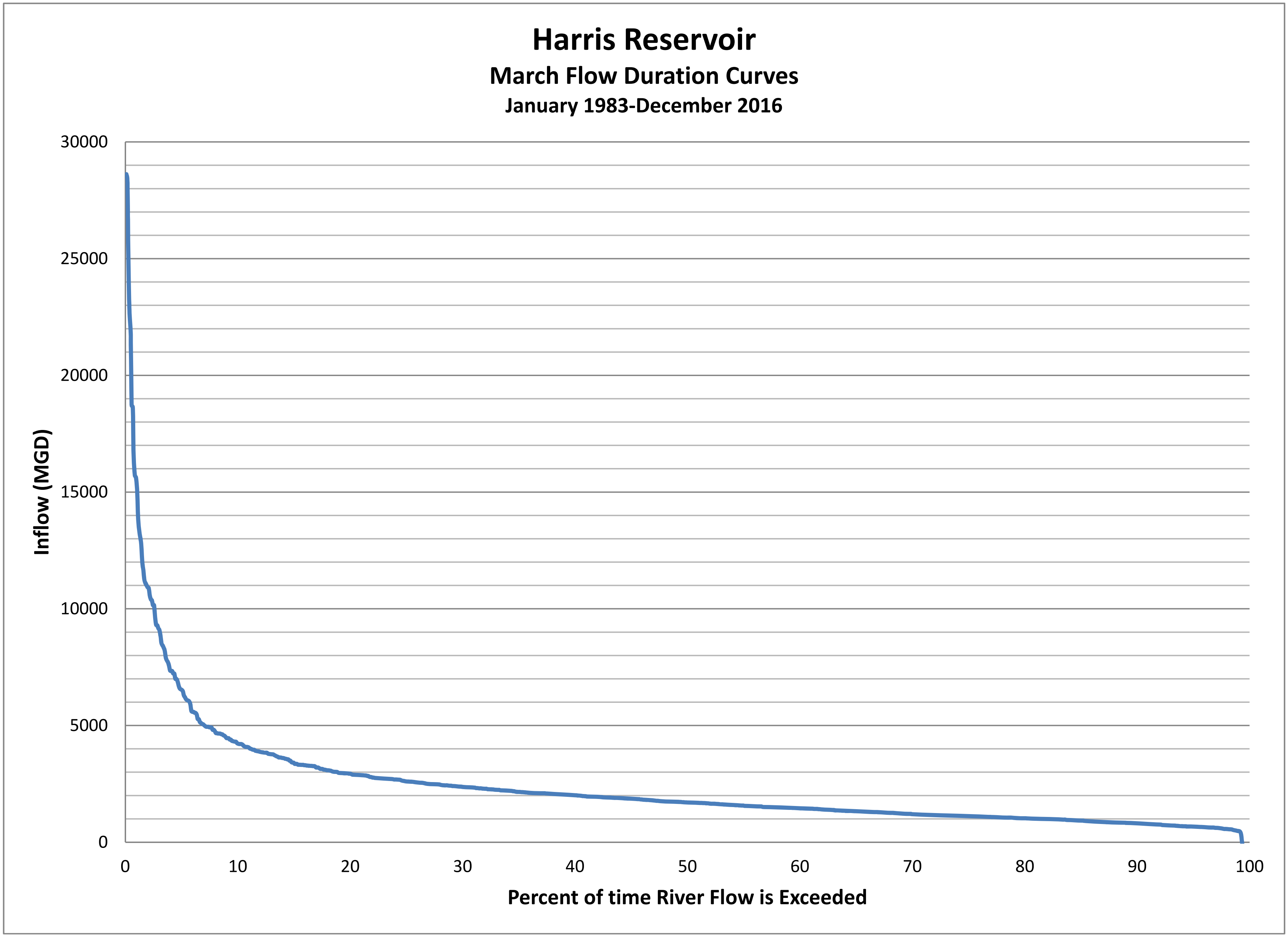
Appendix G
R.L. Harris Flow Duration Curves

Appendix G

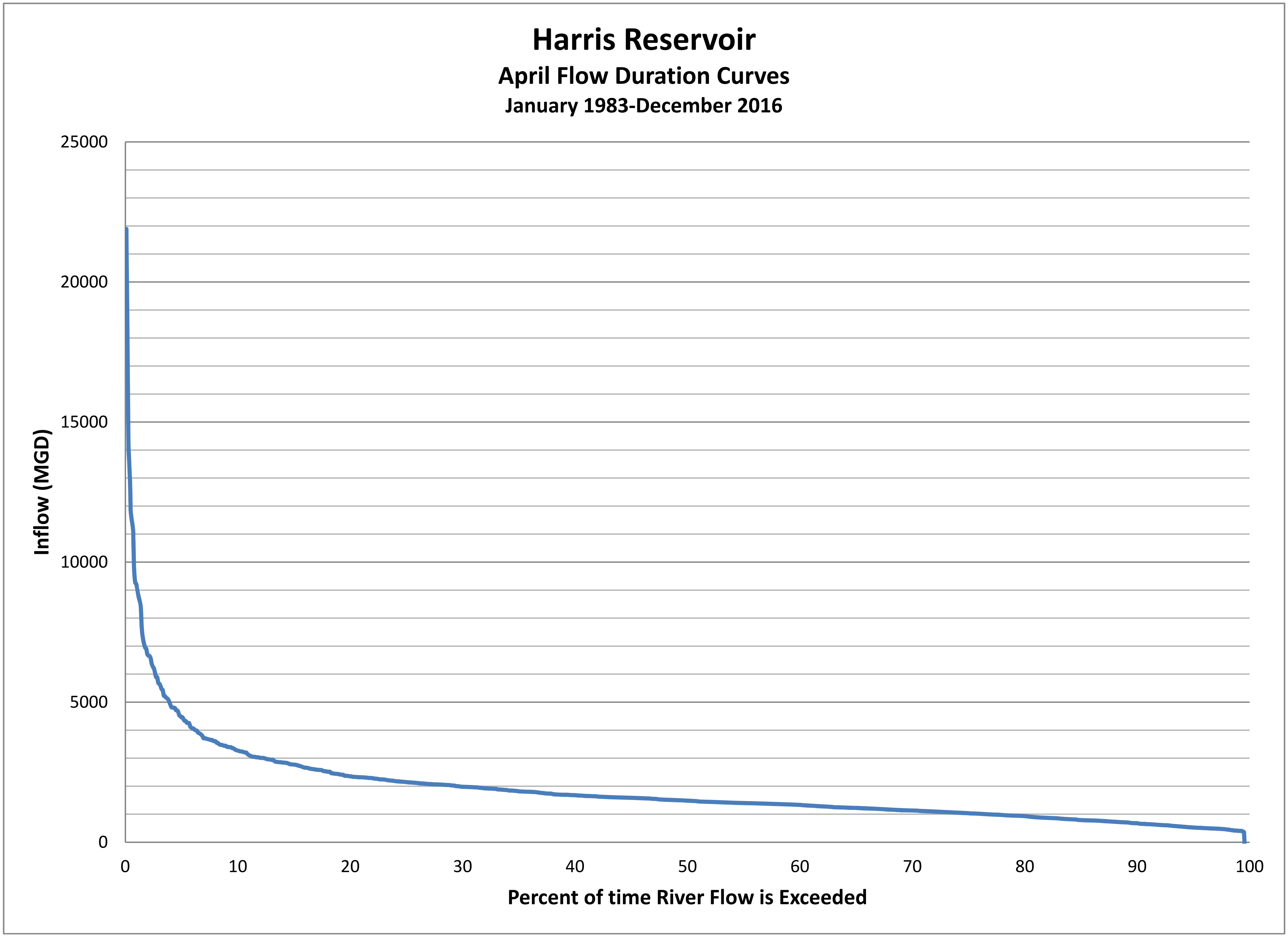


Harris Reservoir
January Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded


Harris Reservoir
February Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

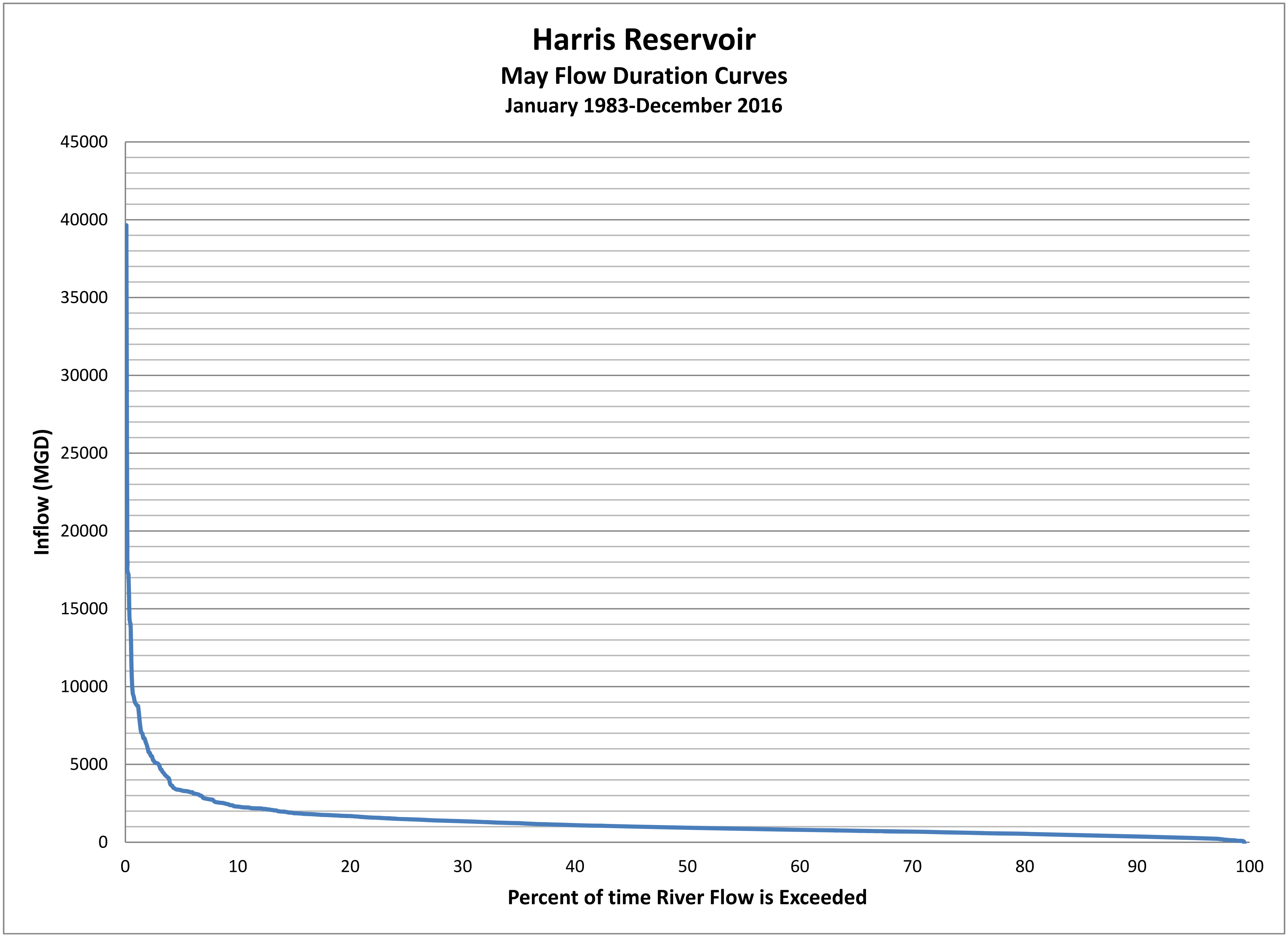

Harris Reservoir
March Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
30000
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

Appendix G

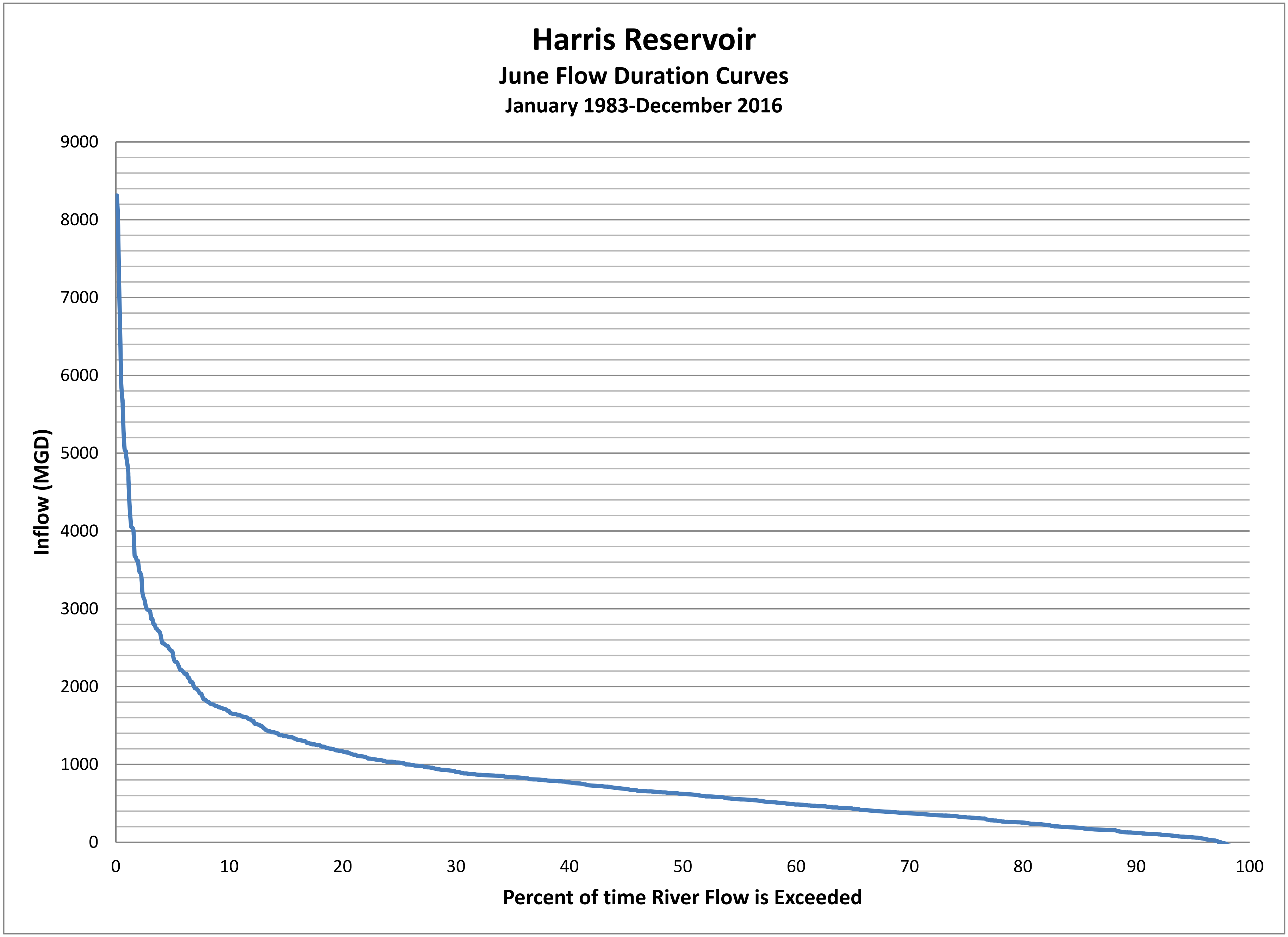


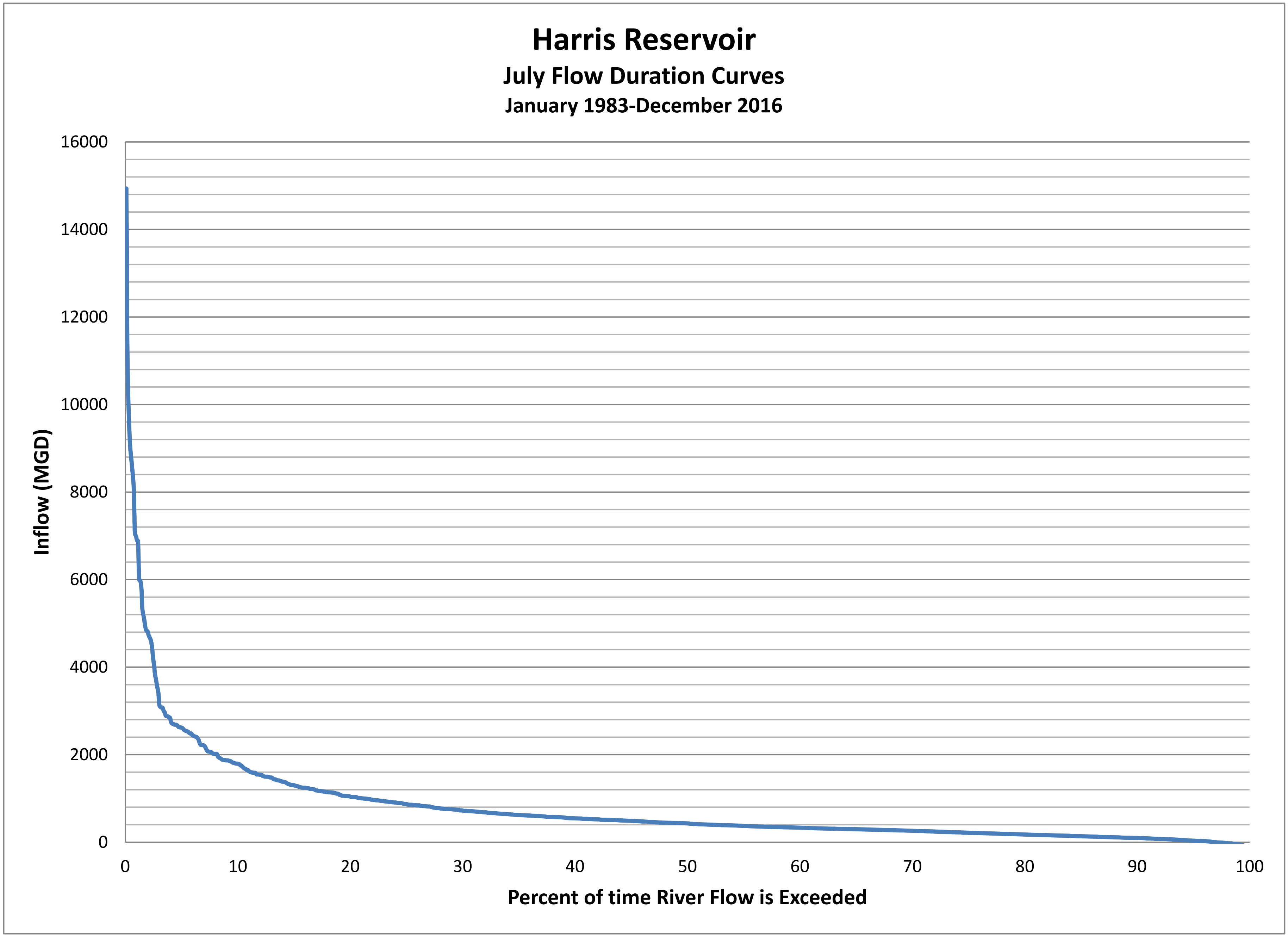
Harris Reservoir
April Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

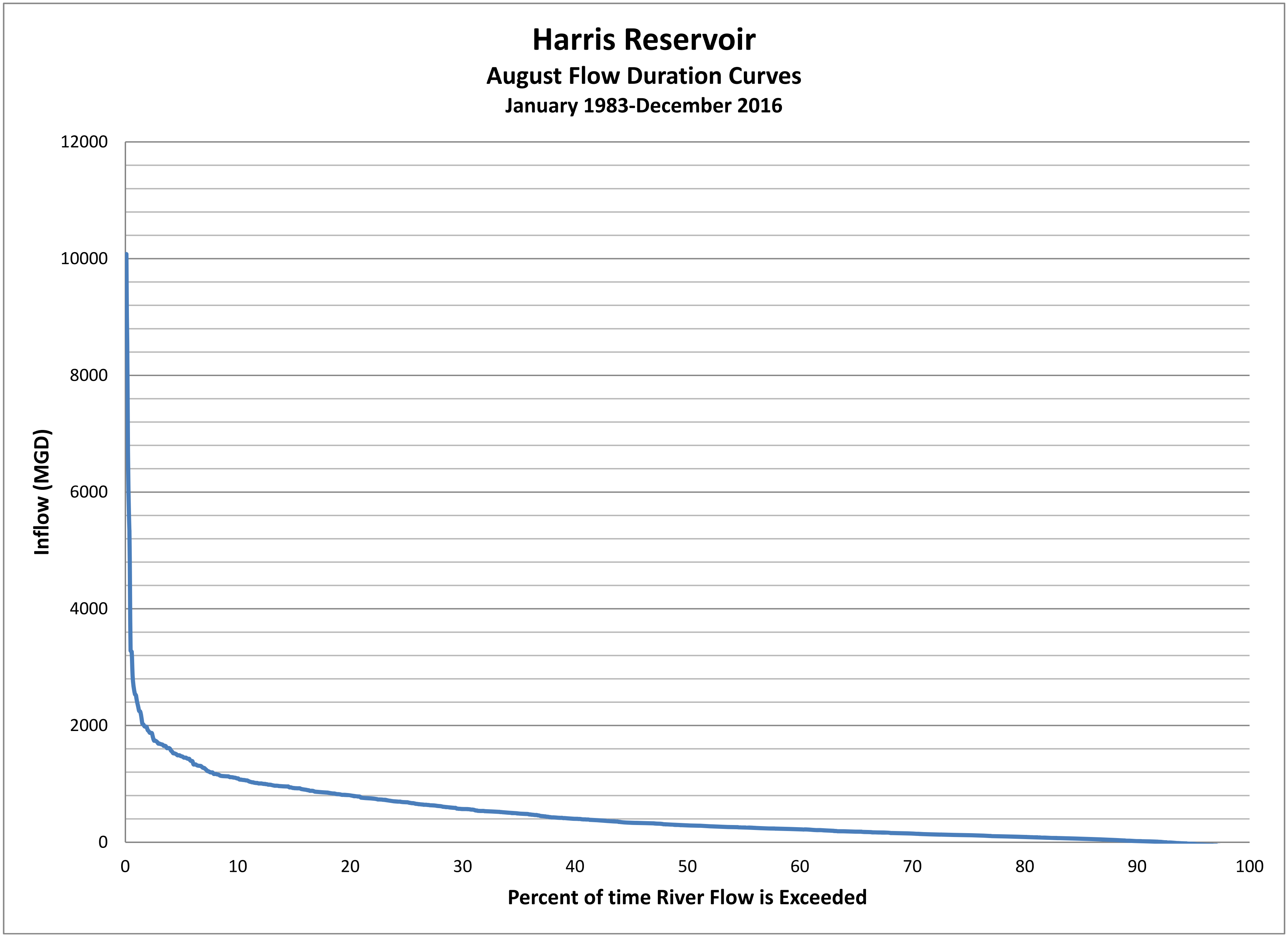
Appendix G

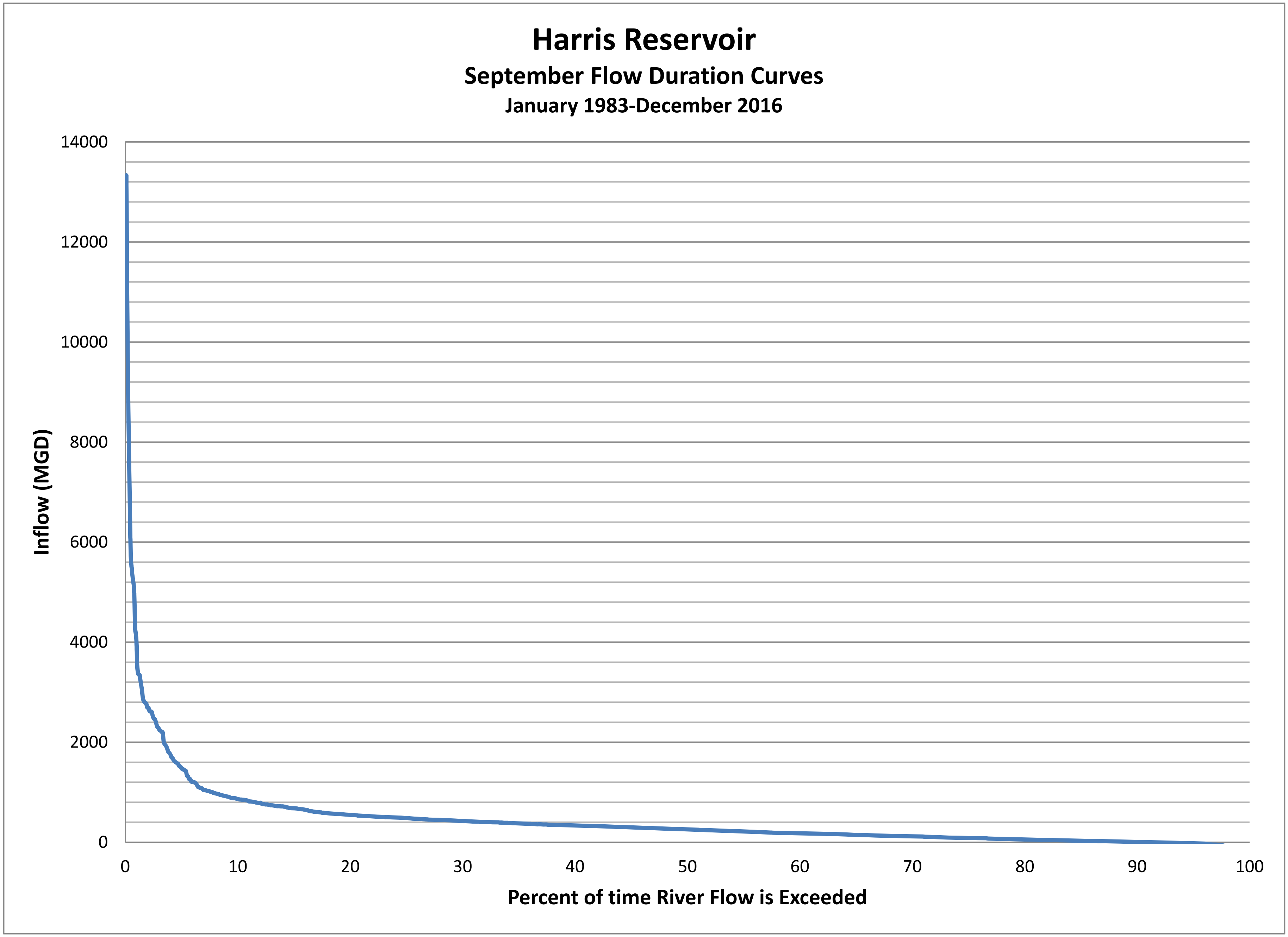


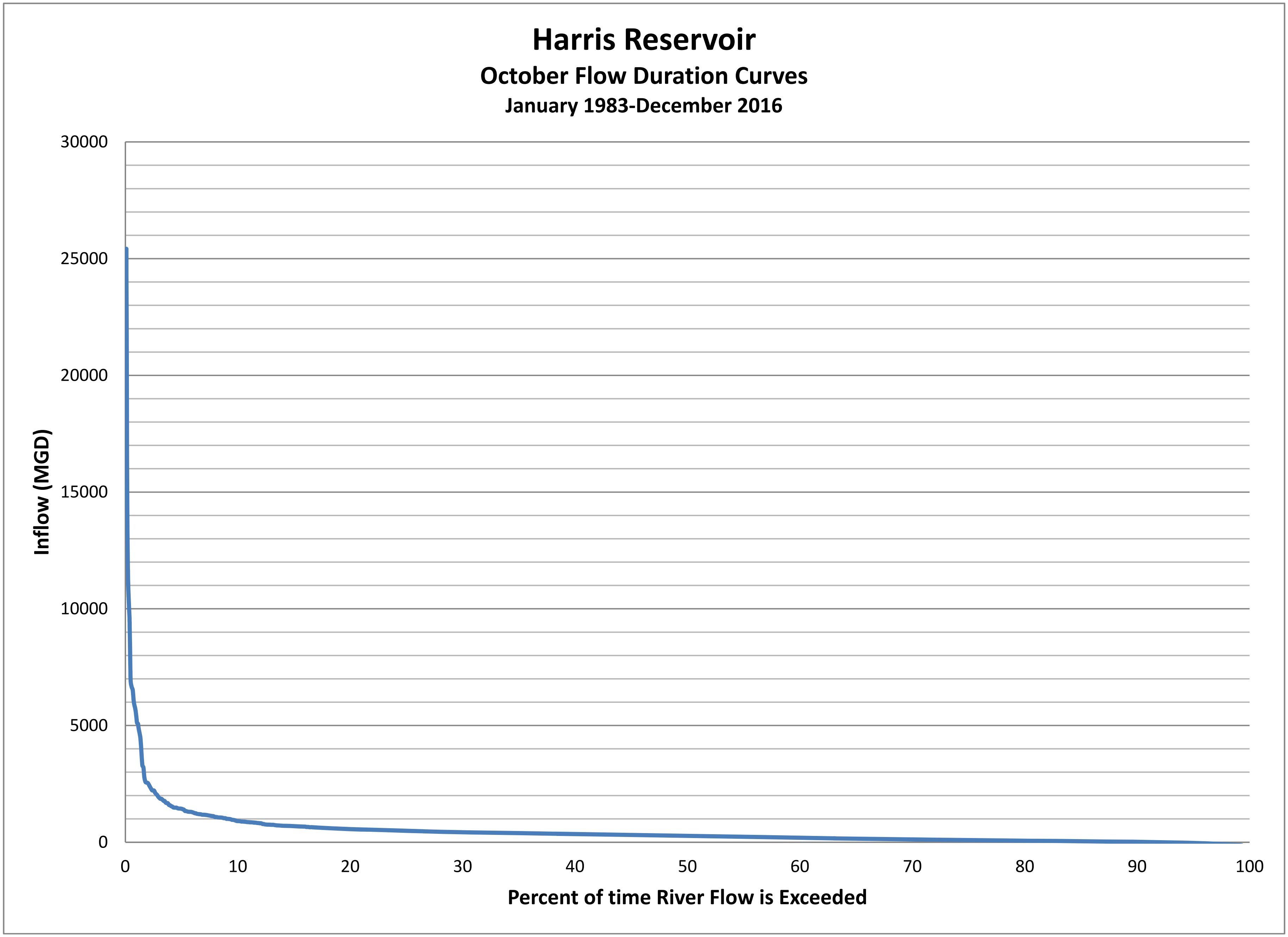
Harris Reservoir
May Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

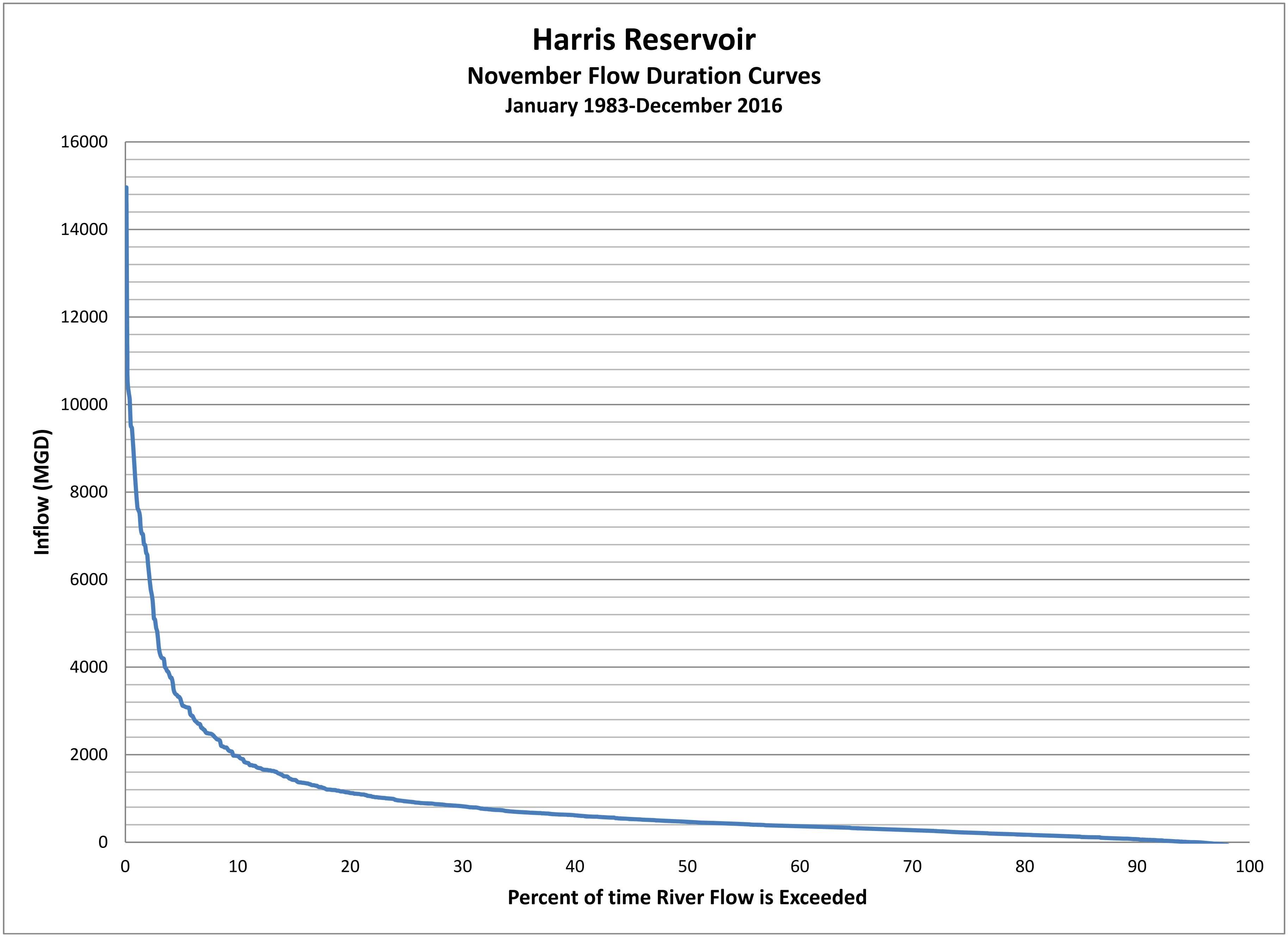

Harris Reservoir
June Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded


Harris Reservoir
July Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

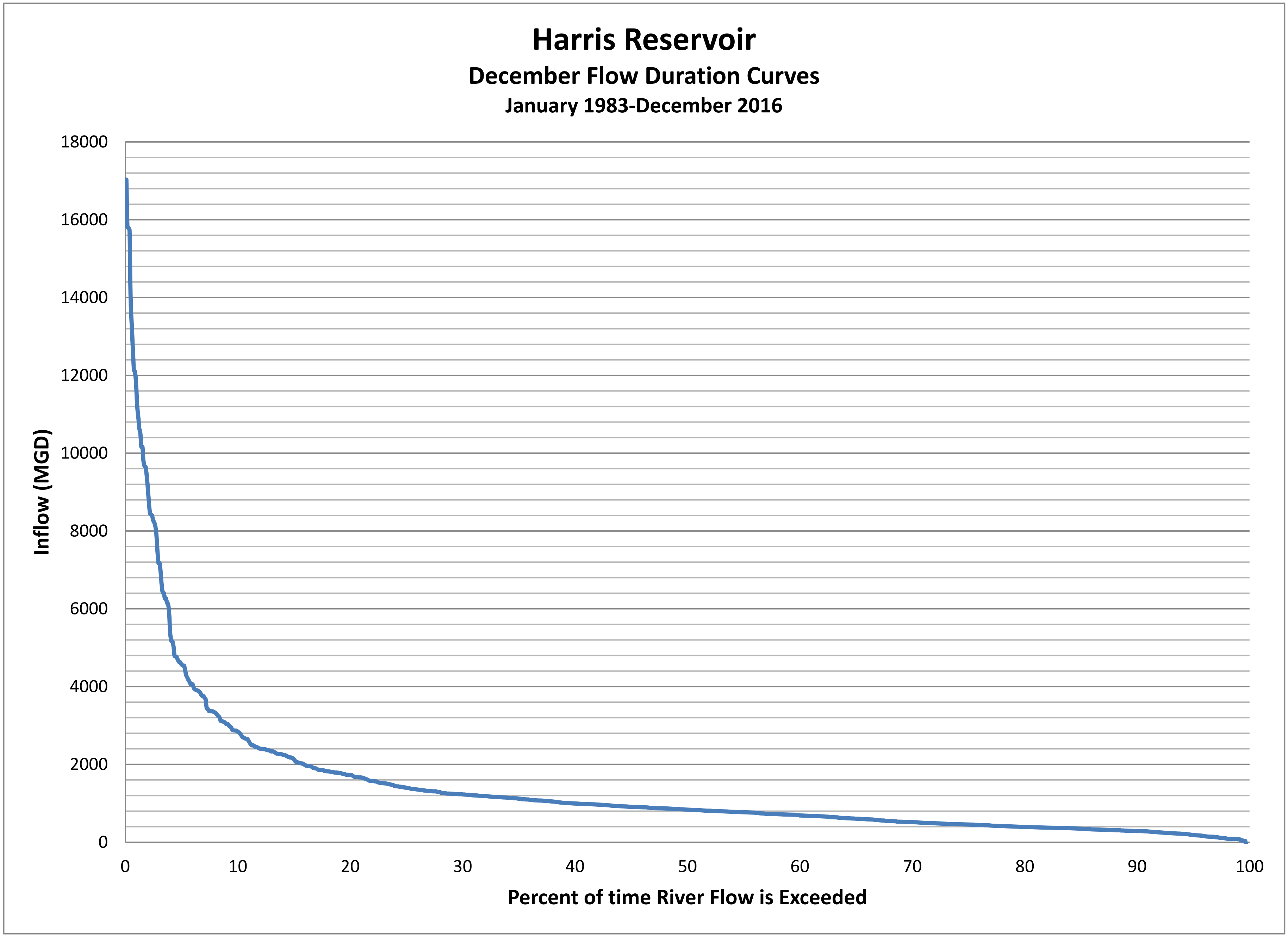

Harris Reservoir
August Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded


Harris Reservoir
September Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded


Harris Reservoir
October Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
30000
25000
20000
15000
10000
5000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded


Harris Reservoir
November Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
16000
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

Appendix G



Harris Reservoir
December Flow Duration Curves
January 1983-December 2016
Inflow (MGD)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
Percent of time River Flow is Exceeded

Appendix H
Physiographic Description of Harris and Skyline

Physiography of the Lake Harris Project Vicinity

The Northern Piedmont

The Northern Piedmont consists of three sections called blocks; the Tallapoosa block, the Coosa block, and the Talladega block. The Project area is within the Tallapoosa and Coosa blocks. The Tallapoosa block contains rocks of the Wedowee Group, the Hackneyville schist, the Cornhouse schist and the Emuckfaw Formation. The Wedowee Group consists of a wide range of sericite phyllites, feldspathic-biotite-quartz gneiss and quartzite. The Hackneyville schist is composed of muscovite and biotite schist, and biotite quartz schist with occasional kyanite. The Cornhouse schist consists of interlayered chlorite-biotitegarnet schist and muscovite-biotite-garnet-quartz-plagioclase schist. Quartzite and layered amphibolites are also present. The Emuckfaw Formation is interlayered metagraywacke and muscovite-garnet-biotite-schist with local occurrences of quartzite and amphibolite (Raymond, et al. 1988).

In addition to the regionally metamorphosed rocks of the Tallapoosa block, granitoid plutons composed of the Elkahatchee quartz diorite gneiss, the Zana granite and Kowaliga gneiss occur in the Tallapoosa block. The Coosa block contains rocks of the Poe Bridge Mountain Group, the Mad Indian Group, the Wedowee Group, the Higgins Ferry Group and the Hatchet Creek Group. The Wedowee Group consists of quartz-graphite-sericite phyllite to fine-grained schist and chlorite-sericite phyllite to fine-grained schist. The Poe Bridge Mountain and Higgins Ferry Groups contain sequences of interlayered coarse-grained graphitic feldspathic mica schist, graphitic and garnetiferous quartzite, garnet mica schist, fine-grained biotite gneiss and quartzite. These groups also are associated with major amphibolite sequences: the Ketchepedrakee Amphibolite with the Poe Bridge Mountain Group and the Mitchell Dam Amphibolite with the Higgins Ferry Group. The Mad Indian and Hatchet Creek Groups consists of feldspathic garnet-quartz-muscovite schist, minor amounts of biotite (garnet) schist and gneiss, micaceous quartzite, migmatitic gneiss and rare amphibolite. They also typically contain abundant pegmatite and small granitoid bodies (Raymond et al. 1988).

Structural Features

The dominant features in the Piedmont are northeast-trending ridges underlain by resistant quartzite and quartz-rich schists. The linear ridges to the northwest and northeast of the dam site are a result of tectonic movement approximately 500 million years ago. Triassic dikes intruded into the area approximately 200 million years ago and show no sign of any movement since that time. The Tallapoosa block contains the Alexander City fault and a series of cataclastic zones. The Alexander City fault divides the Wedowee Group and Emuckfaw Formation (Beg 1987). The Enitachopco fault separates the Coosa block from the Tallapoosa block. The Enitachopco fault also divides the Coosa block into two subregional salient. The Project is located in the northeastern salient containing the Poe Bridge Mountain Group and the Mad Indian Group. The southwest salient contains the Wedowee Group, the Higgins Ferry Group and the Hatchet Creek Group (Raymond et al. 1988).

Mineral Resources in the Project Vicinity

Reportedly, during the late 1830s, gold discovered in Randolph County was found primarily in lode deposits associated with quartz veins. The only known placer deposits were in the Bradley prospect, which is flooded by the backwaters of Lake Harris. The only other gold prospect found within the Project area was the Morris Property prospect, a lode deposit. Many of the gold mines and prospects discovered within Randolph County were discovered southwest of Harris Dam (Beg 1987).

Systematic mica mining in Randolph County started around 1870. Mica is a platy mineral that splits into very thing tough sheets as small as 1/1000 of an inch. Muscovite mica is a very common mineral found in many of the granitic, gneissic, schistose and phyllitic rocks of Randolph County. Commercially, mica is divided into sheet mica and scrap mica. Scrap mica is commonly used as a filler in roofing and siding, shingles, wallboard, drilling mud, rubber, plastic, paints and other synthetic goods. Sheet mica is used as an electrical and heat insulation material. Many of the mica mines and prospects are located in northeastern Randolph County. A number of the prospects fall within Project lands or are covered by Lake Harris (Beg 1987).

Three major varieties of granitic rock occur in Randolph County: the Almond Trondhjemite, the Bluff Springs Granite and the Rock Mills Granite Gneiss. The Almond Trondhjemite and the Bluff Springs Granite are present with the Project area. The Almond Trondhjemite is a light-colored equigranular rock that forms large pavement areas in the Blake Ferry and Almond plutons. The Blake Ferry pluton was quarried for the construction of the R.L. Harris Dam. The Bluff Springs Granite has not been quarried in Randolph County; however, it exhibits similar characteristics and composition to other granitic rocks used for road material and aggregate. The only granite quarry within the Project area was the quarry used during construction of the Harris Dam, which is now flooded by Lake Harris (Beg 1987).

Deposits of mixed sand, clay and gravel occur extensively in the fluvial deposits along the flood plains and low terraces of the major drainage systems within Randolph County. The most extensive deposits occur along the Tallapoosa and Little Tallapoosa rivers. Now many of these larger deposits, found within the Project area, are flooded by Lake Harris; however, deposits are located along the Little Tallapoosa upstream of the area of Project effect. There are six quarries located within the deposits along the Little Tallapoosa (Beg 1987).

Physiography of the Skyline Project Vicinity

Jackson County Mountains District

The Jackson County Mountain district is a submaturely dissected plateau of high relief characterized by mesa-like sandstone remnants above limestone lowland (Sapp and Emplaincourt 1975). Rock formations observed in the Project area include: the Pottsfield formation, Pennington formation, Bangor Limestone, Monteagle Limestone and Tuscumbia Limestone (Raymond et. al.1988 [citation includes information in the following list]):

- **Pottsfield formation** consists primarily of sandstone and shale with some coal and limestone
- **Pennington formation** consists of a lower supratidal dolostone subsequently overlain by fine-grained shallow-marine clastics
- **Bangor Limestone** is a bioclastic and oolitic limestone containing interbeds of mudstone and shale
- **Monteagle Limestone** consists of massive cross-bedded oolitic and bioclastic limestone
- **Tuscumbia Limestone** is a bioclastic or micritic, partially oolitic, limestone with local abundant chert

Structural Features

The Cumberland Plateau (referred to as the Appalachian Plateau) is underlain by Paleozoic sedimentary rocks. The Paleozoic sedimentary rocks are underlain by crystalline basement rock of Precambrian age. The Cumberland Plateau includes northeast-trending anticlines including the Sequatchie, Murphrees Valley, and Wills Valley. The Sequatchie and Wills Valley anticlines are asymmetric to the northwest and include southeast-dipping thrust faults along parts of the northwest limbs. The Murphrees Valley anticline is asymmetric to the southeast and is bounded on the southeast side by the northwest-dipping Straight Mountain fault. Synclinal Sand, Lookout, and Blount mountains separate the anticlines. The Paleozoic sedimentary rocks dip southwestward into the Black Warrior basin beneath the coastal plain overlap (Raymond et al. 1988).

Mineral Resources

Historically, there has been extensive mining within the Cumberland Plateau of Alabama. Two of the largest coalfields lie beneath the province (Raymond et al. 1988). Twenty-one listed abandoned mines previously operated within Jackson County; however, there are no listed mines operating within Jackson County as of 2013 (Whitson 2013). The primary resource mined within the county historically has been coal, commonly found in the Pottsfield formation. There is potential for limestone quarries in Jackson County due to the presence of the Monteagle and Tuscumbia limestones. Historically, the formations quarried in other counties were located within the Cumberland Plateau (Raymond et al. 1988).

Appendix I
Soil Types Located in Lake Harris Vicinity

Soil Types Located in the Lake Harris Vicinity

Clay County Soils

Soils in Clay County encompass approximately 29 acres of the approximate 19,194 acres within the Harris Project boundary. Soils encountered include the Chewacla-Riverview complex, the Grover association, the Madison-Riverview association and the Tatum-Tallapoosa-Riverview association.

- Chewacla is typically found in flood plains and derives from sedimentary rocks. Chewacla is generally described as a somewhat poorly drained silt loam with slopes of 0 to 2 percent.
- Riverview is found in flood plains and derives from sedimentary rocks. Riverview is generally described as a well-drained loam with slopes of zero to two percent and includes three horizons: silt loam, loam and fine sandy loam.
- Grover is typically found on ridges and derives from metamorphic rock. Grover is generally described as a well-drained loam with slopes of 2 to 12 percent and consists of five horizons: sandy loam, clay loam, loam, sandy clay loam and sandy loam.
- Madison is typically found on ridges and derives from schist. Madison is generally described as a well-drained loam with slopes of 3 to 15 percent and includes three horizons: loam, clay and sandy loam.
- Tatum is typically found on hills and derives from schist. Tatum is generally described as a well-drained clayey gravelly loam with slopes of 6 to 20 percent and includes three horizons: gravelly loam, clay and weathered bedrock.
- Tallapoosa is typically found on high hills and derives from slate. Tallapoosa is generally described as a well-drained gravelly loam with slopes of 15 to 45 percent. Tallapoosa includes three horizons: gravelly loam, gravelly loam and weathered bedrock (NRCS 2016a).

Cleburne County Soils

Cleburne County soils encompass approximately 30 acres of the approximate 19,194 acres within the Harris Project boundary. Soils encountered include the Hiwassee-Gwinnett association, the Madison-Louisa association, the Riverview-State-Sylacauga complex, the state fine sandy loam and the Waynesboro-Holston complex.

- Hiwassee typically found on hills and derives from igneous rocks, is generally described as a well-drained clayey loam with slopes of 2 to 15 percent. Hiwassee consists of three horizons: clay loam, clay and loam.
- Gwinnett typically found on hills and derives from granite and gneiss, is generally described as sandy clayey loam with slopes of 2 to 15 percent. Gwinnett consists of four horizons: sandy clay loam, clay, sandy clay loam and weathered bedrock.
- Madison typically found on hills and derives from schist is generally described as a loam with slopes of 10 to 35 percent. Madison consists of four horizons: gravelly sandy loam, clay, sandy clay loam and sandy loam.
- Louisa typically found on hills and derives from mica schist is generally described as a gravelly sandy loam with slopes of 10 to 35 percent. Louisa consists of four horizons: gravelly sandy loam, gravelly sandy loam, channery loam and weathered bedrock.
- Riverview typically found in flood plains and derives from sedimentary rocks is generally described as a loam with slopes of 0 to 2 percent. Riverview consists of three horizons: loam, loam, and loamy fine sand.

- Slate typically found in stream terraces and derives from igneous and metamorphic rock is generally described as a loam with slopes of 0 to 2 percent. Slate consists of three horizons: loam, loam and fine sandy loam.
- Sylacauga typically found in stream terraces and derives from sedimentary rock is generally described as a silty clayey loam with slopes of 0 to 2 percent. Sylacauga consists of three horizons: silt loam, clay loam and loam.
- State, a fine sandy loam, typically found in stream terraces and derives from igneous; metamorphic rock is generally described as a loam with slopes of 0 to 2 percent. Slate consists of three loam horizons.
- Waynesboro typically found on hills and derives from sandstone and shale is generally described as a loam with slopes from 2 to 10 percent. Waynesboro consists of three horizons: fine sandy loam, clay loam and clay.
- Holston typically found on terraces, derives from sandstone and shale is generally described as a loam with slopes of 2 to 10 percent. Holston consists of three horizons: loam, loam and clay loam (NRCS 2016a).

Randolph County Soils

Randolph County soils encompass approximately 19,135 acres of the 19,194 acres within the Harris Project boundary. Soil units encountered include the Altavista, Appling, Augusta, Buncombe, Chewacla, Congaree, Davidson, Louisa, Louisburg, Madison, Mantachie, Ochlockonee, Wedowee, Wehadkee and Wickham. Other units identified within the Project area include Pits, Rock land, Stony rough land and Terrace escarpment. (NRCS 2016a). (Note: citation pertains to information in the following list also.)

Altavista: generally described as a well-drained loam derived from sedimentary rock typically found on stream terraces. Multiple Altavista units identified within the Lake Harris Project area include:

- fine sandy loam with 2 to 6 percent slopes
- gravelly fine sandy loam with 2 to 6 percent slopes
- gravelly fine sandy loam with 6 to 10 percent slopes

Appling: generally described as a well-drained loam derived from igneous and metamorphic rock typically found on hills and hillslopes. Multiple Appling units identified within the Lake Harris Project area include:

- a gravelly sandy loam with 2 to 6 percent slopes
- gravelly sandy loam with 6 to 10 percent slopes
- sandy loam with 2 to 6 percent slopes
- sandy loam with 6 to 10 percent slopes

Augusta: a fine sandy loam, generally described as somewhat poorly drained with slopes of 0 to 2 percent. Augusta typically found on stream terraces is derived from sedimentary rock.

Buncombe: loamy sand is generally described as being excessively drained with slopes of 0 to 5 percent. Buncombe, typically found in levees, is derived from metamorphic rock.

Chewacla: silt loam is generally described as being somewhat poorly drained with slopes of 0 to 2 percent. Chewacla, typically found in flood plains, is derived from loamy alluvium.

Congaree: silt loam is generally described as being moderately well drained with slopes of 0 to 2 percent. Congaree, typically found in flood plains, is derived from sedimentary rock.

Davidson: multiple units were identified within the Lake Harris Project area. Davidson is generally described as well-drained loam derived from metamorphic rocks typically found on hillslopes. These units included:

- gravelly clay loam with 6 to 10 percent slopes
- gravelly clay loam with 10 to 15 percent slopes

Louisa: multiple units were identified within the Lake Harris Project area. Louisa is generally described as a well-drained to somewhat excessively drained loam derived from mica schist, is typically found on hillslopes. These units include:

- gravelly clay loam with 6 to 10 percent slopes
- gravelly sandy loam with 10 to 15 percent slopes
- gravelly sandy loam with 15 to 40 percent slopes
- slaty loam with 10 to 15 percent slopes
- slaty loam with 15 to 40 percent slopes
- stony sandy clay loam with 6 to 10 percent slopes
- stony sandy clay loam with 10 to 15 percent slopes
- stony sandy clay loam with 15 to 40 percent slopes
- stony sandy loam with 10 to 15 percent slopes
- stony sandy loam with 15 to 40 percent slopes

Louisburg: multiple units were identified within the Lake Harris Project area. Louisburg is generally described as a well-drained loam derived from igneous and metamorphic rocks typically found on hillslopes. These units include a stony sandy loam with 6 to 10 percent slopes and a stony sandy loam with 10 to 25 percent slopes.

Madison: multiple units were identified within the Lake Harris Project area. Madison is generally described as a well-drained loam derived from schist typically found on hillslopes. These units include:

- gravelly clay loam with 6 to 10 percent slopes
- gravelly clay loam with 10 to 15 percent slopes
- gravelly clay loam with 15 to 25 percent slopes
- gravelly fine sandy loam with 2 to 6 percent slopes
- gravelly fine sandy loam with 6 to 10 percent slopes
- gravelly fine sandy loam with 10 to 15 percent slopes

Mantachie: a fine sandy loam generally described as somewhat poorly drained with slopes of 0 to 2 percent. Mantachie typically found in flood plains is derived from sedimentary rock.

Ochlockonee: multiple units were identified within the Lake Harris Project area. These units include a fine sandy loam with 0 to 2 percent slopes and a fine sandy loam of local alluvium with 0 to 3 percent slopes. Ochlockonee is generally described as being moderately well drained loam derived from sedimentary rock typically found in flood plains.

Wedowee: gravelly sandy loam generally described as well drained with slopes of 10 to 15 percent. Wedowee, typically found on hillslopes, is derived from igneous rock.

Wehadkee: multiple units were identified within the Lake Harris Project area. Wehadkee generally described as being a poorly drained loam derived from igneous and metamorphic rock is typically found in drainage ways. These units include a fine sandy loam with 0 to 2 percent slopes and the Wehadkee and Mantachie soils with 0 to 2 percent slopes.

Wickham: multiple units were identified within the Lake Harris Project area. Wickham generally described as being a well-drained loam is derived from sedimentary rocks found on stream terraces. These units include:

- fine sandy loam with 2 to 6 percent slopes
- fine sandy loam with 6 to 10 percent slopes
- fine sandy loam with 10 to 15 percent slopes
- gravelly fine sandy loam with 6 to 10 percent slopes
- gravelly fine sandy loam with 10 to 15 percent slopes

Note: There may be a discrepancy in the total number of acres reported as Harris Project acres due to map inconsistencies.

Appendix J
Soil Types Located in Skyline Vicinity

Soil Types Located in the Skyline Vicinity

Jackson County Soils

Jackson County soils encompass all of the approximately 15,063 acres at Skyline. Soil units encountered include: Allen, Barbourville-Cotaco, Bruno, Colbert-Talbott, Colbert, Dunning, Egam, Hollywood, Hartsells, Huntington, Hanceville, Hilly stony land, Hermitage, Holston, Jefferson-Allen, Jefferson, Limestone Rockland, Lindside, Muskingum, Melvin, Monongahela, Rolling Stony Land, Rough Stony Land, Swaim, Sequatchie, Stony Alluvium, Talbott, and Wolftever (NRCS 2016b [Note: citation pertains to information in the following list]).

Allen: generally described as a well-drained loam derived from sandstone and shale typically found on ridges or hillslopes. Multiple Allen units identified within the Skyline Project area included:

- eroded and undulating phase fine sandy loam with 2 to 5 percent slopes
- eroded and rolling phase fine sandy loam with 5 to 12 percent slopes
- rolling phase fine sandy loam with 5 to 12 percent slopes
- undulating phase fine sandy loam with 2 to 5 percent slopes

Barbourville-Cotaco: fine sandy loams generally described as moderately well drained with slopes of 0 to 4 percent. Derived from sandstone and shale, Barbourville-Cotaco is typically found on stream terraces.

Bruno: fine sandy loam and loamy fine sand generally described as moderately well drained with slopes of 0 to 2 percent. Derived from sedimentary rock, Bruno is typically found in floodplains.

Colbert-Talbott: stony silty clay loams generally described as well drained with slopes of 2 to 12 percent. Derived from limestone, Colbert-Talbott is typically found on hillslopes.

Colbert: silty clay loam generally described as moderately well drained with slopes of 5 to 12 percent. Derived from limestone, Colbert is typically found on hillslopes.

Dunning: silty clay generally described as poorly drained with slopes of 0 to 2 percent. Derived from sedimentary rock, Dunning is typically found in depressions.

Egam: silt loam generally described as well drained with slopes of 0 to 2 percent. Derived from limestone, sandstone and shale, Egam is typically found in flood plains.

Hollywood: silty clay generally described as moderately well drained with slopes of 0 to 2 percent. Derived from limestone, Hollywood is typically found on terraces.

Hartsells: generally described as a well-drained loam derived from sandstone typically found on ridges or hillslopes. Multiple units of Hartsells, identified within the Skyline Project area, included:

- rolling shallow phase fine sandy loam
- undulating shallow phase fine sandy loam

- eroded Nauvoo fine sandy loam with 6 to 10 percent slopes
- Nauvoo fine sandy loam with 6 to 10 percent slopes
- undulating phase fine sandy loam

Huntington: silt loam generally described as well drained with slopes of 0 to 2 percent. Derived from sedimentary rock, Huntington is typically found in flood plains.

Hanceville: rolling phase and undulating phase fine sandy loams generally described as well drained with slopes of 0 to 10 percent. Derived from sandstone and shale, Hanceville is typically found on ridges.

Hilly Stony: typically well drained and found on hillslopes with slopes of 10 to 20 percent.

Hermitage: cherty silty clay loam generally described as well drained with slopes of 12 to 25 percent. Derived from cherty limestone, Hermitage is typically found on hillslopes.

Holston: loam generally described as well drained with slopes of 2 to 5 percent. Derived from limestone, sandstone and shale, Holston is found on stream terraces or hillslopes.

Jefferson-Allen: generally described as a well-drained loam derived from sandstone and shale and is typically found on hillslopes with slopes ranging from 5 to 35 percent. Multiple units of Jefferson-Allen identified within the Skyline Project area included:

- eroded hilly phase loam
- hilly phase loam
- eroded rolling phase loam
- severely eroded hilly phase loam
- severely eroded steep phase loam

Jefferson: generally described as a well-drained loam derived from sandstone and shale and is typically found on stream terraces with slopes of two to 12 percent. Multiple Jefferson units identified within the Skyline Project area included:

- eroded undulating phase fine sandy loam
- eroded rolling phase fine sandy loam
- rolling phase fine sandy loam
- undulating phase fine sandy loam

Limestone Rockland: typically well drained and found on hillslopes with slopes of 11 to 40 percent.

Lindside: silt loam generally described as somewhat poorly drained with slopes of 0 to 2 percent. Derived from sedimentary rock, Lindside is typically found in flood plains.

Muskingum: fine sandy and stony fine sandy loams generally described as well drained with slopes of 10 to 20 percent. Derived from sandstone, Muskingum is typically found on hillslopes.

Melvin: silt loam generally described as poorly drained with slopes of 0 to 2 percent. Derived from sedimentary rock, Melvin is typically found in flood plains.

Monongahela: loam generally described as moderately well drained with slopes of 2 to 5 percent. It is typically found on stream terraces and is derived from limestone, sandstone, and shale.

Rolling Stony Land: typically well drained and found on hillslopes with slopes of 2 to 12 percent.

Rough Stony Land: typically well drained and found on hillslopes with slopes of 20 to 45 percent.

Swaim: generally described as a moderately well-drained loam derived from limestone typically found on ridges or hillslopes with slopes of two to 12 percent. Multiple Swaim silty clay loam units identified within the Skyline Project area included:

- eroded and non-eroded undulating phase
- eroded and non-eroded rolling phase

Sequatchie: fine sandy loam generally described as well drained with slopes of 0 to 2 percent. Derived from sedimentary rock, Sequatchie is typically found on stream terraces.

Stony Alluvium is typically well drained and found in flood plains with slopes of 0 to 2 percent.

Talbott: silty clay loam generally described as well drained with slopes of 5 to 12 percent. Derived from limestone, Talbott is typically found on hillslopes.

Wolftever: silt loam generally described as moderately well drained with slopes of 2 to 5 percent. Derived from sedimentary rock, Wolftever is typically found on stream terraces (NRCS 2016b).

Note: There may be a discrepancy in the total number of acres reported as Harris Project acres due to map inconsistencies.

Appendix K
Water Quantity, Water Use, and Discharge Report

Appendix K

WATER QUANTITY, WATER USE, AND DISCHARGE REPORT

R.L. HARRIS HYDROELECTRIC PROJECT

FERC NO. 2628

Prepared for:

ALABAMA POWER COMPANY

BIRMINGHAM, ALABAMA

Prepared by:

Kleinschmidt

March 2018

ALABAMA POWER COMPANY
BIRMINGHAM, ALABAMA

R. L. HARRIS HYDROELECTRIC PROJECT
FERC NO. 2628

WATER QUANTITY, WATER USE, AND DISCHARGE REPORT

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WATER QUANTITY, WATER USE, AND DISCHARGES REPORT

1.0 INTRODUCTION

Alabama Power Company (Alabama Power) is initiating the Federal Energy Regulatory Commission (FERC) relicensing of the 135-megawatt (MW) R.L. Harris Hydroelectric Project (Harris Project), FERC Project No. 2628. The Harris Project consists of a dam, spillway, powerhouse, and those lands and waters necessary for the operation of the hydroelectric project and enhancement and protection of environmental resources. These structures, lands, and water are enclosed within the FERC Project Boundary. Under the existing Harris Project license, the FERC Project Boundary encloses two distinct geographic areas, described below.

Harris Reservoir is the 9,870-acre reservoir (Harris Reservoir) created by the R.L. Harris Dam (Harris Dam). Harris Reservoir is located on the Tallapoosa River, near Lineville, Alabama. The lands adjoining the reservoir total approximately 7,392 acres and are included in the FERC Project Boundary. This includes land to 795 feet mean sea level (msl)[1], as well as natural undeveloped areas, hunting lands, prohibited access areas, recreational areas, and all islands.

The Harris Project also contains 15,063 acres of land within the James D. Martin-Skyline Wildlife Management Area (Skyline WMA) located in Jackson County, Alabama. These lands are located approximately 110 miles north of Harris Reservoir and were acquired and incorporated into the FERC Project Boundary as part of the FERC-approved Harris Project Wildlife Mitigative Plan and Wildlife Management Plan. These lands are leased to, and managed by, the State of Alabama for wildlife management and public hunting and are part of the Skyline WMA (ADCNR 2016b).

For the purposes of this technical report, "Lake Harris" refers to the 9,870-acre reservoir, adjacent 7,392 acres of project land, and the dam, spillway, and powerhouse. "Skyline" refers to the 15,063 acres of Project land within the Skyline WMA in Jackson County. "Harris Project" refers to all the lands, waters, and structures enclosed within the FERC Project Boundary, which includes both Lake Harris and Skyline. "Harris Reservoir" refers to the 9,870-acre reservoir only; Harris Dam refers to the dam, spillway, and powerhouse. The "Project Area" refers to the land and water in the Project Boundary and immediate geographic area adjacent to the Project Boundary (Alabama Power Company 2018).

Lake Harris and Skyline are located within two river basins: the Tallapoosa and Tennessee River Basins, respectively. The only waterbody managed by Alabama Power as part of their FERC license for the Harris Project is the Harris Reservoir.

[1] Also includes a scenic easement (to 800 feet msl or 50 horizontal feet from 793 feet msl, whichever is less, but never less than 795 feet msl)

The Harris Project is the most upstream of the three Alabama Power hydroelectric projects on the Tallapoosa River (the other two projects are Martin, Yates/Thurlow). The Tallapoosa projects are operated to generate hydroelectric power and other project purposes.

The Harris Project is located within the Alabama-Coosa-Tallapoosa (ACT) River Basin. The ACT basin originates just north of the Tennessee-Georgia border, extends into central north Georgia, crosses the Georgia-Alabama state line into north Alabama, and continues across central and south Alabama before terminating in Mobile Bay (USACE 2013). The basin covers 32 counties in Alabama, 18 counties in Georgia, and two counties in Tennessee. The basin drains 22,800 square miles, extending approximately 320 miles. The U.S. Army Corps of Engineers (USACE) owns and maintains five projects in the basin and Alabama Power Company owns and maintains eleven developments (Figure 1-1).

To support the relicensing process and provide baseline information for the Pre-Application Document (PAD), Kleinschmidt Associates (Kleinschmidt) prepared this report to summarize water quantity, withdrawals and use at the Harris Project.

Alabama Power is using FERC's Integrated Licensing Process (ILP) to relicense the Harris Project, which includes a multi-year cooperative effort with interested stakeholders to address operational, recreational, and ecological concerns associated with hydroelectric project operations. Alabama Power is consulting with a wide variety of stakeholders, including state and federal resource agencies, non-governmental organizations, and interested citizens, to gather their input on important relicensing issues.

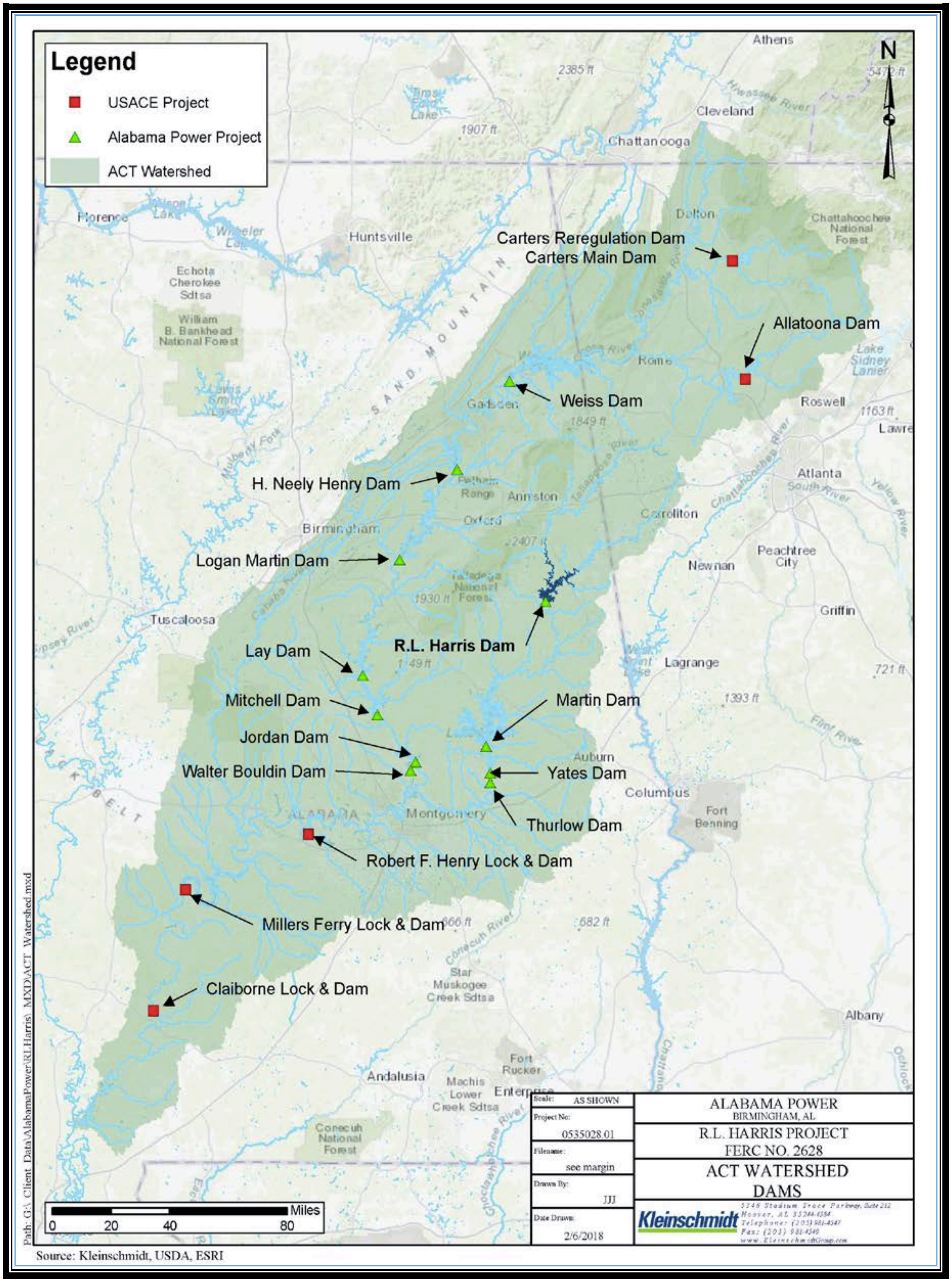


FIGURE 1-1: ACT WATERSHED DAMS

The Harris Project is operated in accordance with its FERC license. In addition, the USACE has issued a Water Control Manual (WCM), last updated in 2014, for the Harris Project. The WCM primarily describes the flood risk management water control plan for Harris Dam, and includes descriptions of the plans for navigation support and drought contingency operations. Furthermore, Alabama Power collaborates with the state of Alabama's Office of Water Resources (OWR) to plan for and mitigate the effects of droughts. Alabama Power also complies with the National Pollutant Discharge Elimination System (NPDES) permitting program administered by the Alabama Department of Environmental Management (ADEM).

Alabama Power's reservoirs provide the majority of storage within the ACT river basin and to a large degree releases from Alabama Power's dams control the flow to the Alabama River from the Coosa and Tallapoosa Rivers. During periods of low flow, many entities often rely on Alabama Power's reservoirs to supply their water needs. Alabama Power has established a water withdrawal policy with respect to these non-project uses of its federally-licensed project lands and waters. This report describes project operations, ecological and navigational flow requirements in the Tallapoosa River, drought plans, the water withdrawal policy, currently known water withdrawals, and NPDES permitted sites near Lake Harris. There are no NPDES permits within Skyline.

2.0 HARRIS PROJECT OPERATION

The Harris Project is a peaking hydroelectric facility and generally operates Monday through Friday to meet peak power demands. Under normal conditions[2], Alabama Power operates the Harris Project by running the turbines to maintain reservoir levels according to the Harris Operating Curve (Figure 2-1). The hydropower generated is available for use during daily peak-load periods.

In the interest of protecting and developing downstream aquatic habitat, Article 13 of the existing FERC license for the Harris Project requires Alabama Power to provide a minimum flow of 45 cubic feet per second (cfs) as measured at the United States Geological Survey (USGS) Gage No. 02414500 Tallapoosa River at Wadley, Alabama (FERC 1973). Furthermore, Alabama Power operates its four reservoirs on the Tallapoosa River to meet the year-round minimum flow requirement below Thurlow Dam (Alabama Power 2013) and to support flows to the Alabama River at the levels specified by the USACE's ACT River Basin Water Control Manual (2014).

Harris Reservoir is maintained at or below the elevations specified by the Harris Operating Curve, except when storing floodwater. From May 1 through October 1, Harris Reservoir is maintained at or below elevation 793 feet mean sea level (msl), depending on inflow conditions, which corresponds to a storage of 425,721 acre-feet. Between October 1 and December 1, the operating curve elevation drops to elevation 785 feet msl. (an additional storage of 78,505 acre-feet). The pool level remains at or below elevation 785 feet msl until April 1. From April 1 to May 1, the operating curve elevation rises to the full pool elevation of 793 feet msl. During the summer, Harris Reservoir provides 207,318 acre-feet of storage between elevations 768 feet

[2] Normal operations include pulsing operations as part of the Green Plan, as explained in Section 5.0.

and 793 feet msl; during winter operation, the reservoir provides 128,813 acre-feet between elevations 768 feet and 785 feet msl.

During high flow conditions, USACE-approved flood control procedures (discussed in Section 3.0 below) are implemented. Furthermore, during low flow conditions, the drought contingency curve (red line in Figure 2-1) is intended to be used as one of several factors in evaluating drought reservoir operations consistent with approved drought plans (discussed in Section 4.0 below). The Harris Project is managed in accordance with the Alabama Drought Response Operating Plan (ADROP), which provides a range of potential responses based on the severity of the drought and the time of year.

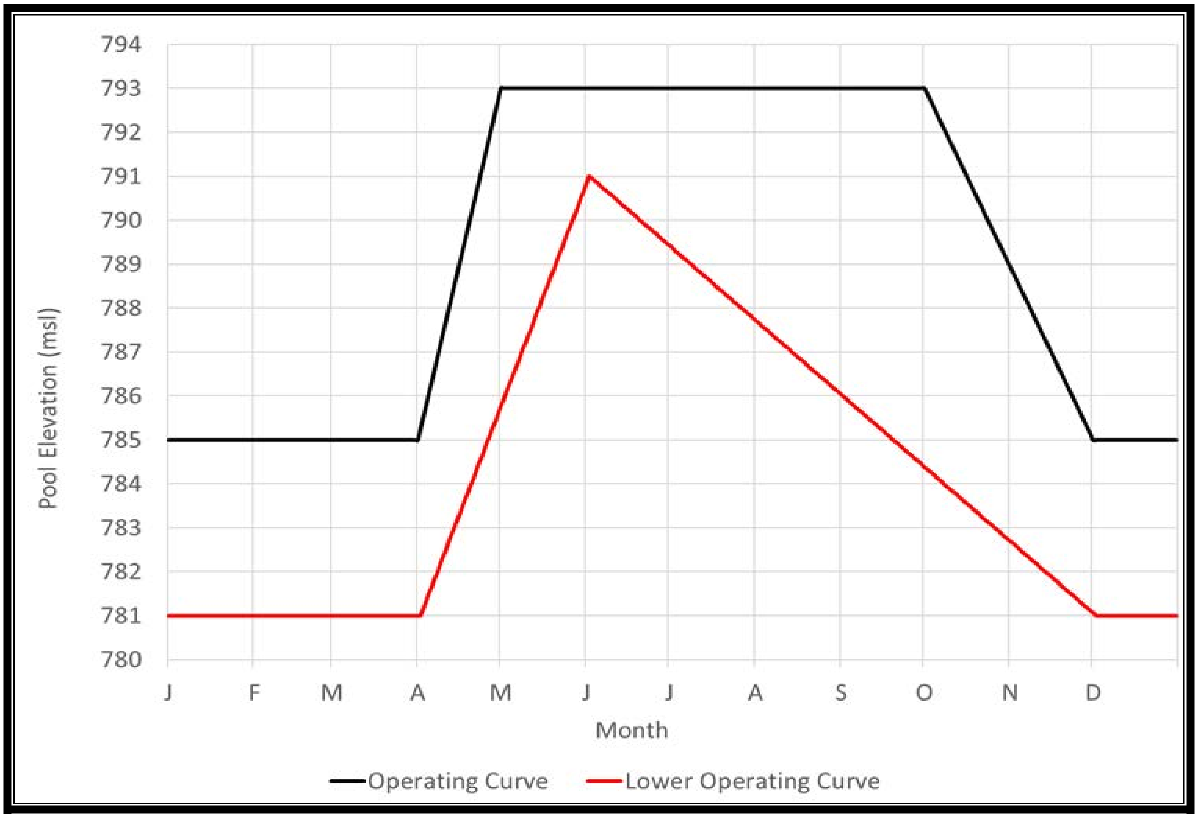


FIGURE 2-1 HARRIS OPERATING CURVE

3.0 WATER CONTROL MANUAL

3.1 OVERVIEW

The USACE's Master Water Control Manual (Master WCM) provides a general reference for day-to-day, real-time water management decision making for the six federal projects operated by USACE and the 11 non-federal developments operated by Alabama Power in the ACT basin. Projects in the ACT basin are operated in a coordinated manner to manage the often-competing uses, meet all authorized uses, ensure that enough water is available to at least minimally satisfy project purposes during droughts, and to maintain a balanced use of storage (USACE 2013). The Master WCM contains nine appendices that describe specific regulations for individual projects in the ACT basin. Alabama Power operates Lake Harris in accordance with the operating plan in Appendix I of the Master WCM issued October 2014. This Harris WCM describes flood management regulations, navigational support plans, and drought contingency operations (USACE 2014).

3.2 Flood Control

The objective of flood control at Harris Dam is to store excess water during high flow events in order to maintain water levels below flood stage downstream and to not cause stages higher than would occur naturally. The WCM provides procedures to be used by Alabama Power to carry out the operation of the Harris Project during floods.

The Harris Project will operate to pass the inflow up to approximately 13,000 cfs by releasing water through the powerhouse to maintain the reservoir near the operating curve (USACE 2014). If the reservoir rises above the operating curve (or is predicted to in the near future) but is below elevation 790 feet msl, the Harris Project will operate to discharge 13,000 cfs or an amount that will not cause the USGS stream gage at Wadley, Alabama (gage No. 02414500), to exceed 13.0 feet, unless greater discharge amounts are required by the induced surcharge curves. When the reservoir rises above elevation 790 feet msl, the powerhouse discharge will be increased to the larger of approximately 16,000 cfs or the amount indicated by the induced surcharge curves. Once the reservoir level begins to fall, all spillway gate openings and the powerhouse discharge will be maintained at those settings until the Harris Reservoir level returns to the operating guide curve. If a second flood enters the reservoir prior to the complete evacuation of the stored flood waters, the release will be as directed by the induced surcharge curve operation plan outlined in the WCM (USACE 2014).

The spillway gates at Harris Dam are generally operated in accordance with the gate opening schedule described in the WCM (USACE 2014). The schedule specifies the gate step and gate position based on the induced surcharge curve.

3.3 Navigation

Alabama Power operates the Harris Project, along with other hydroelectric projects on the Coosa and Tallapoosa Rivers, to support a predictable minimum navigable channel (i.e., a minimum water depth) in the Alabama River.

As outlined in the USACE Master WCM for the ACT River Basin, Alabama Power's Coosa River and Tallapoosa River projects are operated to provide a minimum 7-day average flow of 4,640 cfs (32,480 day-second-feet (dsf)/7 day) to the Alabama River at Montgomery. This flow is subject to being increased for navigation or decreased due to drought, generally described as follows:

> The ACT Master WCM includes a template for Alabama River navigation support, subject to development of a "navigational MOU," or navigation memorandum of understanding,

between Alabama Power and the USACE. This template provides for the use of specified amounts of storage from Alabama Power's reservoirs to support navigation during the June-December period, under certain conditions, including adequate basin inflow. Also, navigation is not supported during drought operations, as defined by the ACT Basin Drought Contingency Plan (discussed in Section 4.0 below).

4.0 DROUGHT OPERATIONS

Droughts vary in duration, magnitude, degree of severity, and geographical extent, and, as a result, are difficult to predict and manage. Significant impacts to hydroelectric projects may occur despite Alabama Power's efforts to conserve water during periods of low rainfall. Effects of drought on hydroelectric operations can be classified into three broad categories: ecological impacts (e.g., changes to water quality and minimum flows), reduced electric generating capacity, and reduced recreational opportunities.

4.1 ALABAMA DROUGHT RESPONSE OPERATING PLAN

The ADROP describes the management of Alabama Power reservoirs within the ACT basin during drought conditions. It was developed by Alabama Power, stakeholders, and state and federal agencies in response to the 2007 drought, which is the drought of record for the ACT basin (Alabama Power 2013). ADROP defines three drought triggers: (1) low basin inflow; (2) low composite conservation storage; and (3) low state line flow. If any one of these triggers is met, navigation support is suspended, and the 4,640 cfs Alabama River flow at Montgomery may be reduced consistent with the plan, depending on the severity of the drought conditions. Under the plan, the "drought triggers" are used to define three incremental Drought Intensity Level (DIL) responses. The DIL responses describe a range of operations for the hydroelectric projects within the ACT basin as a function of the DIL and month. Alabama Power, OWR, and other relevant state and federal agencies monitor specific precipitation and stream flow indicators within the ACT basin. The precipitation indicator is based on the average of normal monthly rainfall at the following airport rain gages: Rome, Anniston, Shelby County, and Montgomery. The stream flow indicator is based on specific percentile ranges of stream flow from eleven USGS gages in the Coosa River basin and seven gages in the Tallapoosa River basin (Alabama Power 2013). Alabama Power evaluates the DIL using the ADROP Decision Tool that was developed by Alabama Power and the USACE Mobile District to implement portions of the WCM in real time operations. ADROP has been incorporated into the WCM and ACT Basin Drought Contingency Plan. A full description of ADROP and associated operational responses for its projects on the Coosa and Tallapoosa Rivers during periods of drought is included in Appendix A.

4.2 STATE DROUGHT PLAN

The State of Alabama Drought Management Plan (Drought Management Plan) was finalized in 2013 (ADECA 2013). The plan gives the Alabama Water Resources Commission, OWR, and the Alabama Drought Assessment and Planning Team responsibility for drought planning, management, mitigation, and response activities. The Drought Management Plan presents the processes and procedures for issuing an Alabama Drought Declaration, which is intended to aid water managers, state agencies, and other stakeholders in making water use and management decisions (ADECA 2013). The Drought Management Plan creates a defined statewide structure to collect, coordinate, and communicate information; identify the areas impacted and associated risks; identify ways to prepare for droughts; develop impact assessments; and prepare response and mitigation recommendations.

The Drought Management Plan consists of four drought declaration levels: drought advisory, drought watch, drought warning, and drought emergency (ADECA 2013). The declaration of a level is based on several drought triggers, including the Lawn and Garden Index, Crop Moisture Index, Palmer Drought Severity Index, Keetch-Bryam Drought Index, USDA-NASS Topsoil Moisture, USGS stream flows, and 180-day rainfall totals (ADECA 2013). In addition to these indices, groundwater levels, public water supply systems, and reservoir levels are considered in decisions to issue a drought declaration.

The Drought Management Plan also identifies five categories of drought impact sectors that should be included in planning, mitigation, and response decisions and activities. The five impact sectors are: domestic, agricultural, environmental, industrial, and recreational.

5.0 HARRIS GREEN PLAN

During the 1990s, Alabama Power began working with stakeholders, including the Alabama Department of Conservation and Natural Resources, U.S. Fish and Wildlife Service, and Alabama Cooperative Fish and Wildlife Research Unit, to develop a plan for specific daily and hourly releases to improve downstream fisheries conditions. The final Harris "Green Plan" was a result of years of discussions, study, and various iterations of the plan. In 2005, Alabama Power began implementing the Harris Green Plan flows, and the Alabama Cooperative Fish and Wildlife Research Unit began monitoring ecological conditions (e.g., water temperature, fisheries, vegetation) downstream of the dam. The Harris Green Plan flows and monitoring have continued since 2005. The Harris Green Plan outlines specific daily and hourly release schedules based on the number of machine hours planned for a specific day. The upstream USGS gage No. 02412000 Tallapoosa River near Heflin, Alabama, is used to set a daily target release from Harris Dam. Alabama Power uses pulse operations from Harris Dam when four or less machine hours occur per day. The daily volume releases are suspended during flood operations. In addition to the specific daily and hourly release schedules, specific drought release criteria are also outlined. The complete criteria for the Green Plan are included in Appendix B.

6.0 WATER WITHDRAWALS

6.1 WATER USE

The Tallapoosa River is managed for several beneficial water uses to meet the demands of upstream and downstream users. Harris Reservoir is a multi-purpose storage reservoir with the federally authorized uses of hydroelectric power generation, flood risk management, and navigation. Additional uses of Harris Reservoir include recreation, water supply, water quality enhancement, and fish and wildlife habitat. Additionally, Harris Reservoir provides approximately eight percent of the storage capacity of the ACT basin (USACE 2013).

6.2 History of Alabama Power's Water Withdrawal Policy

Over the last several decades, a growing number of new demands have been placed on the state of Alabama's water resources. These additional demands have been for such uses as residential water supply due to population growth, industrial growth, agriculture, recreational use, and environmental stewardship. Large storage reservoirs can provide a reliable water supply, and many water withdrawers have sought approval from Alabama Power to use its hydropower reservoirs as a source of water.

Article 14 of the existing FERC license for the Harris Project states that upon the application by any person, association, corporation, federal agency, state, or municipality, Alabama Power will permit reasonable use of its reservoir in the interest of the comprehensive development of the waterway (FERC 1973). Consistent with FERC licensing authority and to address the growing water use demands, Alabama Power developed a water withdrawal policy and permitting process in 1989 to manage water withdrawals. The policy also includes a compensation plan designed to offset the costs to Alabama Power's ratepayers for the impacts associated with withdrawals from its reservoirs.

6.3 Alabama Power Water Withdrawal Policy

Alabama Power's water withdrawal policy was developed to manage withdrawals from its hydropower project reservoirs, including Harris Reservoir, as well as to encourage responsible management and resource planning by water withdrawers. Any party interested in withdrawing 0.1 MGD water or greater from Harris Reservoir may do so only after applying for and receiving a water withdrawal permit[3]. Under the Standard Land Use article in its FERC licenses, Alabama Power has the authority to permit water withdrawals up to 1 MGD without prior FERC authorization, but Alabama Power must obtain FERC's approval before authorizing withdrawals greater than 1 MGD.

In addition to obtaining a water withdrawal permit from Alabama Power, a Declaration of Beneficial Use must be submitted to OWR by each public water system that regularly serves (individually or in combination with other such systems) more than 10,000 households or by any person who diverts, withdraws, or consumes more than 100,000 gallons per day or more from waters of the state (ADECA 2017). After OWR reviews the information in the application and verifies it as complete, OWR will issue a Certificate of Beneficial Use to the withdrawer.

In 2001, OWR requested that Alabama Power implement measures to provide conservation of water resources. In response, Alabama Power implemented a process requiring applicants to demonstrate that they have consulted with the OWR prior to granting permission to withdraw from its reservoirs.

[3] Residential withdrawals are typically addressed under Non-Transferable Lakeshore Use Permits.

6.4 Alabama Power Water Withdrawal Permitting Process

The first formal step in obtaining a water withdrawal permit is for the interested party to submit a request to Alabama Power through the "Non-Residential Permit Application Process (Appendix C). Before this application is formally submitted, the applicant typically schedules a meeting with an Alabama Power representative to discuss the specifics of the proposed water withdrawal, potential impacts to project resources resulting from the withdrawal, compensation for the water withdrawal impacts, and any other pertinent information that will need to be included in the permit application.

Alabama Power's review of the Non-Residential Permit form is divided into three phases. In the first phase, Alabama Power staff reviews the information provided in Section 1 of the application or, if necessary, requests more information from the applicant. After this review, if Alabama Power determines that the application is acceptable, the applicant submits the information required in Phase 2. Alabama Power then reviews this information to determine whether to seek approval from FERC (Phase 3). In addition to the proposed withdrawal amount, the decision to seek FERC approval is based on whether the proposed use will enhance or have no effect on the project's environmental, recreational, or aesthetic values, including the resources identified as sensitive.

Upon Alabama Power's acceptance of the proposed water withdrawal application, the prospective withdrawer and Alabama Power enter into a Water Withdrawal Agreement. This agreement covers details specific to the water withdrawal, including terms and conditions. A standard Water Withdrawal Agreement includes a number of clauses and statements which establish that the Agreement: is not a "water sales" agreement; does not convey any property rights (including riparian rights); is based on other joint use agreements approved by the FERC; may be tailored to address unique withdrawal issues; and will be included in any FERC approval application.

An important part of the permitting process includes requiring the prospective withdrawer to consult with various state and federal resource agencies (identified in Phase 2 of the Non-Residential Permit Application Form in Appendix C). In some instances, the consultation phase may be conducted concurrently with the Water Withdrawal Agreement negotiations.

In addition to the Water Withdrawal Agreement, the withdrawer must also obtain property rights (i.e., an easement) from Alabama Power to use project lands in which Alabama Power owns.

6.5 FERC Approval Process

For any proposed water withdrawal request exceeding 1 MGD, Alabama Power petitions FERC for approval using the applicant information provided to Alabama Power and a properly executed Water Withdrawal Agreement. FERC evaluates the proposed plans, prepares an environmental report of the proposed water withdrawal, and reviews comments submitted by resource agencies and other stakeholders. Once FERC makes a final decision regarding the proposed water withdrawal and a FERC order is issued, Alabama Power either formally authorizes the withdrawer to begin construction and operation or notifies the applicant that the proposed water withdrawal was not approved. Depending on various factors, including staff resources, information requests, interventions, and contested issues, FERC approval can take as little as six months up to several years.

6.6 COMPENSATION FOR WATER WITHDRAWALS

In 1989, Alabama Power adopted a water withdrawal compensation policy for the purpose of ensuring that the withdrawer makes Alabama Power's electric customers whole for the impacts caused by the withdrawal of project waters. The current compensation policy was developed using a pricing method similar to that employed by the USACE and has been accepted by FERC. Furthermore, Alabama Power's water withdrawal compensation method is consistent with OWR's long-term water withdrawal management goals. The compensation method is intended to help offset impacts to hydroelectric energy production at Alabama Power's hydro projects. There are three primary components to the compensation method: (1) Replacement Energy Charge, (2) Storage Value Charge, and (3) Storage Reservation Charge.

6.6.1 REPLACEMENT ENERGY CHARGE

The removal of water from a point upstream of a hydroelectric dam causes a direct loss of energy to all downstream dams, because the water that has been removed will not pass through the turbines. Alabama Power uses an energy budget model to calculate the amount of lost generation based on the magnitude of the withdrawal. The replacement energy cost is based on the highest cost resources operated each day to replace lost hydroelectric generation caused by the water withdrawal. Alabama Power encourages water withdrawers to return as much water as possible by offering a credit against energy charges for any identifiable and verifiable amounts of water returned to the reservoir.

6.6.2 STORAGE VALUE CHARGE

The storage value charge is based on the costs associated with impounding the required volume of water. The storage value of a reservoir is the capability to store an amount of water, making it available for use during periods of low flow in a river. A reservoir's storage capacity is critical to ensuring a reliable and dependable supply of water to meet the needs for which the reservoir was constructed. Without the reservoir, there is no storage value, and without the storage value in the reservoir, there can be no assurance that water will be available for use during low river flow conditions.

6.6.3 STORAGE RESERVATION CHARGE

The storage reservation charge is 10 percent of the storage cost for water not withdrawn but allotted for future withdrawal. The storage reservation charge is a means by which the withdrawer can plan for future growth and ensure that resources are reserved for anticipated future demands. For example, if a water withdrawer has been approved for a 25 MGD withdrawal but only expects to withdraw 10 MGD during a given year, the withdrawer will pay the storage value charge associated with the 10 MGD and 10 percent of the storage value charge for the remaining 15 MGD. The storage reservation charge does not apply to withdrawers with a fixed withdrawal without any future growth.

6.7 CURRENT WATER WITHDRAWALS

Table 6-2 contains a list and Figure 6-1 depicts the locations of the currently known water withdrawals and discharges on or near Harris Reservoir[4]. The list does not include single homeowner withdrawals but rather those of a larger commercial or municipal nature that require a Certificate of Beneficial Use from OWR.

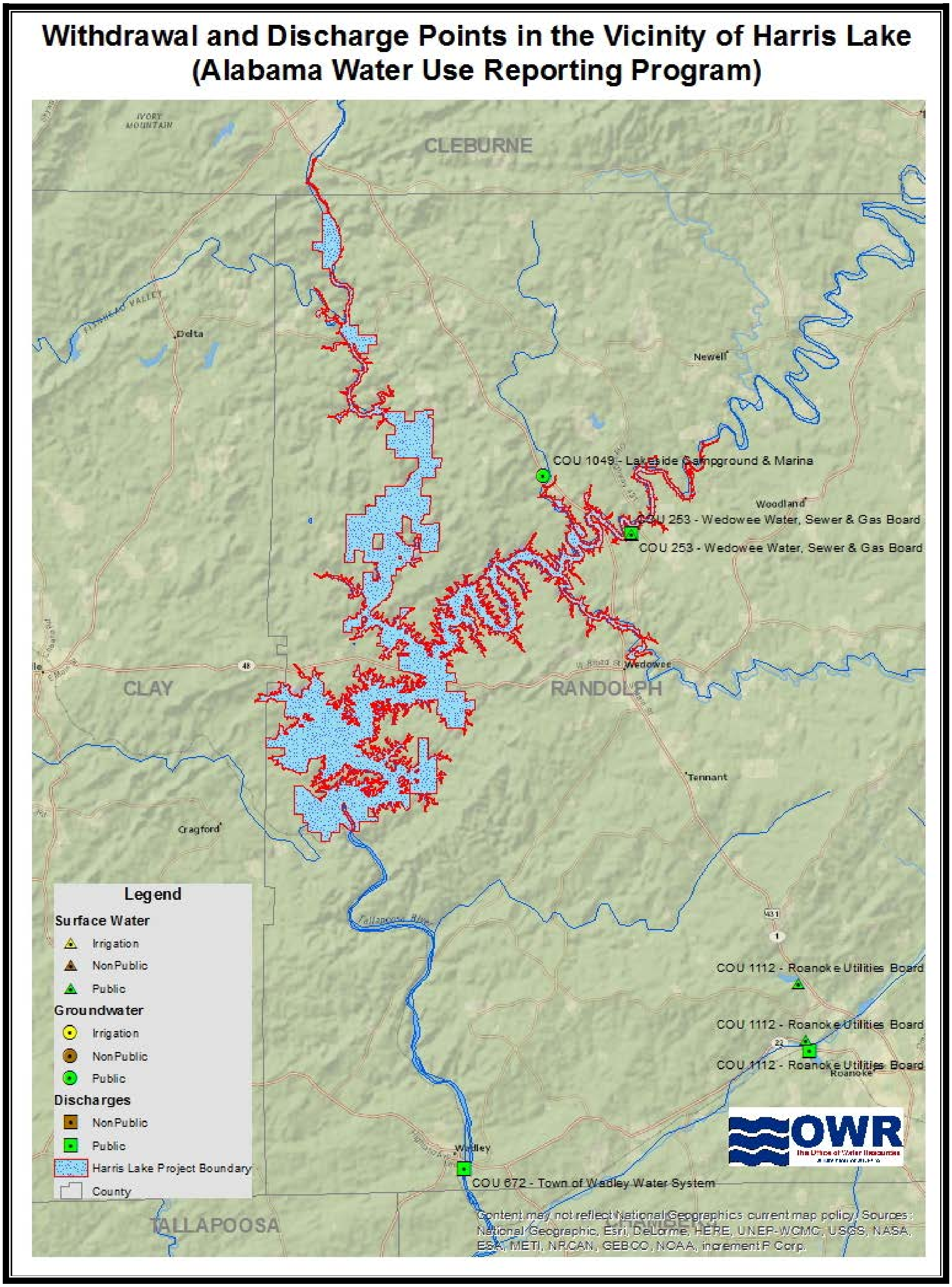
Alabama Power has approved one easement allowing a water withdrawal within the Harris Project Boundary. On April 1, 1988, under the delegated authority provisions of Article 61 of the Harris Project License, Alabama Power granted an easement to the Town of Wedowee-Utility Board, allowing for construction, operation, and maintenance of a new floating water intake system and related facilities. The easement limits the intake to a maximum withdrawal of 0.5 MGD. This withdrawal is used to meet the water supply needs for Northeast Randolph County Service District via the John Swann Water Treatment Plant.

TABLE 6-1 WATER WITHDRAWAL AND DISCHARGES REGISTERED UNDER THE ALABAMA WATER USE REPORTING PROGRAM

Name	Owner	Groundwater/ Surface Water/ Discharge Name	Average Daily (MGD)	Maximum Daily (MGD)
Cohobadiah Creek	Lakeside Campground & Marina	Well No. 1	0.003	0.02
Upper Little Tallapoosa River	Wedowee Water, Sewer & Gas Board	John G. Swann Water Treatment Plant - No. 1	0.411	0.75
Highpine Creek	Roanoke Utilities Board	Roanoke Filter Plant No. 1 - Crystal Lake	0.822	1.96
Highpine Creek	Roanoke Utilities Board	Roanoke Filter Plant No. 2 - Jones Creek Lake	0.000	1.96
Upper Little Tallapoosa River	Wedowee Water, Sewer & Gas Board	Lagoon	0.045	0.15
Hurricane Creek	Town of Wadley Water System	Wadley Lagoon AL0062847	0.123	0.15
Highpine Creek	Roanoke Utilities Board	Roanoke HCR	0.395	3.50

Source: ADECA 2017

[4] There are no current water withdrawals or discharge permits in the Skyline Project Boundary.



Source: ADECA 2017

FIGURE 6-1 WITHDRAWAL AND DISCHARGE POINTS IN THE VICINITY OF HARRIS LAKE

6.8 Future Water Withdrawals

Demand for water in the Southeastern United States has significantly increased in the past several decades and is expected to continue in the next decade. Several entities responsible for water management in Alabama are pursuing short and long-term solutions to growing concerns regarding water supply and demand. In response to this growing water demand, several processes are in place to resolve long-term water concerns. The outcome of these efforts and negotiations are unknown but are certain to impact water management not only in Alabama but throughout the entire Southeastern United States.

With very little industrial and agricultural use in the Lake Harris area, most of the demand for water results from municipal use. The populations of Randolph and Clay counties are projected to decrease by 2.7 percent and 12.8 percent, respectively, between 2015 and 2040; the population of Cleburne county is projected to increase 3.3 percent (CBER 2017).

7.0 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The NPDES permit program was created in 1972 by the Clean Water Act to regulate point sources that discharge pollutants to waters of the United States (EPA 2017a). The Environmental Protection Agency (EPA) has authorized state governments to manage the permitting and enforcement activities of the NPDES program. NPDES permits specify numeric limits on the levels of pollutants that can be discharged and contain monitoring and reporting requirements.

EPA has authorized the Alabama Department of Environmental Management (ADEM) to manage the NPDES program in Alabama. Prior to discharging any pollutants into surface waters, an entity must obtain a NPDES permit from ADEM. The permits are issued for a five-year term and may be renewed or administratively extended. The application process requires that the public be notified and allowed to comment. The application requires information such as the purpose of the application, previous permit numbers, business activity, and waste storage and disposal.

The continued operation of the Harris Project requires a NPDES permit (General NPDES Permit Number ALG360017) for the nine existing discharge points at the powerhouse: three for cooling water discharges; two for discharges from sumps and drains; one for plant and unit oil/water separators; one for uncontaminated stormwater; one for uncontaminated stormwater from bulk petroleum secondary containment areas; and one for wastewater resulting from maintenance and repair activities. The permit was reissued effective March 1, 2017 for a period of five years (ADEM 2016).

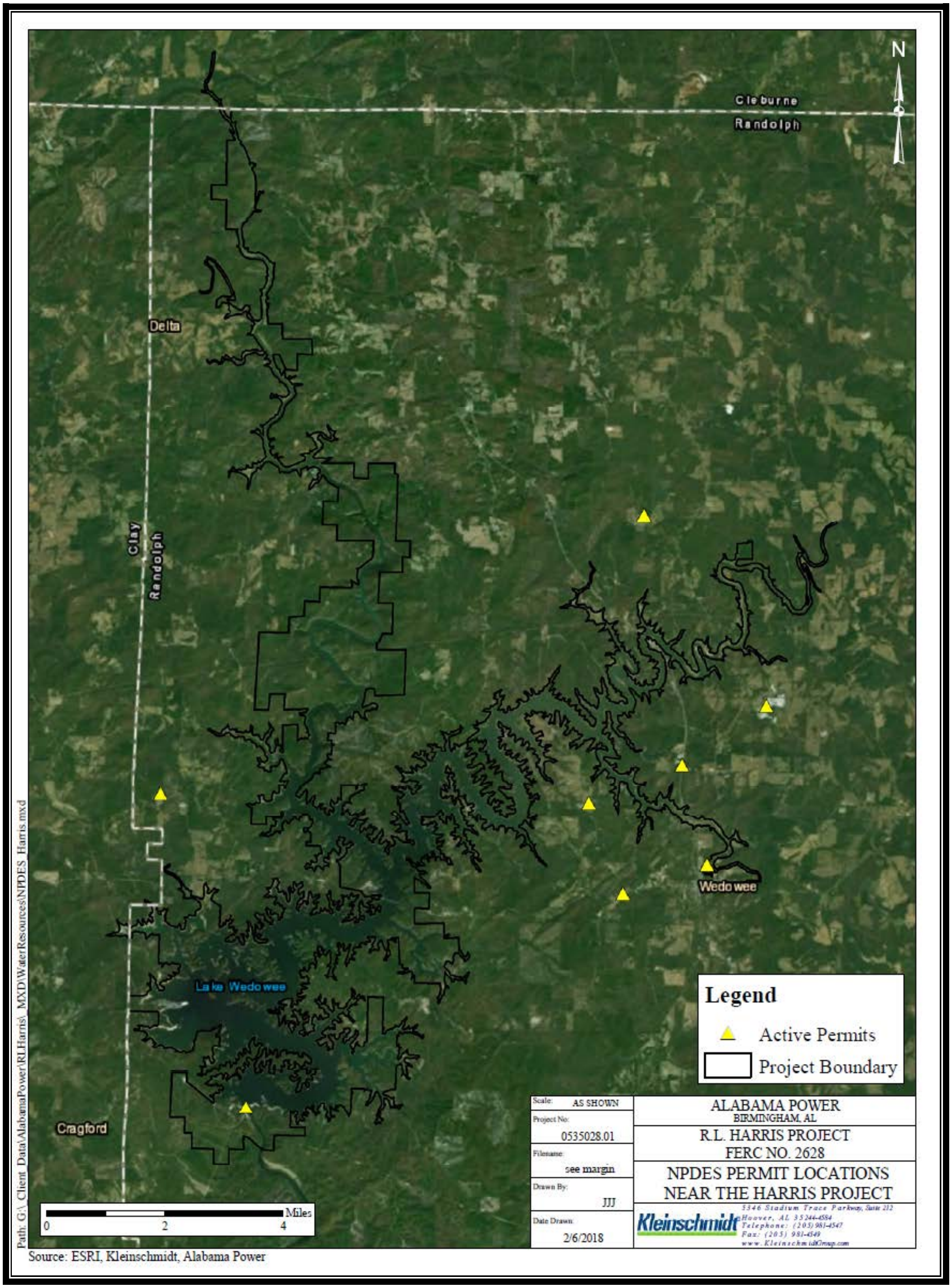
A list of active NPDES permits near the Harris Project is shown in Table 7-1, and the locations of the facilities are shown in Figure 7-1 (EPA 2017b).[5]

[5] There are no NPDES permitted facilities near or within the Skyline WMA.

TABLE 7-1 LIST OF ACTIVE NPDES PERMITS NEAR THE HARRIS PROJECT

Permit Number	Facility Name	City, County	Permit Expiration	Permit Type
ALG360017	Harris Hydroelectric Project	Lineville, Randolph Co.	1/31/2021	General NPDES Permit
ALG110360	Randolph County Concrete, Inc	Wedowee, Randolph Co.	8/31/2022	Minor: General Permit Covered Facility
ALA001178	Kevin Yates Farm	Wedowee, Randolph Co.	2/20/2018	Minor: Individual State Issued Permit (non-NPDES)
ALA000832	Eric Payne Farm	Wedowee, Randolph Co.	10/24/2018	Minor: Individual State Issued Permit (non-NPDES)
ALA000903	Big Mac Farm	Lineville, Clay Co	11/19/2018	Minor: Individual State Issued Permit (non-NPDES)
ALG020182	Wedowee Asphalt Plant*	Wedowee, Randolph Co.	9/30/2022	Minor: General Permit Covered Facility
AL0075191	Wedowee Quarry*	Wedowee, Randolph Co.	10/31/2017	Minor: NPDES Individual Permit
AL0024171	Wedowee Lagoon	Wedowee, Randolph Co.	9/30/2020	Minor: NPDES Individual Permit
ALG890033	Wortham Pit	Newell, Randolph Co.	1/31/2018	Minor: General Permit Covered Facility

Source: EPA 2017b
*At the same location in Figure 7-1.



Source: ESRI, Kleinschmidt, Alabama Power 2018

FIGURE 7-1 NPDES PERMIT LOCATIONS NEAR THE HARRIS PROJECT

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APPENDIX A

ALABAMA-ACT DROUGHT RESPONSE OPERATIONS PLAN
NOVEMBER 2016 REVISION

Alabama-ACT Drought Response Operations Plan (ADROP)

Overview

Alabama Power Company (APC) operates eleven hydropower dams in the Alabama-Coosa-Tallapoosa (ACT) River Basin. On the Tallapoosa River, Alabama Power operates the Harris, Martin, Yates and Thurlow hydroelectric dams and their reservoirs. On the Coosa River APC operates the Weiss, Neely Henry, Logan Martin, Lay, Mitchell, Jordan, and Bouldin hydroelectric dams and their reservoirs. The Coosa and Tallapoosa Rivers converge to form the Alabama River at Montgomery, Alabama. Alabama Power operates no reservoirs on the Alabama River, but its upstream operations can impact Alabama River flows and elevations. In addition to requirements contained in Alabama Power's Federal Energy Regulatory Commission ("FERC") licenses for its dams, Alabama Power provides flows to the Alabama River consistent with the U.S. Army Corps of Engineers (USACE) Water Control Manual (WCM) for the ACT river basin.

The Alabama-ACT Drought Response Operations Plan (ADROP) provides a plan for managing APC's reservoirs within the ACT Basin during drought conditions. APC and the Alabama Office of Water Resources (OWR), along with state and federal resource agencies[1], will monitor defined rain and stream flow indicators within the ACT basin. When drought indicators reach specified levels, drought intensity level responses are triggered, resulting in pre-determined incremental reductions or increases of flow from APC's reservoirs.

ADROP provides for three incremental drought intensity level (DIL) and corresponding DIL responses based on the severity of drought conditions. These incremental DIL responses are not rigid but provide a bracketed range of operations allowing for flexibility and smoother transitions in and out of a drought and from level to level. ADROP's drought response triggers are primarily based on past operating experiences and lessons learned during 2007, the current drought of record for the basin. ADROP is a dynamic plan; it may evolve or be expanded in the future as requirements within the basin may shift. Moving forward, any substantive revisions made to ADROP will be made in consultation with OWR and the resource agencies. Any provisions that will affect APC's federal hydropower license requirements will be filed with the FERC for prior approval.

The following provides a snapshot of operations for normal water years, an explanation of ADROP's drought indicators, triggers for each of the three incremental drought response levels, and a summary of operations at each drought response level.

[1] Resource Agencies to be included are US Fish and Wildlife Service (USFWS), Alabama Department of Conservation and Natural Resources (ADCNR), Alabama Department of Environmental Management (ADEM) and US Army Corps of Engineers (USACE).

Normal Conditions

During a normal water year, APC releases a weekly target of 32,480 cubic feet per second-days (a measure of volume) out of Bouldin, Jordan and Thurlow dams into the Alabama River. This release equates to a 7 day average flow target of 4,640 cubic feet per second (cfs).

In accordance with FERC requirements to protect threatened and endangered species downstream of Jordan Dam on the Coosa River, APC provides a minimum continuous flow of 2,000 cfs from July through March. From April 1st through May 31st, in order to provide for recreation and attraction flows for fish spawning, APC releases a continuous base flow of 4,000 cfs for 18 hours per day and an 8,000 cfs pulse flow for the rest of the day. During the month of June, the base and pulse flows are reduced incrementally to a continuous base flow of 2,000 cfs. From April 1st to October 31st, and on weekends and special holidays, additional recreational flows are released from Jordan Dam as scheduled in APC's FERC license guidelines. APC provides a year-round minimum continuous flow release from Thurlow Dam on the Tallapoosa River.

Drought Indicators

Drought indicators are used to describe the onset, magnitude, duration, severity and extent of a drought. Because there is a well-established rain and stream gauging network in the ACT basin, ADROP relies on precipitation and stream flow indicators. Observations of precipitation and stream flow will be used to indicate when the ACT is entering into (or recovering from) a drought. ADROP's precipitation indicator is based on the average of normal monthly rainfall at the following airport rain gages: Rome, Anniston, Shelby County and Montgomery. ADROP's stream flow indicator is based on the U.S. Geological Survey ("USGS") real-time gauging system[2]. USGS gages to be monitored are as follows[3]:

On the Coosa River

- 02397000: Mayo's Bar – Coosa River
- 02397530 State Line, AL/GA – Coosa River
- 02398300: Gaylesville – Chattooga River
- 02399200: Blue Pond – Little River
- 02401390: Ashville - Big Canoe Creek
- 02401000: Crudup – Big Wills Creek
- 02404400: Jackson Shoals – Choccolocco Creek
- 02405500: Vincent - Kelly Creek
- 02407514: Westover – Yellowleaf Creek
- 02406500: Alpine – Talladega Creek
- 02408540: Rockford – Hatchet Creek

On the Tallapoosa River

- 02412000: Heflin – Tallapoosa River
- 02413300: Newell – Little Tallapoosa River
- 02415000: Hackneyville – Hillabee Creek

[2] Real-time data for each of these gages is available on the USGS's National Water Information System website at http://waterdata.usgs.gov/al/nwis/rt.
[3] Gages used as indicators may be added or removed in the future needs.

- 02418230: Loachapoka – Sougahatchee Creek
- 02418760: Chewacla – Chewacla Creek
- 02419000: Tuskegee – Uphapee Creek
- 02419890: Montgomery Water Works, Tallapoosa River

On the Cahaba, Alabama and Tensaw Rivers

- 02425000: Marion Junction – Cahaba River
- 02428400: Claiborne L&D – Alabama River
- 02471019: Mount Vernon – Tensaw River

Precipitation and stream flow indicators are outlined by month in Table 1. The top line shows the combined normal average precipitation at the ACT rainfall gages listed above. The second line shows ranges of flow percentiles that will be used to indicate when the ACT is entering a drought. The third line shows ranges of flow percentiles used to determine when the ACT is emerging from a drought.

ADROP Implementation and Notification

APC continually records and monitors the drought indicators within ADROP for its reservoirs located in the ACT basin for potential and ongoing drought operations. On the first and third Tuesday of each month, APC evaluates the DIL utilizing the ADROP Decision Tool. DIL are further explained below and can also be found in Table 2. The ADROP Decision tool was developed between APC and the Mobile USACE District to implement portions of the WCM into real time operations. The output from the decision tool shows the sum of the DILs that are true along with the corresponding Alabama River flow target. The results from the ADROP Decision Tool and the supporting data are sent to the Mobile USACE District.

As conditions begin to decline, OWR will schedule and facilitate meetings of the Alabama Drought Monitoring & Impact Group (MIG) a subcommittee of the Alabama Drought Assessment and Planning Team (ADAPT). The role of the MIG is to analyze data that reflects past and current drought efforts and to assist with decisions concerning drought declarations levels for the State of Alabama. The MIG is comprised of federal, state, and local agencies and other water resources professionals. During these meetings, APC will discuss current project operations, the results of the ADROP Decision Tool, and future changes to operations. In addition to these scheduled meetings, when a DIL is triggered, APC will provide OWR, USFWS, ADCNR and ADEM with a report containing the latest weather forecast, hydrologic conditions, operations for Coosa and Tallapoosa River projects, and an update of the most recent ADROP Decision Tool. Additionally, APC provides industrial users on the Alabama River the results of the ADROP Decision Tool. These notification paths will continue until the ADROP Decision Tool shows that the basin has returned to normal operations. When normal operations have returned for APC reservoirs, a final communication will be sent to OWR and the resource agencies that drought coordination has ended. APC will continue to participate and provide information to MIG meetings until the OWR declares the State of Alabama has emerged from drought conditions and the MIG meetings will end. At this time, APC and OWR will continue to monitor drought indicators for future drought development.

Explanation of Drought Intensity Level (DIL) Triggers

*DIL 1 Trigger: Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow*

The trigger for the DIL 1 response is one of the following criteria is met:

- Inflow into the basin is less than the total needed to meet the 7 day average flow target of 4,640 cubic feet per second ("cfs") and to fill APC's reservoirs (see Table 4)
- A basin-wide composite storage equal to or less than drought contingency elevation/volumes (see Figure 1)
- A flow at or below the 7Q10 flows for Rome, Georgia as measured at the Alabama/Georgia state line gage (see Table 5)

*DIL 2 Trigger: DIL 1 criteria **+** (Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow)*

The trigger for the DIL 2 response is two of the criteria in DIL1 are met.

*DIL 3 Trigger: Low Basin Inflows **+** (Low Composite Storage **+** Low State Line Flow)*

The trigger for DIL 3 is the combination of DIL 1 criteria and **both** of the following:

- A basin-wide composite storage equal to or less than drought contingency elevation/volumes (see Figure 1)
- A flow at or below the 7Q10 flows for Rome, Georgia as measured at the Alabama/Georgia state line gage (see Table 5)

Explanation of Drought Intensity Level (DIL) Responses

The following explains how flows will change throughout the year at the different drought intensity levels. Table 3 is a matrix of the operational response to drought intensity levels.

Drought Intensity Level 1 Response

- **Coosa River Operations:** From July 1st through March 31st, 2,000 cfs will be released from Jordan Dam. From April 1st through June 15th, 4,000 cfs will be released from Jordan Dam as base flows. From June 15th to July 1st, releases from Jordan Dam will be ramped down to the 2,000 cfs minimum flow. Any inflow into the Coosa River basin in excess of these Jordan Dam minimum releases may be used to refill upstream reservoirs or discharged through Jordan Dam or Bouldin Dam above the corresponding targeted Alabama River release. [4]
- **Tallapoosa River Operations:** From May 1st through December 31st, half of all inflows into Yates Dam will be released from Thurlow Dam. From January 1st through April 30th, the greater of either half the inflows into Yates Dam or two times inflows as

[4] In all drought intensity levels, fish attraction pulses and recreational releases are suspended; however, flows above those needed to fill and meet the base minimum flow may be used for pulsing, recreational or flushing releases.

measured at the Heflin, Alabama gage will be released. During this time, Thurlow Dam releases will be greater than 350 cfs. Any inflow into the Tallapoosa River basin in excess of these Thurlow Dam minimum releases may be used to refill upstream reservoirs or discharged through Thurlow Dam above the corresponding targeted Alabama River release.

- **Alabama River Flows:** A 10% reduction in APC's release into the Alabama River will be in effect from October 1st through April 30th. From May 1st through September 30th, the full targeted release will be maintained.
- **Rule Curve Variances:** APC will seek variances from the USACE and FERC as needed to improve the likelihood of filling APC's reservoirs to full summer pool elevations.

Drought Intensity Level 2 Response

- **Coosa River Operations:** From October 1st through March 31st, flows in a range between 1,600 and 2,000 cfs will be released from Jordan Dam. From April 1st through June 15th, 2,500 cfs will be released from Jordan Dam as base flows. From June 15th to July 1st, releases from Jordan Dam will be ramped down to the 2,000 cfs minimum flow. From July 1st to September 30th, flows will be 2000 cfs. Any inflow into the Coosa River basin in excess of these Jordan Dam minimum releases may be used to refill upstream reservoirs or discharged through Jordan Dam or Bouldin Dam above the corresponding Alabama River release target.
- **Tallapoosa River Operations:** Releases from Thurlow Dam will be 350 cfs from October 1st through April 30th. From May 1st through September 30th, half of the inflows into Yates Dam will be released. Any inflow into the Tallapoosa River basin in excess of these Thurlow Dam minimum releases may be used to refill upstream reservoirs or discharged through Thurlow Dam above the corresponding targeted Alabama River release.
- **Alabama River Flows:** A 20% reduction in APC's targeted release into the Alabama River will be in effect from October 1st through May 31st. From June 1st through September 30th, a 10% reduction in the targeted release will be in effect.
- **Rule Curve Variances:** APC will seek variances from the USACE and FERC as needed to improve the likelihood of filling APC's reservoirs to full summer pool elevations.

Drought Intensity Level 3 Response

- **Coosa River Operations:** From October 1st through November 30th, 1,800 cfs will be released from Jordan Dam. From December 1st through March 31st, 1,600 cfs will be released from Jordan Dam. From April 1st through June 30th, releases from Jordan Dam will be made in a range between 1,600 and 2,000 cfs. From July 1st through September 30th, 2,000 cfs will be released from Jordan Dam. Any inflow into the Coosa River basin in excess of these Jordan Dam minimum releases may be used to refill upstream reservoirs or discharged through Jordan Dam or Bouldin Dam above the corresponding targeted Alabama River release.
- **Tallapoosa River Operations:** From October 1st through June 30th, a flow of 400 cfs will be maintained at the Montgomery Water Treatment Plant. During this time, releases from Thurlow Dam may occasionally be less than 350 cfs. From July 1st through September 30th, 350 cfs will be released from Thurlow Dam. Any inflow into

the Tallapoosa River basin in excess of these Thurlow Dam minimum releases may be used to refill upstream reservoirs or discharged through Thurlow Dam above the corresponding targeted Alabama River release.

- **Alabama River Flows:** From October 1st through April 30th, APC's targeted release will be reduced to an average 2,000 cfs into the Alabama River. During May and June, a 20% reduction in the targeted release will be in effect. From July 1st through September 30th, a 10% reduction in the targeted release will be in effect.
- **Rule Curve Variances:** APC will seek variances from the USACE and FERC as needed to improve the likelihood of filling APC's reservoirs to full summer pool elevations.

Table 1: Indicators

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rain*	<5.3	<5.1	<6.1	<4.6	<4.0	<3.9	<4.7	<3.5	<3.6	<2.7	<4.3	<4.7
Flow**	10th – 25th	10th – 25th	10th – 25th	10th – 25th	10th – 25th	<10th	<10th	<10th	<10th	10th – 25th	10th – 25th	10th – 25th
	50th –75th	50th –75th	50th –75th	50th –75th	50th –75th	25th –50th	25th –50th	25th –50th	25th –50th	50th –75th	50th –75th	50th –75th

*Average normal rainfall of 4 meteorological stations within ACT Basin
**Lower range of percentiles indicates basin is moving into drought; Upper range of percentiles indicates basin is coming out of drought

Table 2: Drought Intensity Levels Triggers

DIL 1 Trigger	Low Basin Inflows **or** Low Composite Storage **or** Low State Line Flow
DIL 2 Trigger	DIL 1 criteria **+** (Low Basin Inflows or Low Composite Storage **or** Low State Line Flow)
DIL 3 Trigger	Low Basin Inflows + Low Composite Storage + Low State Line Flow

Table 3: Drought Intensity Level Response Matrix[1]

<table>
<tr><th></th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>June</th><th>July</th><th>Aug</th><th>Sept</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td rowspan="4">Drought Intensity Level Triggers</td><td colspan="12">Normal Operations</td></tr>
<tr><td colspan="12">DIL 1: Low Basin Inflows or Low Composite Storage or Low State Line Flow</td></tr>
<tr><td colspan="12">DIL 2: DIL 1 criteria + (Low Basin Inflows or Low Composite Storage or Low State Line Flow)</td></tr>
<tr><td colspan="12">DIL 3: Low Basin Flows + Low Composite Storage + Low State Line Flow</td></tr>
<tr><td rowspan="4">Coosa River Flow[2]</td><td colspan="3">Normal Operations 2000 cfs</td><td colspan="2">4000 (8000)</td><td>4000 - 2000</td><td colspan="6">Normal Operations 2000 cfs</td></tr>
<tr><td colspan="3">Jordan
2000 +/- cfs</td><td colspan="2">Jordan
4000 +/- cfs</td><td>6/15 Linear Ramp down</td><td colspan="3">Jordan
2000 +/- cfs</td><td colspan="3">Jordan
2000 +/- cfs</td></tr>
<tr><td colspan="3">Jordan
2000 +/- cfs</td><td colspan="2">Jordan
2500 +/- cfs</td><td>6/15 Linear Ramp down</td><td colspan="3">Jordan
2000 +/- cfs</td><td colspan="3">Jordan
2000 – 1600 +/- cfs</td></tr>
<tr><td colspan="3">Jordan
1600 +/- cfs</td><td colspan="3">Jordan
1600 - 2000 +/- cfs</td><td colspan="3">Jordan
2000 +/- cfs</td><td colspan="2">Jordan
1800 +/- cfs</td><td>Jordan
1600 +/- cfs</td></tr>
<tr><td rowspan="4">Tallapoosa River Flow[3]</td><td colspan="12">Normal Operations 1200 cfs</td></tr>
<tr><td colspan="4">Greater of: ½ Yates Inflow or
2 x Heflin Gage (Thurlow releases > 350 cfs)</td><td colspan="5">½ Yates Inflow</td><td colspan="3">½ Yates Inflow</td></tr>
<tr><td colspan="4">Thurlow 350 cfs</td><td colspan="5">½ Yates Inflow</td><td colspan="3">Thurlow 350 cfs</td></tr>
<tr><td colspan="6">Maintain 400 cfs at Montgomery WTP
(Thurlow release 350 cfs)</td><td colspan="3">Thurlow 350 cfs</td><td colspan="3">Maintain 400 cfs at Montgomery WTP
(Thurlow release 350 cfs)</td></tr>
<tr><td rowspan="4">Alabama River Flow[4]</td><td colspan="12">Normal Operations 4640 cfs</td></tr>
<tr><td colspan="4">4200 cfs (10% Cut) - Montgomery</td><td colspan="5">4640 cfs - Montgomery</td><td colspan="3">Reduce 4640 cfs – 4200 cfs Montgomery</td></tr>
<tr><td colspan="5">3700 cfs (20% Cut) - Montgomery</td><td colspan="4">4200 cfs (10% Cut) - Montgomery</td><td colspan="3">Reduce: 4200 cfs - 3700 cfs Montgomery
(1 Week ramp)</td></tr>
<tr><td colspan="4">2000 cfs Montgomery</td><td colspan="2">3700 cfs Montgomery</td><td colspan="3">4200 cfs (10% Cut) Montgomery</td><td colspan="3">Reduce 4200 cfs - 2000 cfs Montgomery
(1 Month ramp)</td></tr>
<tr><td rowspan="4">Guide Curve Elevation</td><td colspan="12">Normal Operations: Elevations follow Guide Curves as prescribed in License (Measured in Feet)</td></tr>
<tr><td colspan="12">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="12">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
<tr><td colspan="12">USACE Variances: As Needed; FERC Variance for Martin</td></tr>
</table>

1. **Note these are base flows that will be exceeded when possible**
2. **Jordan flows are based on a continuous +/- 5% of target flow**
3. **Thurlow flows are based on a continuous +/-5% of target flow; Flows are reset on noon each Tuesday based on the prior day's daily average at Heflin or Yates**
4. **Alabama River flows are 7-Day Average Flow**

Table 4: Low Basin Inflows Guide

Month	Coosa Filling Volume	Tallapoosa Filling Volume	Total Filling Volume	Montgomery Flow Target	*Total Basin Inflow Needed
January	628	0	628	4640	5268
February	626	120	747	4640	5387
March	603	2900	3503	4640	8143
April	1683	2585	4269	4640	8909
May	248	0	248	4640	4888
June	0	0	0	4640	4640
July	0	0	0	4640	4640
August	0	0	0	4640	4640
September	-612	-1304	-1916	4640	2724
October	-1371	-2132	-3503	4640	1137
November	-920	-2186	-3106	4640	1534
December	-821	0	-821	4640	3819

- Total Basin Inflow needed is sum of Total Filling Volume + 4640 cfs Release.
- All numbers are in cfs-days.
- Numbers are connected to reservoir rule curves; assumption that all are at top of rule curve elevation.
- When new rule curves are put into effect, numbers will need to be modified.

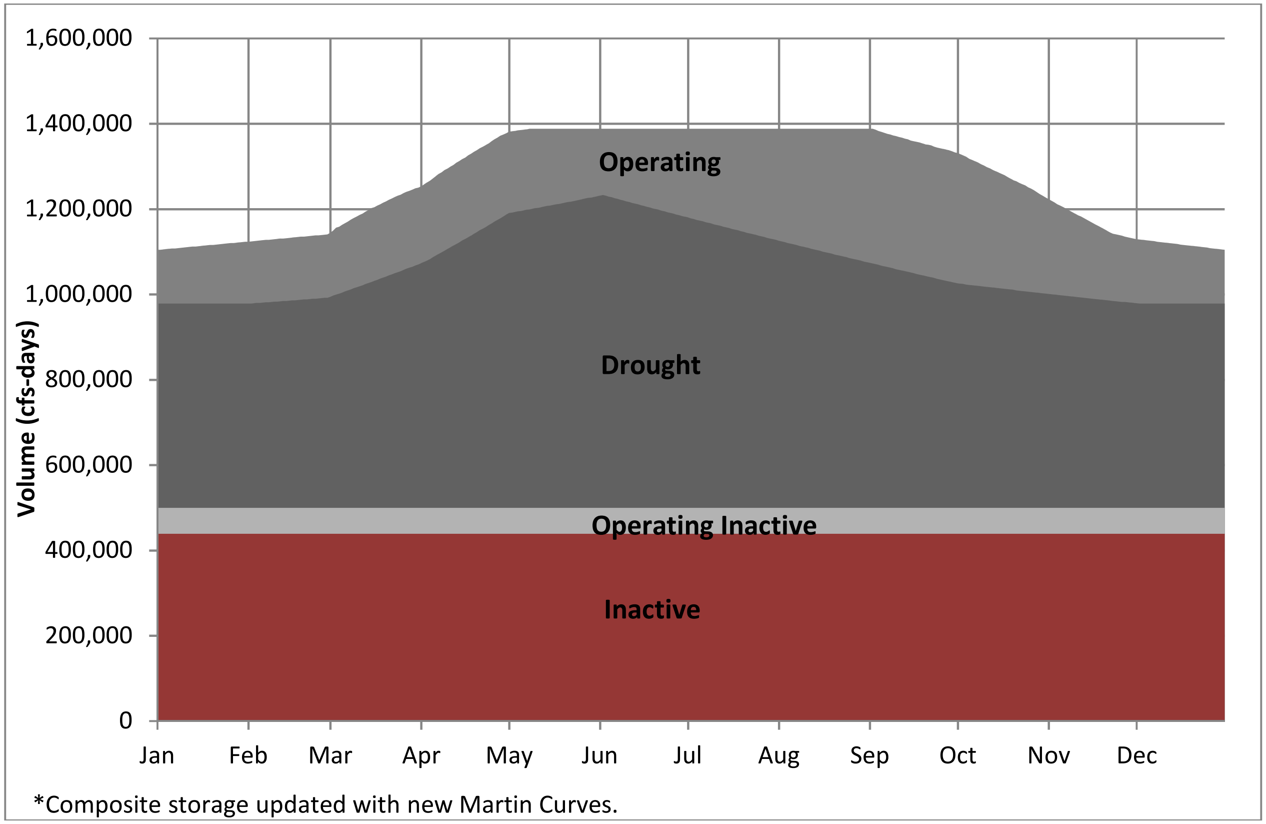
Table 5: Low State Line Flow

A Low State Line Flow occurs, when the Mayo's Bar gage measures a flow below the monthly historical 7Q10 flow. 7Q10 is defined as the lowest flow over a 7 day period that would occur once in 10 years.

Month	Mayo's Bar (cfs-days)
January	2544
February	2982
March	3258
April	2911
May	2497
June	2153
July	1693
August	1601
September	1406
October	1325
November	1608
December	2043

USACE Computation 1949 - 2006

Figure 1: Low Composite Storage



Low Composite Storage occurs when APC composite storage is less than or equal to the storage available within the drought contingency curves for APC's reservoirs. Composite storage is the sum of the amounts of storage available at the current elevation for each reservoir down to the drought contingency curve at each APC plant.

APPENDIX B

GREEN PLAN OPERATIONS

R L HARRIS RELEASE CRITERIA – *Effective March 1, 2005*

1. Daily Release Schedule
    a. The required Daily Volume Release will be at least 75% of the prior day's flow at the USGS Heflin Gauge.
    b. In the event that the Heflin Gauge is not in service, the required Daily Volume Release will be at least one-fourth of the previous day's inflow into R L Harris Reservoir.
    c. The Daily Volume Release will not to be below 100 DSF.
    d. Operations to ensure that flows at Wadley remain above the 45 cfs minimum mark shall continue.
    e. The required Daily Volume Release will be suspended if R L Harris is engaged in flood control operations.
    f. The required Daily Volume Release will be suspended if it jeopardizes the ability to fill R L Harris.
2. Hourly Release Schedule
    a. If less than two machine hours are scheduled for a given day, then the generation will be scheduled as follows:
        i. One-fourth of the generation will be scheduled at 6 AM.
        ii. One-fourth of the generation will be scheduled at 12 Noon.
        iii. One-half of the generation will be scheduled for the peak load.
        iv. If the peak load is during the morning, one-fourth of the generation will be scheduled at 6 PM.
    b. If two to four machine hours are scheduled for a given day, then generation will be scheduled as follows:
        i. Thirty minutes of generation will be scheduled at 6 AM.
        ii. Thirty minutes of generation will be scheduled at 12 Noon.
        iii. The remaining generation will be scheduled for the peak load.
        iv. If the peak load is during the morning, thirty minutes of the generation will be scheduled at 6 PM.
3. Two Unit Operation
    a. On the average, there will be more than 30 minutes between the start times between the two units.
    b. Two units may come online with less than 30 minute difference in their start times if there is a system emergency need.
4. Spawning Windows

    Spring and Fall spawning windows will scheduled as conditions permit. The operational criteria during spawning windows will supersede the above criteria.

R L Harris Release Criteria – *Effective March 1, 2005*

1. Daily Release Schedule

   a. The required Daily Volume Release will be at least 75% of the prior day's flow at the USGS Heflin Gauge.

   b. In the event that the Heflin Gauge is not in service, the required Daily Volume Release will be at least one-fourth of the previous day's inflow into R L Harris Reservoir.

   c. The Daily Volume Release will not to be below 100 DSF.

   d. Operations to ensure that flows at Wadley remain above the 45 cfs minimum mark shall continue.

   e. The required Daily Volume Release will be suspended if R L Harris is engaged in flood control operations.

   f. The required Daily Volume Release will be suspended if it jeopardizes the ability to fill R L Harris.

Drought 2007-2008 R L Harris Release Criteria

a. If the flows at Wadley are at or above 100 cfs, there will be one pulse per day, which will result in a Daily Volume Release of approximately 50 DSF.

b. The flows at Wadley will not be lower than the flows at Heflin.

R L HARRIS MINIMUM FLOW PROCEDURE

STEP 1: CREATE SCHEDULE BASED ON PRIOR DAY'S HEFLIN FLOW

Prior Day's Heflin Flow (DSF)					Generation At 6 AM	Generation At 12 Noon	Generation As System Needs	Total Machine Time	R L Harris Total Disch (DSF)
0	<	HEFLIN Q	<	150	10 MIN	10 MIN	10 MIN	30 MIN	133
150	<	HEFLIN Q	<	300	15 MIN	15 MIN	30 MIN	1 HR	267
300	<	HEFLIN Q	<	600	30 MIN	30 MIN	1 HR	2 HRS	533
600	<	HEFLIN Q	<	900	30 MIN	30 MIN	2 HRS	3 HRS	800
900	<	HEFLIN Q			30 MIN	30 MIN	3 HRS	4 HRS	1,067

STEP 2: ADD ADDITIONAL PEAK GENERATION AS NEEDED

STEP 3: ADJUST SCHEDULE IF NECESSARY

TOTAL SCH GENERATION	Generation At 6 AM	Generation At 12 Noon	Generation As System Needs	Total Machine Time	R L Harris Total Disch (DSF)
IF GENERATION = 1 MACH HR	15 MIN	15 MIN	30 MIN	1 HR	267
IF GENERATION = 2 MACH HRS	30 MIN	30 MIN	1 HR	2 HRS	533
IF GENERATION = 3 MACH HRS	30 MIN	30 MIN	2 HRS	3 HRS	800
IF GENERATION = 4 MACH HRS	30 MIN	30 MIN	3 HRS	4 HRS	1,067
IF GENERATION = 5+ MACH HRS			ALL		

<u>NOTES</u>

1. SCHEDULING OF GENERATION DOES NOT PRECLUDE THE ADDITION OF GENERATION AT ANY TIME.
2. ALL START TIMES ARE APPROXIMATE.
3. WHEN PULSING, IF THE SYSTEM DOES NOT DICTATE GENERATION DURING THE PM, A PULSE WILL BE SCHEDULED AT 6 PM.
4. R L HARRIS MIN FLOW PROCEDURE WILL BE SUSPENDED DURING ANY OF THE FOLLOWING CONDITIONS:
   A) TALLAPOOSA RIVER HAS BEEN PLACED UNDER FLOOD CONTROL OPERATIONS.
   B) FISH SPAWNING OPERATIONS HAVE BEEN SCHEDULED.
   C) APC HAS DECLARED THAT CONDITIONS EXIST THAT THREATEN THE SPRING FILLING OF R L HARRIS RESERVOIR.

APPENDIX C

NON-RESIDENTIAL PERMIT APPLICATION PROCESS

ALABAMA POWER
A SOUTHERN COMPANY

General Guidelines for Non-Residential Use of Project Lands and Waters

The following general guidelines are for non-APC structures and facilities intended to serve non-residential operations, generate revenue, etc., on Alabama Power Company's project lands and waters, including, but not limited to public marinas, restaurants, apartments and other rental properties, overnight campgrounds, bed and breakfasts, etc. These guidelines apply to new and existing developments where proposed additions, modifications, repairs, etc., require a new permit. They do not attempt to address every specific situation that may exist on a reservoir, but are provided as general guidelines to assist landowners in their decision to build.

These guidelines represent the maximum allowances Alabama Power will consider. Alabama Power may reduce or deny proposed development within the project boundary to comply with the Federal Energy Regulatory Commission (FERC) license requirements, purposes and operations.

ALABAMA POWER COMPANY RESERVES THE RIGHT TO MAKE EXCEPTIONS AND MODIFICATIONS TO THESE GUIDELINES AT ANY TIME AND AT ITS SOLE DISCRETION.

These general guidelines are implemented by Alabama Power Company to allow it to provide for orderly and reasonable shoreline management of its reservoirs, recognizing that peculiarities in shorelines and property lines exist on the reservoirs and may require flexibility on the part of Alabama Power and/or landowners.

PERMIT PROCESS

Per Alabama Power's FERC licenses, agency consultation and FERC authorization are required before Alabama Power can permit certain non-residential facilities located in project lands and waters. **Absolutely no construction, earthmoving, or other work may be started on, within or partially within the project boundary prior to Alabama Power issuing a permit.**

Alabama Power will evaluate permit applications under the following guidelines:

GENERAL SITE CONDITIONS

1. Required shoreline - 100 feet, minimum

2. Side lot line setback - 25 feet, minimum

STRUCTURE DIMENSIONS

1. Total Footprint Area – 1000 square feet, maximum, per 100 feet of shoreline

The Total Footprint Area includes the deck surface area of all structures (docks, piers, boat slip fingers, swim platforms, etc.) plus the water surface area occupied by vessels. Alabama Power may permit additional square footage for General Public Marinas, if also approved through the FERC process.

2. Boat slip wet dimensions (open water area only) – Will be evaluated during the non-residential permit application process. Dimension maximums must be consistent with those necessary to moor boats meeting current state law.

3. Length of structure into lake – lesser of 150 feet or 1/4 the distance across local water. General Public Marinas may exceed this length if approved by APC through the FERC process.

4. Spacing between multiple docks on the same property – 50 feet, minimum

5. Requests for additional deck area for swim platforms or other activities will be reviewed for approval on a case-by-case basis, subject to the total footprint area limit.

OTHER

1. Boat lifts and canopies may be allowed in marinas but are not allowed in other non-residential developments.

2. Causeways are not allowed.

3. Docks, boat slips, piers, etc., may be floating or fixed.

4. Floatation shall be encased or closed cell (extruded) expanded polystyrene of good quality and manufactured for marine use which will not become waterlogged or sink when punctured. No structures may be constructed with un-encapsulated white beaded foam.

ATTORNEYS' FEES

By accepting a Nontransferable Lakeshore Use Permit ("Permit") and agreeing to the terms of the Permit, you agree and acknowledge that the Company has a right to request, and you have an obligation to pay any and all attorneys' fees, expenses, and/or costs incurred by the Company relating to the enforcement of the rules, regulations, provisions, terms and/or conditions of the Permit, including, without limitation, any and all attorneys' fees, expenses, and costs incurred by the Company relating to remedying any action, construction or activity that is not in compliance with the terms of the Permit, whether caused by you, your family members, guests, agents, employees and/or contractors.

Permittee Statement: I have received, read, understand and agree to abide by these General Guidelines for Non-Residential Use of Project Lands and Waters.

Signed: ____ Date: ___________________
Permittee

General Guidelines for Multiple Single-Family Type Dwelling Use of Project Lands and Waters

The following general guidelines are for community piers, landings, boat docks or similar structures and facilities intended to serve non-commercial multiple single-family type dwellings on Alabama Power Company's project lands and waters, including but not limited to condominiums, subdivisions, campgrounds that offer yearly leases, etc. These guidelines apply to new and existing developments where proposed additions, modifications, repairs, etc., require a new permit. They do not attempt to address every specific situation that may exist on a reservoir, but are provided as general guidelines to assist landowners in their decision to build.

These guidelines represent the maximum allowances Alabama Power will consider. Alabama Power may reduce or deny proposed development within the project boundary to comply with Federal Energy Regulatory Commission (FERC) license requirements, purposes and operations.

ALABAMA POWER COMPANY RESERVES THE RIGHT TO MAKE EXCEPTIONS AND MODIFICATIONS TO THESE GUIDELINES AT ANY TIME AND AT ITS SOLE DISCRETION.

These general guidelines are implemented by Alabama Power Company to allow it to provide for orderly and reasonable shoreline management of its reservoirs, recognizing that peculiarities in shorelines and property lines exist on the reservoirs and may require flexibility on the part of Alabama Power and/or landowners.

PERMIT PROCESS

Per Alabama Power's FERC licenses, Alabama Power, without consultation or review by others, may permit facilities that can accommodate up to a total of 10 watercraft on one property.

Agency consultation and FERC authorization are required before Alabama Power can permit certain facilities that can accommodate more than a total of ten watercraft, at one property. **Absolutely no construction, earthmoving, or other work may be started on, within or partially within the project boundary prior to Alabama Power issuing a permit.**

Alabama Power will evaluate permit applications under the following guidelines:

GENERAL SITE CONDITIONS

1. Required shoreline - 100 feet, minimum

2. Side lot line setback - 25 feet, minimum

STRUCTURE DIMENSIONS

1. Total Footprint Area – 1000 square feet, maximum, per 100 feet of shoreline

The Total Footprint Area includes the deck surface area of all structures (docks, piers, boat slip fingers, swim platforms, etc.) plus the water surface area occupied by vessels.

2. Boat slip wet dimensions (open water area only) – Will be evaluated during the application process. Dimension maximums must be consistent with those necessary to moor boats meeting current state law.

3. Length of structure into lake – lesser of 150 feet or 1/4 the distance across local water

4. Spacing between multiple docks on the same property – 50 feet, minimum

5. Requests for additional deck area for swim platforms or other activities will be reviewed for approval on a case-by-case basis, subject to the total footprint area limit.

6. Causeways are not allowed.

ALABAMA POWER
A SOUTHERN COMPANY

OTHER

1. Boat lifts, roofs and canopies are not allowed.

2. Docks, boat slips, piers, etc., may be floating or fixed.

3. Floatation shall be encased or closed cell (extruded) expanded polystyrene of good quality and manufactured for marine use which will not become waterlogged or sink when punctured. No structures may be constructed with un-encapsulated white beaded foam.

ATTORNEYS' FEES

By accepting a Nontransferable Lakeshore Use Permit ("Permit") and agreeing to the terms of the Permit, you agree and acknowledge that the Company has a right to request, and you have an obligation to pay any and all attorneys' fees, expenses, and/or costs incurred by the Company relating to the enforcement of the rules, regulations, provisions, terms and/or conditions of the Permit, including, without limitation, any and all attorneys' fees, expenses, and costs incurred by the Company relating to remedying any action, construction or activity that is not in compliance with the terms of the Permit, whether caused by you, your family members, guests, agents, employees and/or contractors.

Permittee Statement: I have received, read, understand and agree to abide by these General Guidelines for Multiple Single-Family Type Dwelling use of Project Lands and Waters.

Signed: ____ Date: ____________________
Permittee

Appendix L
Baseline Water Quality Report

Appendix L

HARRIS DAM
RELICENSING

BASELINE WATER QUALITY REPORT

R. L. HARRIS HYDROELECTRIC PROJECT

FERC NO. 2628

Prepared for:

ALABAMA POWER COMPANY

BIRMINGHAM, ALABAMA

Alabama Power

Prepared by:

Kleinschmidt

March 2018

ALABAMA POWER COMPANY
BIRMINGHAM, ALABAMA

R.L. HARRIS HYDROELECTRIC PROJECT
FERC No. 2628

BASELINE WATER QUALITY REPORT

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BASELINE WATER QUALITY REPORT

1.0 INTRODUCTION

Alabama Power Company (Alabama Power) is initiating the Federal Energy Regulatory Commission (FERC) relicensing of the 135-megawatt (MW) R.L. Harris Hydroelectric Project (Harris Project), FERC Project No. 2628. The Harris Project consists of a dam, spillway, powerhouse, and those lands and waters necessary for the operation of the hydroelectric project and enhancement and protection of environmental resources. These structures, lands, and water are enclosed within the FERC Project Boundary. Under the existing Harris Project license, the FERC Project Boundary encloses two distinct geographic areas, described below.

Harris Reservoir is the 9,870-acre reservoir (Harris Reservoir) created by the R.L. Harris Dam (Harris Dam). Harris Reservoir is located on the Tallapoosa River, near Lineville, Alabama. The lands adjoining the reservoir total approximately 7,392 acres and are included in the FERC Project Boundary. This includes land to 795 feet mean sea level (msl)[1], as well as natural undeveloped areas, hunting lands, prohibited access areas, recreational areas, and all islands.

The Harris Project also contains 15,063 acres of land within the James D. Martin-Skyline Wildlife Management Area (Skyline WMA) located in Jackson County, Alabama. These lands are located approximately 110 miles north of Harris Reservoir and were acquired and incorporated into the FERC Project Boundary as part of the FERC-approved Harris Project Wildlife Mitigative Plan and Wildlife Management Plan. These lands are leased to, and managed by, the State of Alabama for wildlife management and public hunting and are part of the Skyline WMA (ADCNR 2016b).

For the purposes of this technical report, "Lake Harris" refers to the 9,870-acre reservoir, adjacent 7,392 acres of project land, and the dam, spillway, and powerhouse. "Skyline" refers to the 15,063 acres of Project land within the Skyline WMA in Jackson County. "Harris Project" refers to all the lands, waters, and structures enclosed within the FERC Project Boundary, which includes both Lake Harris and Skyline. "Harris Reservoir" refers to the 9,870-acre reservoir only; Harris Dam refers to the dam, spillway, and powerhouse. The "Project Area" refers to the land and water in the Project Boundary and immediate geographic area adjacent to the Project Boundary (Alabama Power Company 2018).

Lake Harris and Skyline are located within two river basins: the Tallapoosa and Tennessee River Basins, respectively. The only waterbody managed by Alabama Power as part of their FERC license for the Harris Project is the Harris Reservoir.

To support the relicensing process and summarize baseline water quality information for the Pre-Application Document (PAD), Kleinschmidt Associates (Kleinschmidt) prepared this report to

[1] Also includes a scenic easement (to 800 feet msl or 50 horizontal feet from 793 feet msl, whichever is less, but never less than 795 feet msl)

summarize baseline operational data collected from 2005 to 2016. Although the Harris Project has been operating since 1983, Alabama Power, after consultations with interested stakeholders, implemented a pulsing scheme in 2005 (referred to as the "Green Plan"), which created a new operational baseline. Therefore, this report summarizes data from 2005 through 2016.

2.0 PROJECT DESCRIPTION

2.1 Lake Harris

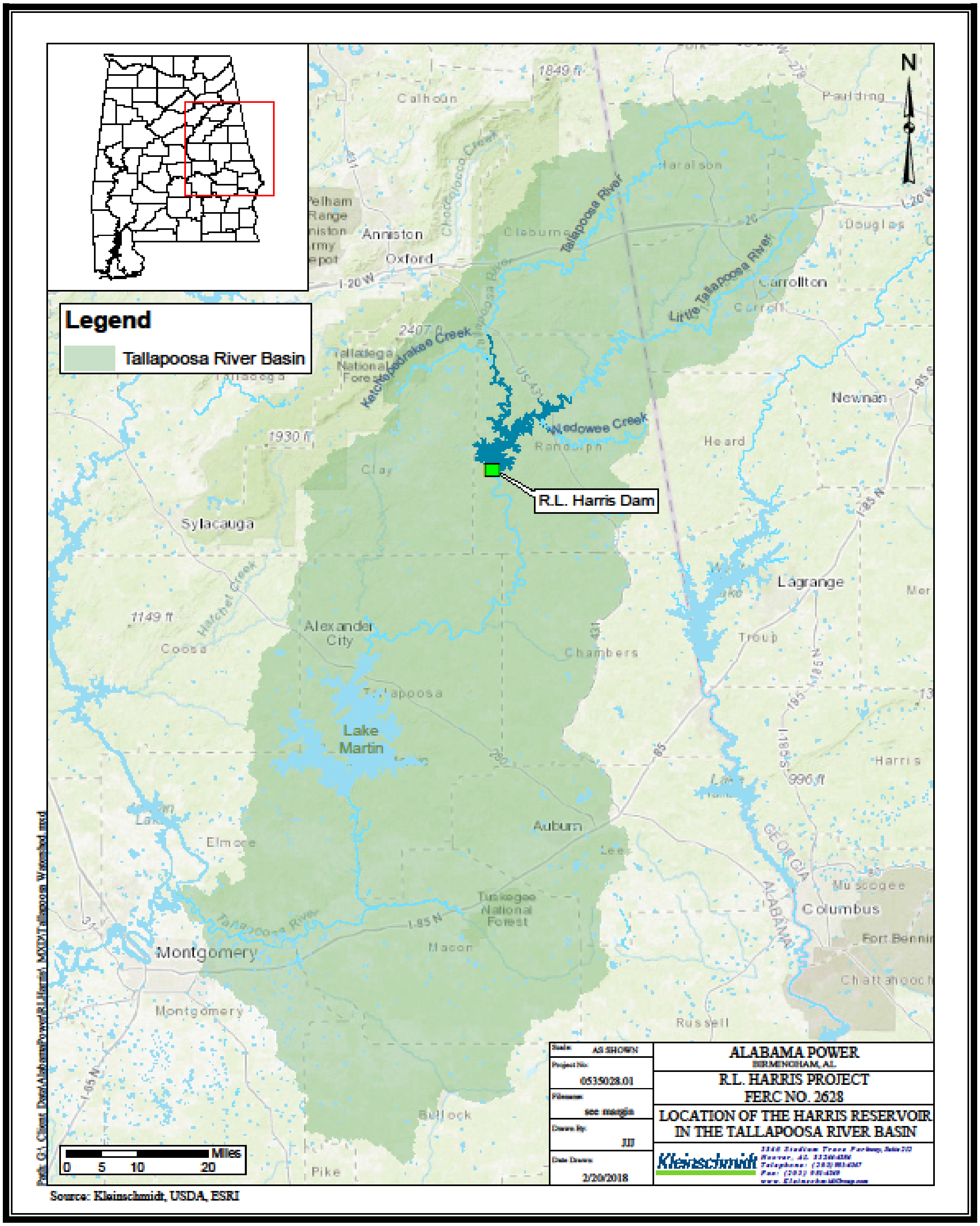
Harris Reservoir is located within the Tallapoosa River Basin (Figure 2-1). The Harris Reservoir extends up the Tallapoosa River approximately 29 miles from Harris Dam with approximately 367 miles of shoreline. The reservoir surface area is approximately 9,870 acres at normal full pool elevation of 793 feet mean sea level (msl) and has a mandatory 8-foot drawdown to 785 feet msl from December to April. The normal tailwater elevation with one unit operating is 664.9 feet msl; with two units operating, it is 667.7 feet msl. The gross storage capacity of Harris Reservoir is approximately 425,721 acre-feet, and the usable storage capacity is approximately 207,317 acre-feet.

The Harris Dam consists of a concrete gravity dam, powerhouse, and spillway totaling 1,142 feet long with a maximum height of 151.5 feet. The spillway has five radial gates for passing floodwaters in excess of turbine capacity and one radial trash gate. Each radial gate measures 40 feet 6 inches high and 40 feet wide.

The Harris powerhouse is a concrete structure and is integral with the intake facilities. It houses two units totaling 135 MW, which are comprised of two vertical generators each rated at 71,740 Kilovolts (kV) and two vertical Francis turbines each rated at 95,000 horsepower (hp). Project intake structures are located at 746 feet msl and are equipped with a skimmer weir that can incrementally raise the effective intake elevation approximately 18 feet to a maximum elevation of approximately 764 feet msl.

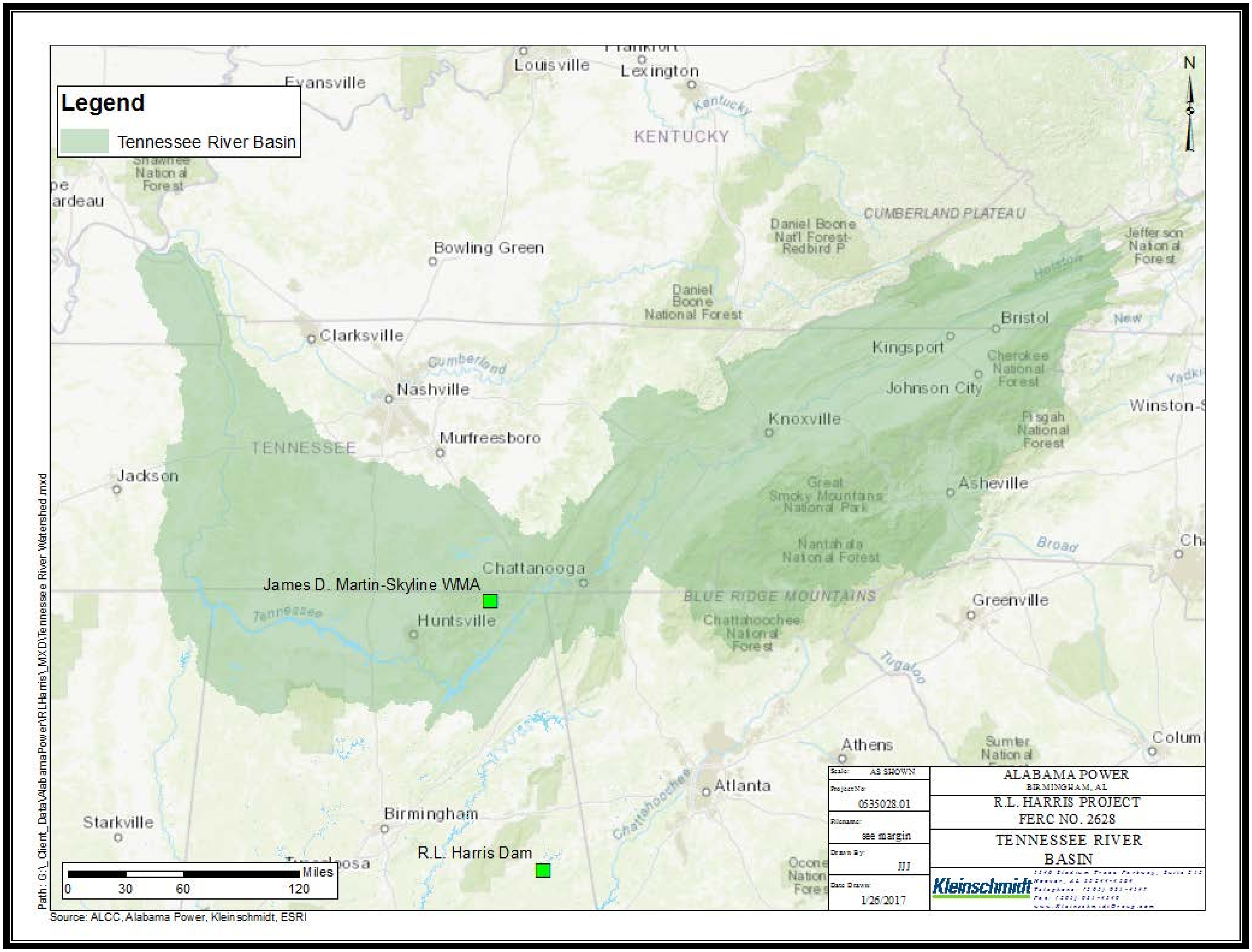
2.2 Skyline

The Harris Project contains 15,063 acres of land within the Skyline WMA located within the Tennessee River Basin in Jackson County near Scottsboro, Alabama (Figure 2-2). These Harris Project lands are located approximately 110 miles north of Harris Reservoir. Portions of the drainage areas for Coon Creek and Crow Creek fall within the Skyline boundary.



Source: Kleinschmidt, USDA, ESRI 2018

FIGURE 2-1 TALLAPOOSA RIVER BASIN



Source: ALCC, Alabama Power, Kleinschmidt, ESRI 2017

FIGURE 2-2 TENNESSEE RIVER BASIN

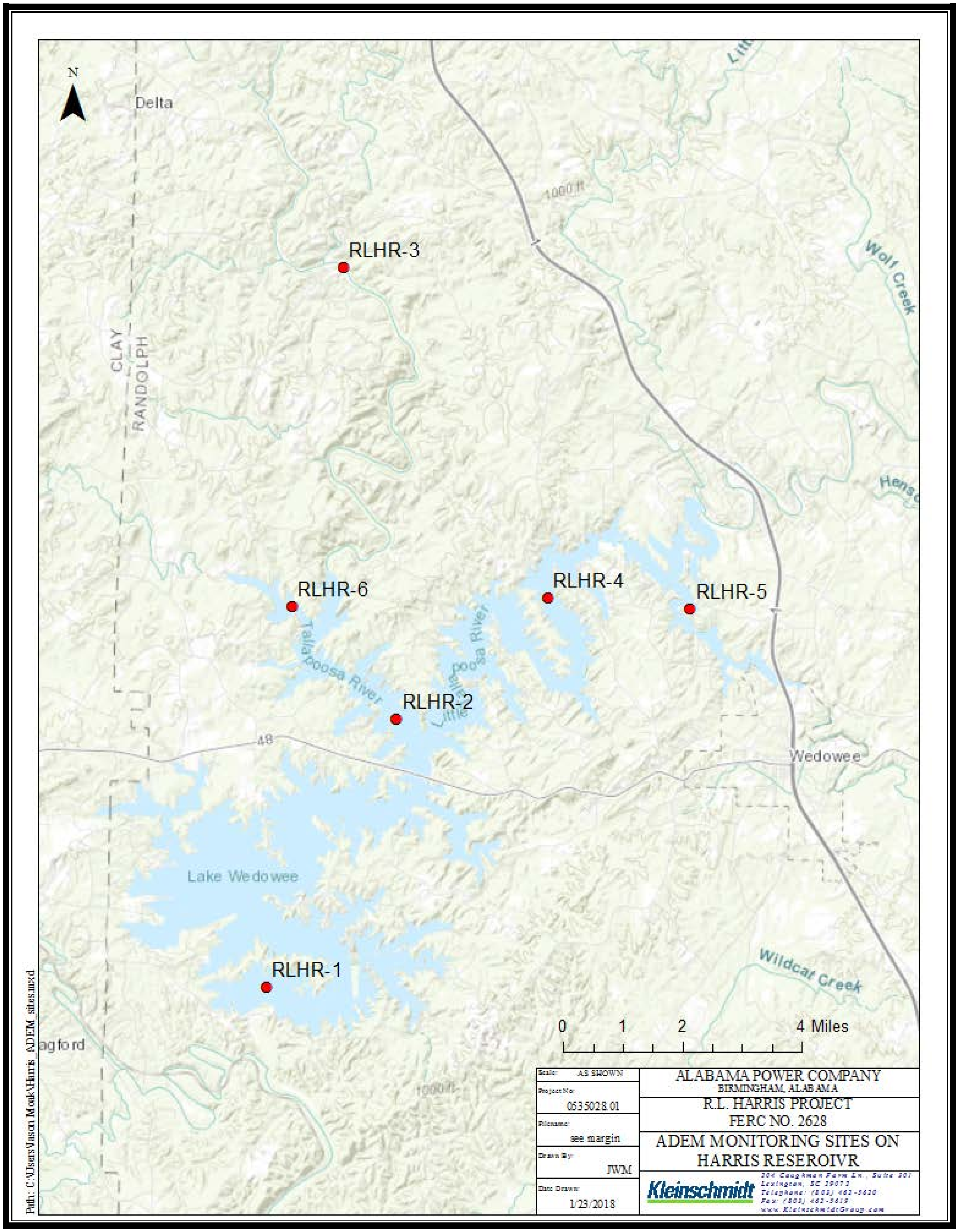
3.0 RESERVOIR WATER QUALITY

The Alabama Department of Environmental Management (ADEM) performed water quality sampling at several Harris Reservoir sites, including the forebay. ADEM's 2013 report for Harris Reservoir includes a presentation of water quality data collected in 2010, with comparisons to previous years extending back to 1997 (ADEM 2013a). In the 2013 report, ADEM noted that concentrations of nutrients (nitrogen and phosphorus), chlorophyll *a*, and total suspended solids (TSS) were generally lower than samples collected in 2005. Long-term monitoring of water quality indicates that Harris Reservoir is currently mesotrophic with an average Trophic State Index (TSI) value of 49 (ADEM 2016). Data collected by ADEM in 2015 indicated a TSI value of 38, which is in the oligotrophic range. A mesotrophic or oligotrophic classification indicates that substantial nutrient loading does not normally occur in Harris Reservoir.

As part of its monitoring program, ADEM collects basic water quality data throughout a vertical profile from the reservoir surface to the bottom at regular depth intervals (approximately 3 feet) (Figure 3-1). Water temperature, dissolved oxygen, pH, and conductivity data from these forebay profiles collected between 2005 and 2015 are presented in Figure 3-2 to Figure 3-5. Generally, during the spring and summer, the Harris Reservoir stratifies into three layers:

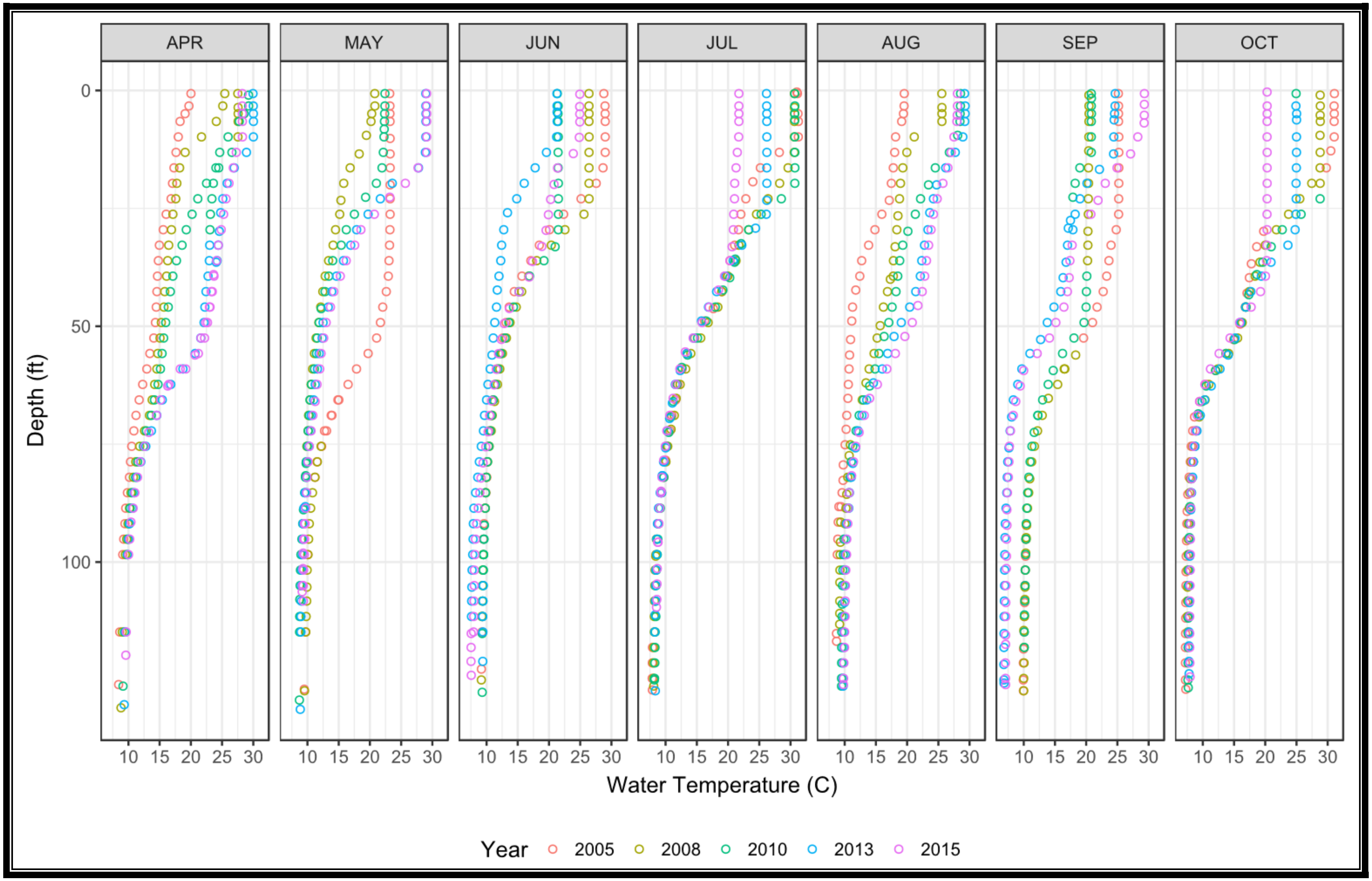
- an epilimnion, which is fairly uniform in temperature and is well oxygenated,
- a hypolimnion, a cold, less oxygenated bottom layer, and
- a metalimnion or thermocline, which is a transition layer between the epilimnion and hypolimnion.

ADEM collected and analyzed monthly surface water samples for numerous parameters at six stations on Harris Reservoir in April through October during their sampling years between 2005 and 2015. These data are summarized in Table 3-1 to Table 3-6. Water clarity, as measured by mean Secchi Disk depth, is typically higher in the lower reaches of the reservoir and lower in the upper reaches, ranging from 8.9 ft at RLHR-1 to 4.3 ft at RLHR-3. Similarly, concentrations of nutrients such as nitrogen and phosphorus, as well as chlorophyll *a* concentrations, were higher at the upper reservoir stations (RLHR-3 and RLHR-5).



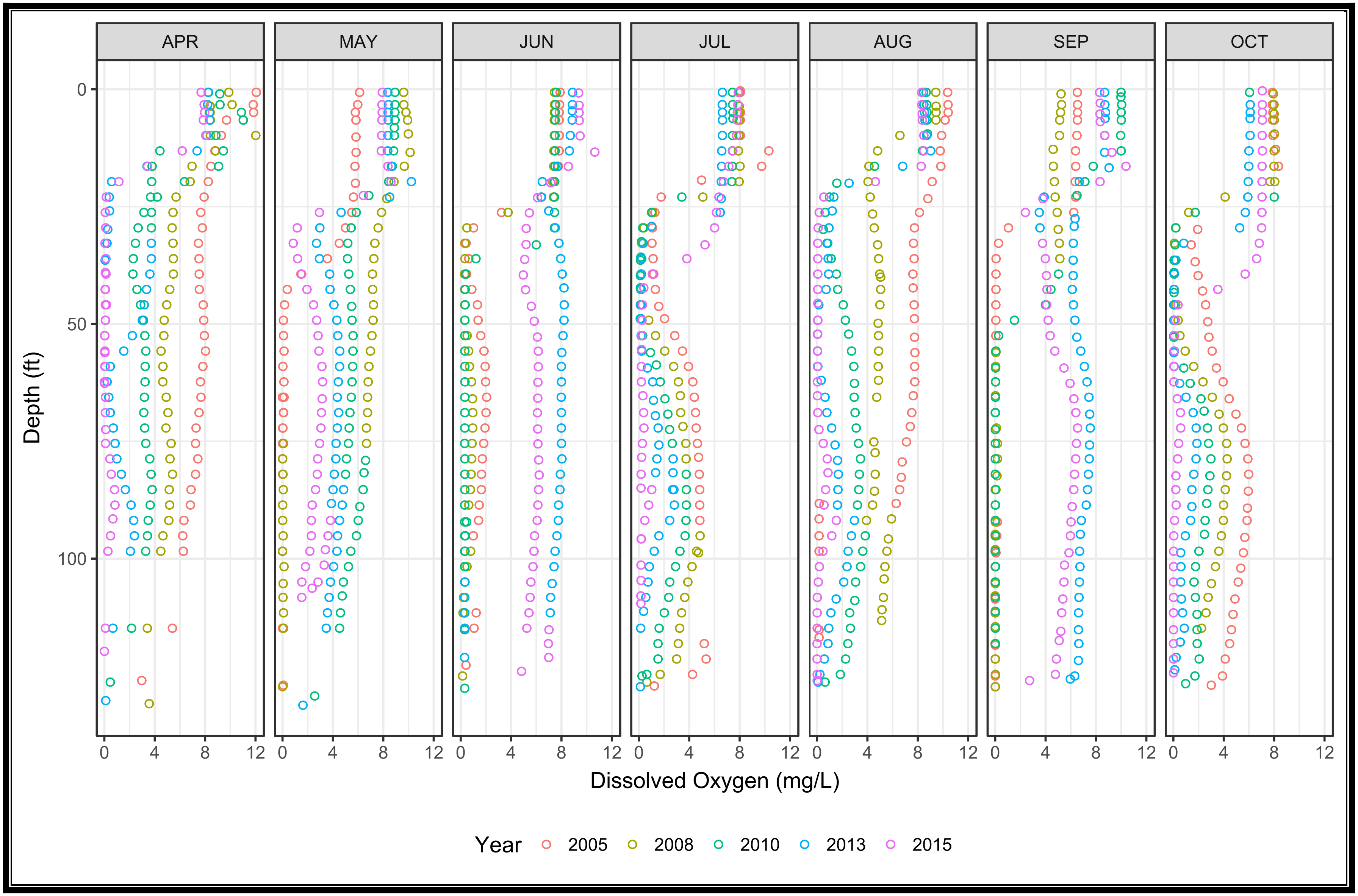
Source: ADEM, Kleinschmidt, ESRI 2018

FIGURE 3-1 ADEM MONITORING SITES ON HARRIS RESERVOIR



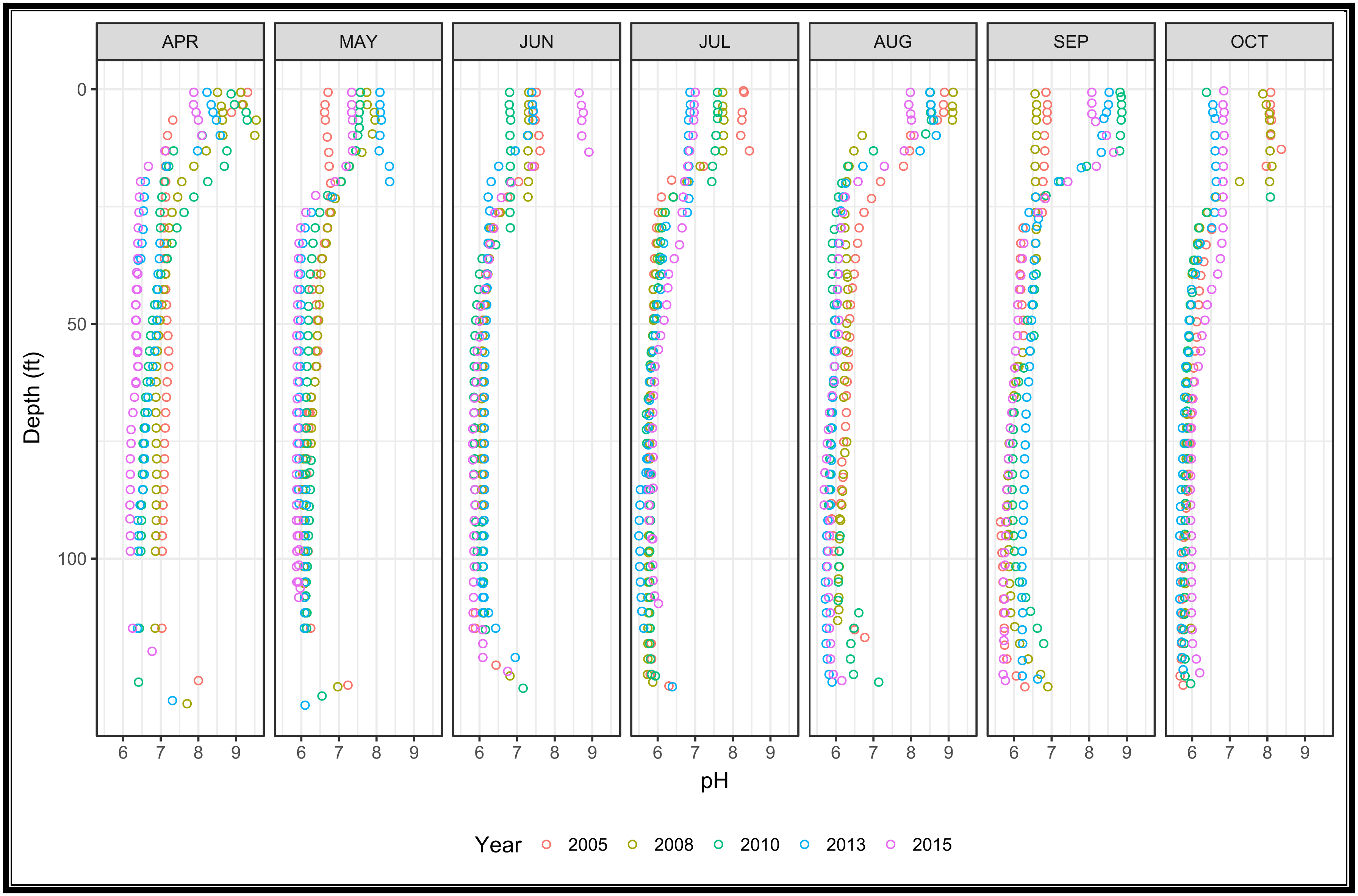
Source: ADEM 2017

FIGURE 3-2 HARRIS RESERVOIR FOREBAY (RLHR-1) WATER TEMPERATURE PROFILES



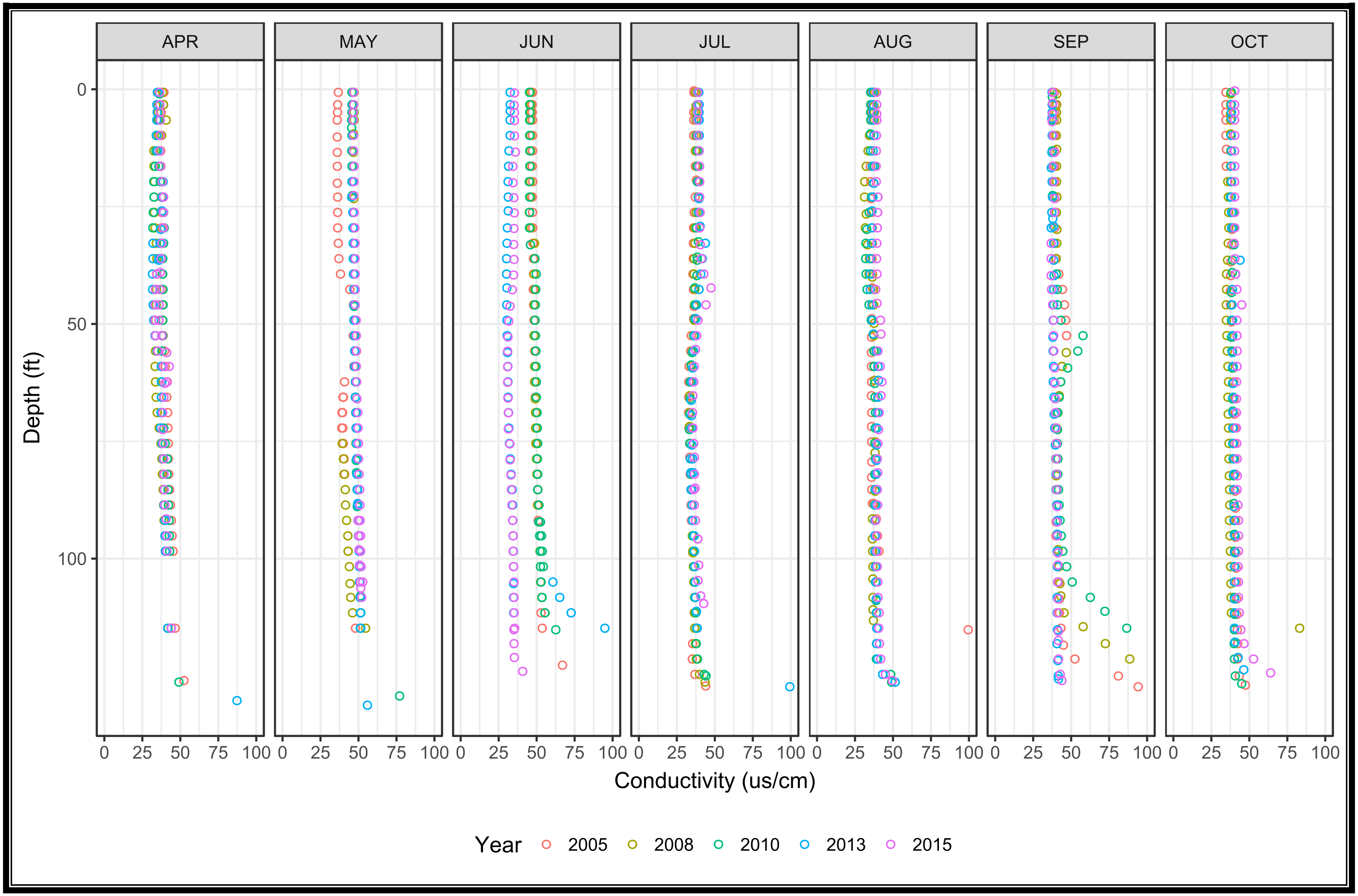
Source: ADEM 2017

FIGURE 3-3 HARRIS RESERVOIR FOREBAY (RLHR-1) DISSOLVED OXYGEN PROFILES



Source: ADEM 2017

FIGURE 3-4 HARRIS RESERVOIR FOREBAY (RLHR-1) PH PROFILES



Source: ADEM 2017

FIGURE 3-5 HARRIS RESERVOIR FOREBAY (RLHR-1) CONDUCTIVITY PROFILES

TABLE 3-1 SUMMARY OF ADEM SAMPLE RESULTS FOR RLHR-1 SITE (2005-2015)

Parameter	n	Mean	SD	Min	Max	Units
Algal growth potential	2	2.6	0.4	2.32	2.91	MSC
Alkalinity, total	37	11.8	3.1	6.1	24.1	mg/L
Ammonia-nitrogen	37	0.012	0.045	0.000	0.201	mg/L
5-day BOD	30	0.1	0.4	0.0	2.1	mg/L
Calcium	12	2.46	0.31	1.95	2.86	mg/L
Chloride	30	2.4	0.3	1.8	3.6	mg/L
Chlorophyll *a*	37	6.4	5.3	0.0	20.8	mg/m3
Depth, bottom	30	37.4	2.0	32.4	40	m
Depth, Secchi disk depth	37	2.7	0.7	1.2	4.2	m
Escherichia coli	7	3.7	4.6	1	11	MPN/100mL
Fecal Coliform	3	1.0	0.0	1	1	cfu/100 mL
Hardness, Ca, Mg	21	10.6	1.8	7.26	13.6	mg/L
Nitrate + Nitrite	37	0.024	0.037	0.000	0.169	mg/L
Kjeldahl nitrogen	37	0.244	0.189	0.000	0.625	mg/L
Light attenuation, depth at 99%	37	6.8	1.9	3.6	12.8	m
Magnesium	12	1.16	0.13	0.90	1.34	mg/L
Orthophosphate	37	0.005	0.004	0.000	0.012	mg/L
Phosphorus	37	0.014	0.008	0.000	0.027	mg/L
Total dissolved solids	37	26.6	15.8	0.0	66.0	mg/L
Total suspended solids	37	2.6	3.2	0.0	11.0	mg/L
Turbidity	37	2.2	0.9	0.4	4.9	NTU

Source: ADEM 2017; Data from 2005, 2007, 2008, 2010, 2013, and 2015

Key:

BOD	Biochemical Oxygen Demand
Ca	Calcium
cfu	Colony Forming Unit
m	Meter
m3	Cubic Meter
mg	Milligram
Mg	Magnesium
mg/L	Milligram per liter
MPN	Most Probable Number
MSC	Maximum Standing Crop
n	Number of Samples
NTU	Nephelometric Turbidity Unit
SD	Standard Deviation

TABLE 3-2 SUMMARY OF ADEM SAMPLE RESULTS FOR RLHR-2 SITE (2005-2015)

Parameter	n	Mean	SD	Min	Max	Units
Algal growth potential	2	2.6	0.5	2.26	2.9	MSC
Alkalinity, total	39	13.2	3.6	9.49	29.6	mg/L
Ammonia-nitrogen	39	0.015	0.049	0.000	0.236	mg/L
5-day BOD	32	0.0	0.0	0.0	0.0	mg/L
Calcium	13	2.57	0.30	2.18	2.97	mg/L
Chloride	32	2.5	0.4	1.9	3.3	mg/L
Chlorophyll *a*	39	7.6	5.5	0.0	24.6	mg/m3
Depth, bottom	32	26.9	1.3	23.5	28.3	m
Depth, Secchi disk depth	39	2.0	0.5	0.9	3.2	m
Escherichia coli	7	1.1	0.4	1	2	MPN/100 mL
Fecal Coliform	3	1.0	0.0	1	1	cfu/100 mL
Hardness, Ca, Mg	22	11.5	1.8	7.74	14.6	mg/L
Nitrate + Nitrite	39	0.027	0.054	0.000	0.311	mg/L
Kjeldahl nitrogen	39	0.298	0.221	0.000	0.761	mg/L
Light attenuation, depth at 99%	39	5.4	1.0	3.1	7.6	m
Magnesium	13	1.22	0.14	1.04	1.43	mg/L
Orthophosphate	39	0.006	0.004	0.000	0.015	mg/L
Phosphorus	39	0.018	0.009	0.000	0.051	mg/L
Total dissolved solids	39	32.2	17.6	0.0	73.0	mg/L
Total suspended solids	39	2.6	2.9	0.0	15.0	mg/L
Turbidity	41	3.0	1.3	0.1	6.5	NTU

Source: ADEM 2017; Data from 2005, 2007, 2008, 2010, 2013, and 2015

Key:

BOD	Biochemical Oxygen Demand
Ca	Calcium
cfu	Colony Forming Unit
m	Meter
m3	Cubic Meter
mg	Milligram
Mg	Magnesium
mg/L	Milligram per liter
MPN	Most Probable Number
MSC	Maximum Standing Crop
n	Number of Samples
NTU	Nephelometric Turbidity Unit
SD	Standard Deviation

TABLE 3-3 SUMMARY OF ADEM SAMPLE RESULTS FOR RLHR-3 SITE (2005-2015)

Parameter	n	Mean	SD	Min	Max	Units
Algal growth potential	2	6.4	1.6	5.26	7.46	MSC
Alkalinity, total	31	14.7	4.4	11.1	29.3	mg/L
Ammonia-nitrogen	31	0.019	0.051	0.000	0.177	mg/L
5-day BOD	24	0.0	0.0	0.0	0.0	mg/L
Calcium	12	2.76	0.30	2.35	3.24	mg/L
Chloride	24	2.0	0.2	1.5	2.5	mg/L
Chlorophyll *a*	31	12.5	9.1	0.0	39.2	mg/m3
Depth, bottom	24	8.1	1.1	4	9.3	m
Depth, Secchi disk depth	31	1.3	0.4	0.6	2.2	m
Escherichia coli	9	29.4	53.0	1	160.7	MPN/100 mL
Fecal Coliform	2	6.5	6.4	2	11	cfu/100 mL
Hardness, Ca, Mg	16	12.2	1.2	10.4	14.1	mg/L
Nitrate + Nitrite	31	0.055	0.064	0.000	0.203	mg/L
Kjeldahl nitrogen	31	0.381	0.241	0.000	0.902	mg/L
Light attenuation, depth at 99%	31	3.3	0.8	1.6	6.1	m
Magnesium	12	1.32	0.17	1.10	1.55	mg/L
Orthophosphate	31	0.006	0.005	0.000	0.024	mg/L
Phosphorus	31	0.028	0.016	0.000	0.079	mg/L
Total dissolved solids	31	35.0	18.2	0.0	66.0	mg/L
Total suspended solids	31	5.5	3.9	0.0	18.0	mg/L
Turbidity	34	7.6	5.4	0.2	26.2	NTU

Source: ADEM 2017; Data from 2005, 2007, 2008, 2010, 2013, and 2015

Key:

BOD	Biochemical Oxygen Demand
Ca	Calcium
cfu	Colony Forming Unit
m	Meter
m3	Cubic Meter
mg	Milligram
Mg	Magnesium
mg/L	Milligram per liter
MPN	Most Probable Number
MSC	Maximum Standing Crop
n	Number of Samples
NTU	Nephelometric Turbidity Unit
SD	Standard Deviation

TABLE 3-4 SUMMARY OF ADEM SAMPLE RESULTS FOR RLHR-4 SITE (2005-2015)

Parameter	n	Mean	SD	Min	Max	Units
Algal growth potential	2	4.9	0.8	4.27	5.46	MSC
Alkalinity, total	33	13.0	3.0	8.9	26.9	mg/L
Ammonia-nitrogen	33	0.014	0.031	0.000	0.142	mg/L
5-day BOD	26	0.6	1.6	0.0	7.1	mg/L
Calcium	12	2.57	0.24	2.24	2.99	mg/L
Chloride	26	3.5	0.5	2.7	4.8	mg/L
Chlorophyll *a*	32	10.4	6.3	0.0	22.4	mg/m3
Depth, bottom	25	18.4	1.5	13.9	19.6	m
Depth, Secchi disk depth	32	1.8	0.5	1.0	2.9	m
Escherichia coli	7	5.0	6.9	1	18.9	MPN/100 mL
Fecal Coliform	2	1.0	0.0	1	1	cfu/100 mL
Hardness, Ca, Mg	17	11.7	1.0	10.4	13.6	mg/L
Nitrate + Nitrite	33	0.066	0.076	0.000	0.317	mg/L
Kjeldahl nitrogen	33	0.366	0.192	0.000	0.702	mg/L
Light attenuation, depth at 99%	32	4.8	1.1	2.5	6.9	m
Magnesium	12	1.27	0.13	1.10	1.51	mg/L
Orthophosphate	33	0.005	0.004	0.000	0.014	mg/L
Phosphorus	33	0.023	0.015	0.000	0.074	mg/L
Total dissolved solids	33	37.7	39.7	0.0	208.0	mg/L
Total suspended solids	33	4.7	5.9	0.0	34.0	mg/L
Turbidity	31	4.0	1.6	2.4	8.7	NTU

Source: ADEM 2017; Data from 2005, 2007, 2008, 2010, 2013, and 2015

Key:

BOD	Biochemical Oxygen Demand
Ca	Calcium
cfu	Colony Forming Unit
m	Meter
m3	Cubic Meter
mg	Milligram
Mg	Magnesium
mg/L	Milligram per liter
MPN	Most Probable Number
MSC	Maximum Standing Crop
n	Number of Samples
NTU	Nephelometric Turbidity Unit
SD	Standard Deviation

TABLE 3-5 SUMMARY OF ADEM SAMPLE RESULTS FOR RLHR-5 SITE (2005-2015)

Parameter	n	Mean	SD	Min	Max	Units
Algal growth potential	1	6.2	NA	6.21	6.21	MSC
Alkalinity, total	22	12.9	4.2	7.6	24.1	mg/L
Ammonia-nitrogen	22	0.016	0.032	0.000	0.113	mg/L
5-day BOD	14	0.2	0.8	0.0	2.9	mg/L
Calcium	10	2.32	0.40	1.63	2.84	mg/L
Chloride	14	3.4	0.5	2.5	4.2	mg/L
Chlorophyll *a*	22	11.2	6.0	0.0	20.5	mg/m3
Depth, bottom	15	11.3	1.6	8.1	13.5	m
Depth, Secchi disk depth	22	1.7	0.4	1.1	2.5	m
Escherichia coli	6	8.6	12.1	1	28.5	MPN/100 mL
Fecal Coliform	1	20.0	NA	20	20	cfu/100 mL
Hardness, Ca, Mg	14	10.8	1.6	7.98	13.3	mg/L
Nitrate + Nitrite	22	0.060	0.074	0.000	0.251	mg/L
Kjeldahl nitrogen	22	0.400	0.194	0.000	0.772	mg/L
Light attenuation, depth at 99%	22	4.7	1.0	2.8	6.6	m
Magnesium	10	1.20	0.20	0.94	1.50	mg/L
Orthophosphate	22	0.004	0.004	0.000	0.013	mg/L
Phosphorus	22	0.026	0.018	0.000	0.073	mg/L
Total dissolved solids	22	32.7	17.7	0.0	77.0	mg/L
Total suspended solids	22	4.7	4.5	0.0	16.0	mg/L
Turbidity	22	4.1	1.6	0.3	8.5	NTU

Source: ADEM 2017; Data from 2005, 2007, 2008, 2010, 2013, and 2015

Key:

BOD	Biochemical Oxygen Demand
Ca	Calcium
cfu	Colony Forming Unit
m	Meter
m3	Cubic Meter
mg	Milligram
Mg	Magnesium
mg/L	Milligram per liter
MPN	Most Probable Number
MSC	Maximum Standing Crop
n	Number of Samples
NTU	Nephelometric Turbidity Unit
SD	Standard Deviation

TABLE 3-6 SUMMARY OF ADEM SAMPLE RESULTS FOR RLHR-6 SITE (2005-2015)

Parameter	n	Mean	SD	Min	Max	Units
Algal growth potential	1	3.5	NA	3.47	3.47	MSC
Alkalinity, total	23	12.7	4.0	8.1	28.2	mg/L
Ammonia-nitrogen	23	0.023	0.059	0.000	0.241	mg/L
5-day BOD	16	0.3	1.2	0.0	4.7	mg/L
Calcium	8	2.49	0.37	1.99	2.96	mg/L
Chloride	16	2.2	0.3	1.6	2.6	mg/L
Chlorophyll *a*	23	7.9	7.1	0.0	30.3	mg/m3
Depth, bottom	17	12.8	1.0	10.7	14.6	m
Depth, Secchi disk depth	23	1.9	0.4	0.9	2.7	m
Escherichia coli	6	3.2	5.0	1	13.4	MPN/100 mL
Fecal Coliform	1	23.0	NA	23	23	cfu/100 mL
Hardness, Ca, Mg	13	10.8	1.5	8.7	13.4	mg/L
Nitrate + Nitrite	23	0.036	0.041	0.000	0.160	mg/L
Kjeldahl nitrogen	23	0.324	0.198	0.000	0.611	mg/L
Light attenuation, depth at 99%	23	4.9	1.1	3.2	7.3	m
Magnesium	8	1.20	0.18	0.91	1.45	mg/L
Orthophosphate	23	0.005	0.004	0.000	0.012	mg/L
Phosphorus	23	0.018	0.017	0.000	0.082	mg/L
Total dissolved solids	23	286.3	1213.4	0.0	5852.0	mg/L
Total suspended solids	23	3.3	3.9	0.0	14.0	mg/L
Turbidity	23	4.3	1.9	0.2	9.4	NTU

Source: ADEM 2017; Data from 2005, 2007, 2008, 2010, 2013, and 2015

Key:

BOD	Biochemical Oxygen Demand
Ca	Calcium
cfu	Colony Forming Unit
m	Meter
m3	Cubic Meter
mg	Milligram
Mg	Magnesium
mg/L	Milligram per liter
MPN	Most Probable Number
MSC	Maximum Standing Crop
n	Number of Samples
NTU	Nephelometric Turbidity Unit
SD	Standard Deviation

4.0 DOWNSTREAM WATER QUALITY

ADEM performed monitoring in the Tallapoosa River at three sites downstream of Harris Reservoir from 2005 through 2016 (Figure 4-1). The site immediately downstream of Harris Dam (MARE-12) was sampled monthly in 2015 from April to October (Table 4-1). Dissolved oxygen levels at this station were lowest in October but remained above 5.0 milligrams per liter (mg/L).

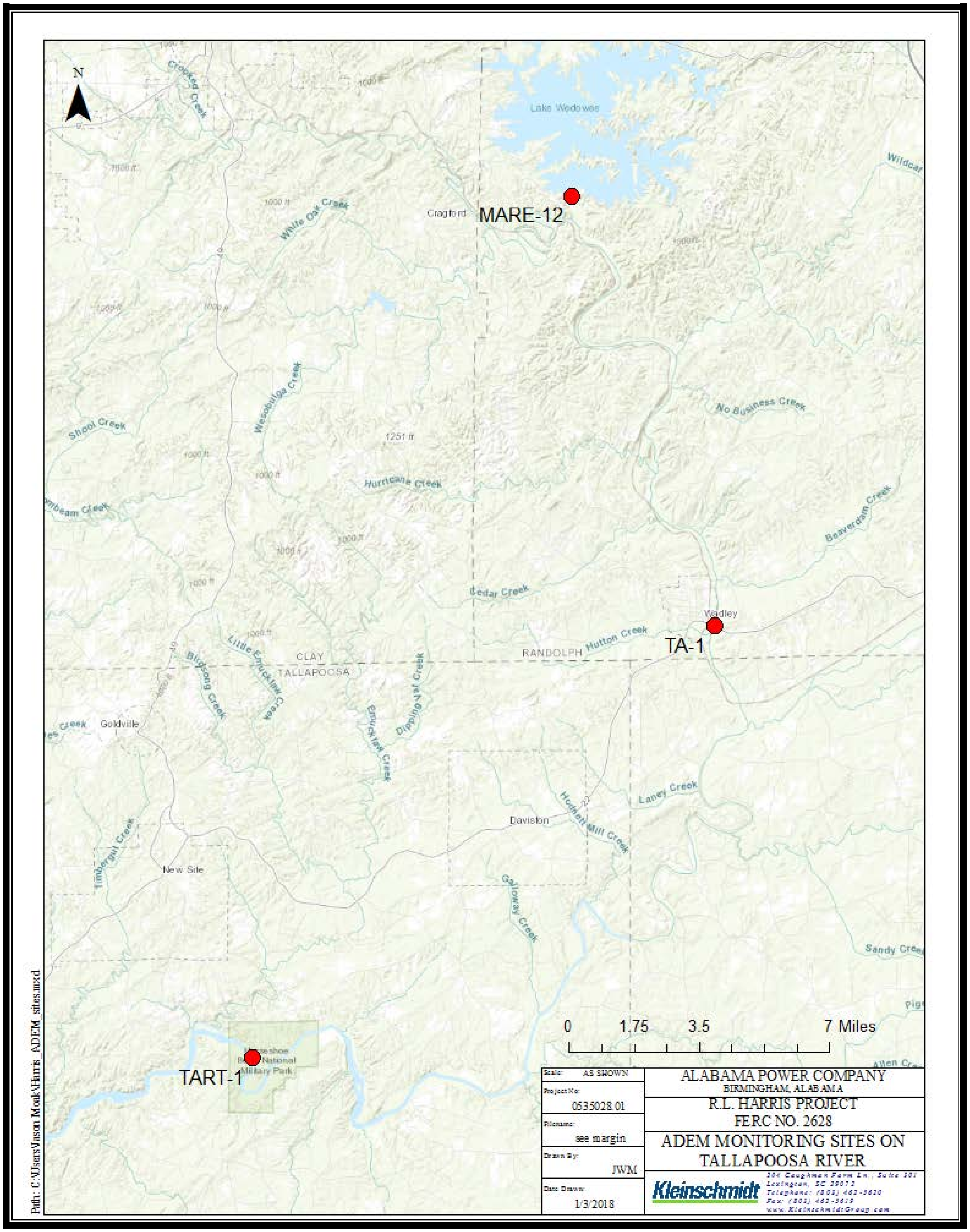
From May to October 2016, in anticipation of relicensing, Alabama Power conducted a study to help identify an appropriate location for installing a monitor to record dissolved oxygen and temperature data during generation to support an application for a Section 401 Water Quality Certificate from ADEM. The hydroelectric generation period for each hydroelectric unit is defined as the time from turbine start until turbine shut down. Dissolved oxygen concentrations and water temperatures measured after the initial reading following the beginning of the generation period and through turbine shut down were included in this analysis. Results from four different monitoring locations found that dissolved oxygen concentrations ranged from 5.39 mg/L to 11.01 mg/L. The average temperature recorded during this study ranged from 21.65 to 22.02 degrees Celsius.

Using the results of this study, the vicinity of Station 3 was selected as the most advantageous monitoring location. Water depth, access to the location, mixing upstream, and the vicinity of the station location were all taken into consideration. Station 3 is located directly downstream of the Unit 1 and Unit 2 turbine discharge area at a sufficient distance to allow for adequate mixing when both units are operating. Also, the location appears to be deep enough to ensure the sensors remain under water at all times.

Table 4-2 presents a summary of discrete chemistry samples collected by ADEM at the Wadley site (TA-1) located approximately 14 miles downstream of Harris Dam. Results of in-stream measurements indicated the highest water temperatures occurred during July and August (Figure 4-2). Lowest dissolved oxygen levels were typically experienced in the late summer and early fall, though no measurements less than 6.0 mg/L were recorded (Figure 4-3). Measurements of pH were typically circumneutral (Figure 4-4), and conductivity was generally between 40 to 50 microsiemens per centimeter (us/cm) (Figure 4-5).

In addition to water quality sampling, ADEM performs macroinvertable bioassessments to address water quality and total maximum daily loads (TMDLs). Macroinvertebrates can be used as bioindicators of water quality and a water body can be listed as impaired based on the results of the macroinvertebrate bioassessment. ADEM performed a macroinvertebrate bioassessment in July 2010 at this site. Results of that study rated the site as “fair/poor” (ADEM 2010).

Table 4-3 presents a summary of results for discrete chemistry samples collected by ADEM at the Horseshoe Bend site (TART-1) located approximately 44 miles downstream of Harris Dam. Results of in-stream measurements indicated the highest water temperatures occurred during July and August (Figure 4-6). Lowest dissolved oxygen levels were typically experienced in the late summer and early fall, though no measurements less than 6.0 mg/L were recorded (Figure 4-7). Measurements of pH were typically circumneutral (Figure 4-8), and conductivity was generally between 35 to 50 us/cm (Figure 4-9).



Source: ADEM, Kleinschmidt 2018

FIGURE 4-1 ADEM MONITORING SITES ON TALLAPOOSA RIVER

TABLE 4-1 ADEM WATER QUALITY DATA FROM HARRIS DAM TAILRACE (MARE-12)

Date	Water Temperature (°C)	DO (mg/L)	pH	Specific conductance (µs/cm)
4/29/2015	16.92	7.58	6.62	38
5/28/2015	18.76	5.74	6.43	38
6/16/2015	21.35	7.39	6.98	38
7/28/2015	24.23	7.92	6.31	36
8/27/2015	25.56	7.90	6.34	39
9/30/2015	22.26	6.40	6.33	39
10/29/2015	18.89	5.24	6.45	41

Source: ADEM 2017

Key: DO dissolved oxygen
C Centigrade
mg/L milligrams per liter
µs/cm microsiemens per centimeter

TABLE 4-2 SUMMARY OF ADEM SAMPLE RESULTS FOR TALLAPOOSA RIVER AT WADLEY (TA-1)

Parameter	n	Mean	Min	Max	Units
Alkalinity, total	46	11.2	7.3	14.4	mg/L
Ammonia-nitrogen	45	0.010	0.000	0.236	mg/L
BOD, 5-day	45	0.35	0.00	4.40	mg/L
Calcium	3	2.25	2.04	2.56	mg/L
Chloride	45	2.71	1.64	5.00	mg/L
Chlorophyll *a*	46	1.39	0.00	5.34	ug/L
Escherichia coli	16	208.6	0.0	2419.6	MPN/100 mL
Fecal Coliform	17	95.1	2.0	640.0	CFU/100 mL
Hardness, Ca, Mg	22	10.4	7.4	14.0	mg/L
Nitrate + Nitrite	46	0.136	0.000	0.365	mg/L
Kjeldahl nitrogen	46	0.221	0.000	1.090	mg/L
Magnesium	3	1.12	1.03	1.18	mg/L
Orthophosphate	45	0.006	0.000	0.014	mg/L
Phosphorus	45	0.021	0.000	0.153	mg/L
Total dissolved solids	46	39.5	0.0	98.0	mg/L
Total suspended solids	46	6.2	0.0	103.0	mg/L
Turbidity	54	8.5	0.1	193.0	NTU

Source: ADEM 2017; Data from samples in 2005-2014

Key:
BOD Biochemical Oxygen Demand
cfu Colony Forming Unit
µg/L Microgram per liter
mg/L Milligram per liter
n Number of Samples
NTU Nephelometric Turbidity Unit

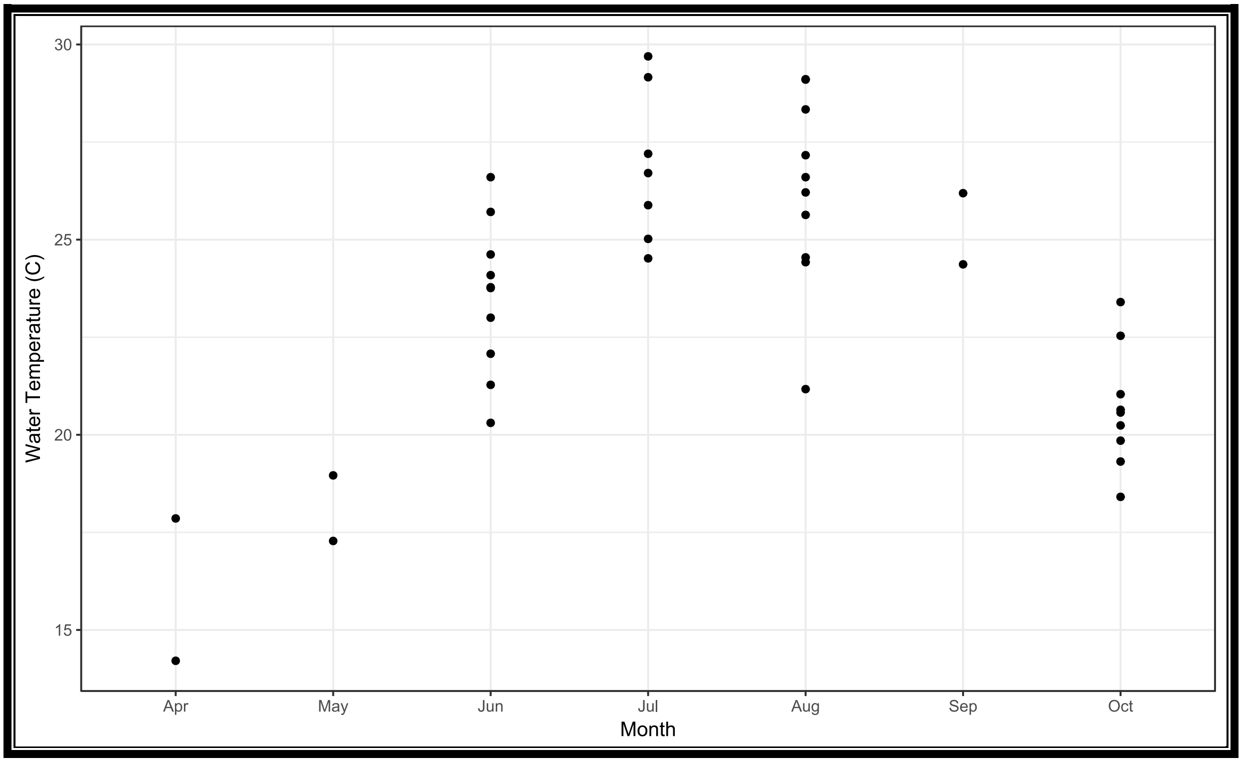


FIGURE 4-2 ADEM WATER TEMPERATURE DATA (2005-2015) FROM TALLAPOOSA RIVER AT WADLEY (TA-1)

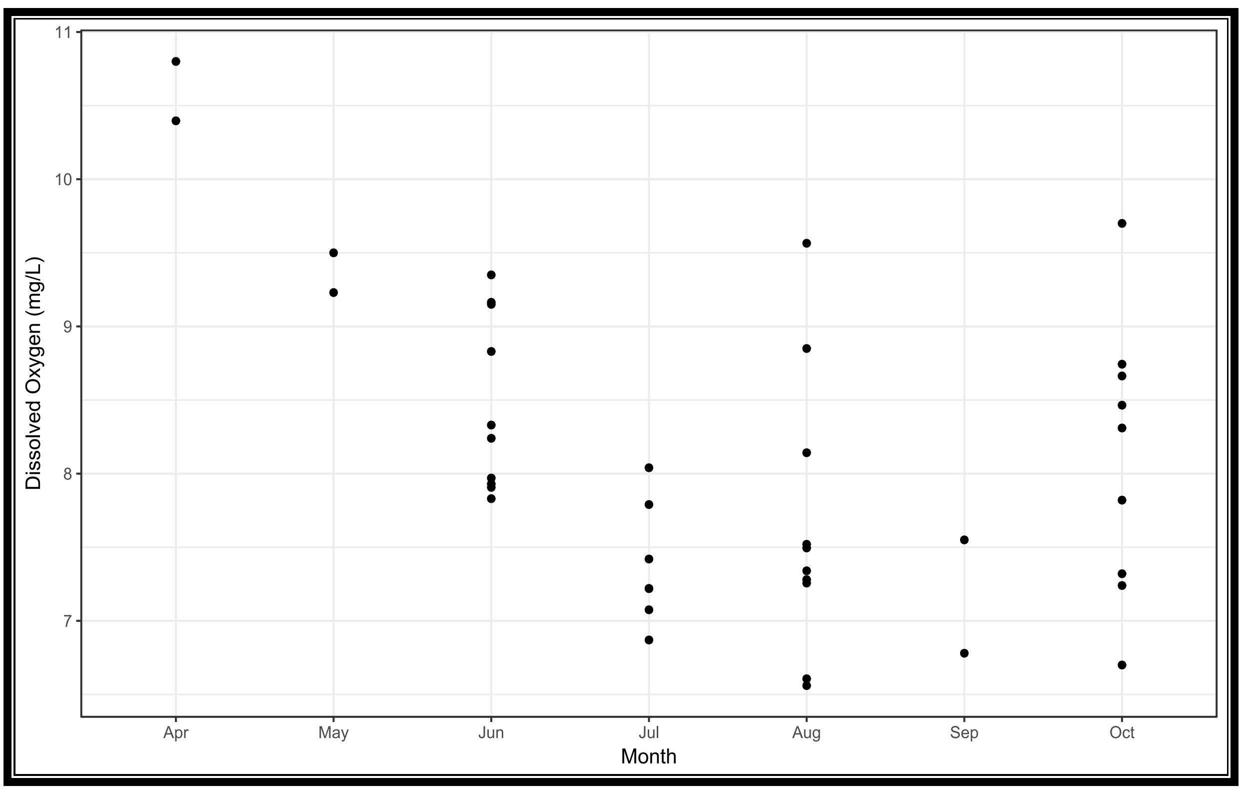


FIGURE 4-3 ADEM DISSOLVED OXYGEN DATA (2005-2015) FROM TALLAPOOSA RIVER AT WADLEY (TA-1)

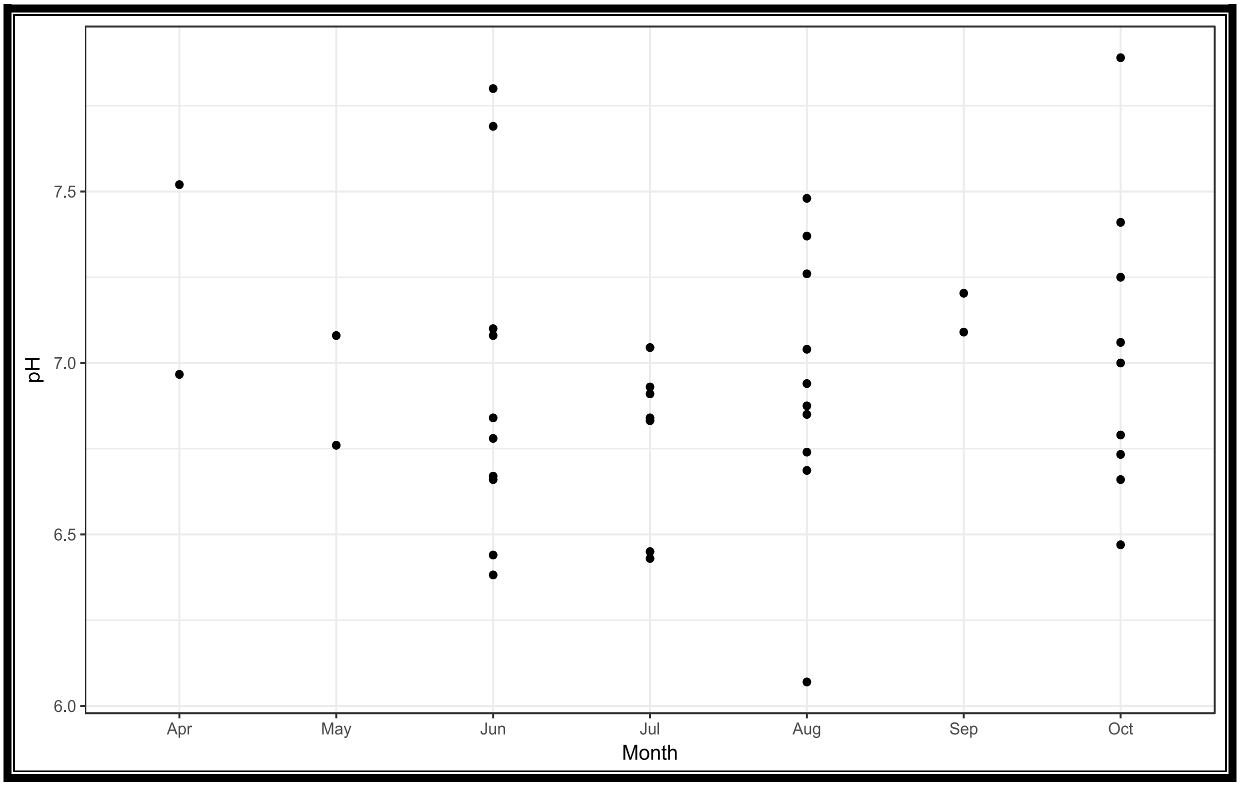


FIGURE 4-4 ADEM PH DATA (2005-2015) FROM TALLAPOOSA RIVER AT WADLEY (TA-1)

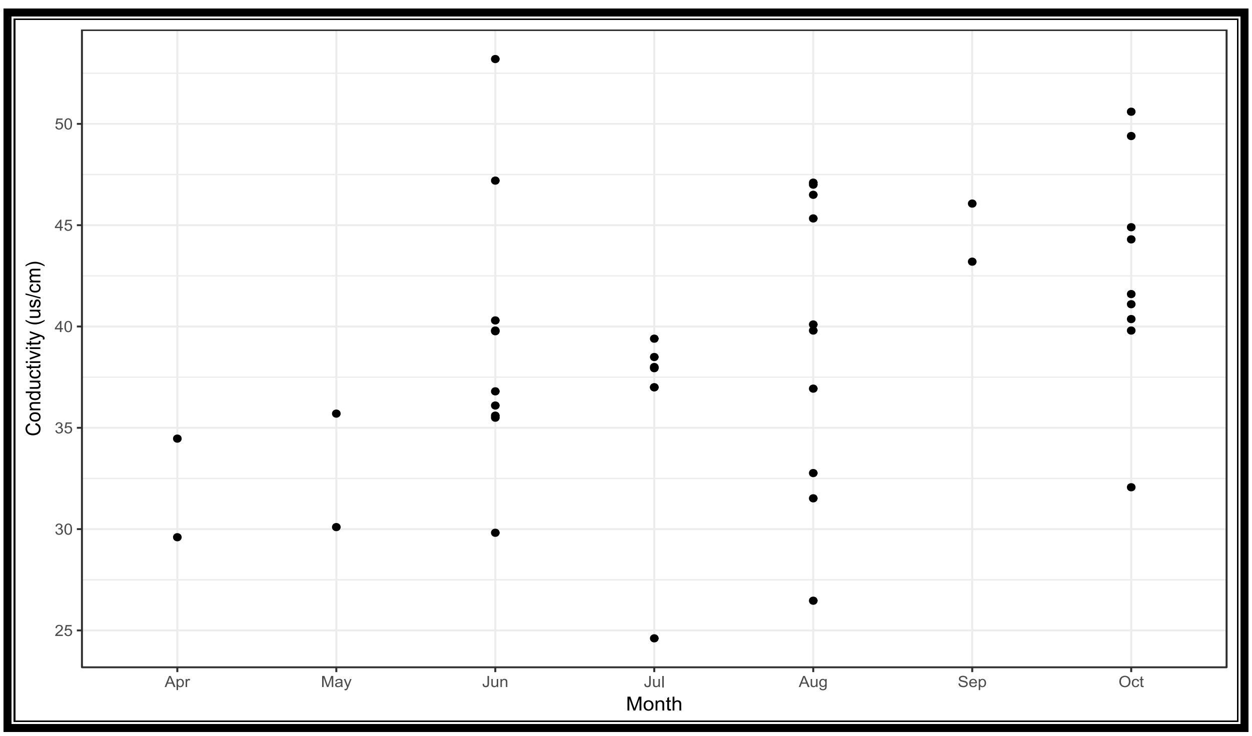


FIGURE 4-5 ADEM CONDUCTIVITY DATA (2005-2015) FROM TALLAPOOSA RIVER AT WADLEY (TA-1)

TABLE 4-3 SUMMARY OF ADEM SAMPLE RESULTS FOR TALLAPOOSA RIVER AT HORSESHOE BEND (TART-1)

Parameter	n	Mean	Min	Max	Units
Algal growth potential	1	1.56	1.56	1.56	MSC
Alkalinity, total	50	12.8	8.6	20.8	mg/L
Ammonia-nitrogen	50	0.009	0.000	0.113	mg/L
BOD, 5-day	50	0	0	0	mg/L
Calcium	3	2.45	2.25	2.66	mg/L
Chloride	50	2.53	1.90	3.48	mg/L
Chlorophyll *a*	50	1.55	0.00	12.50	µg/L
Escherichia coli	31	167.9	6.3	2419.6	MPN/100 mL
Hardness, Ca, Mg	3	11.7	10.9	12.8	mg/L
Nitrate + Nitrite	50	0.143	0.000	0.333	mg/L
Kjeldahl nitrogen	50	0.259	0.000	0.625	mg/L
Magnesium	3	1.36	1.29	1.49	mg/L
Orthophosphate	50	0.005	0.000	0.019	mg/L
Phosphorus	50	0.017	0.009	0.037	mg/L
Sulfate	28	2.02	1.57	2.83	mg/L
Total dissolved solids	50	33.8	0.0	98.0	mg/L
Total suspended solids	50	5.6	0.0	55.0	mg/L
Turbidity	59	8.3	0.3	34.2	NTU

Source: ADEM 2017; Data from 2010, 2011, 2015, & 2016

Key:

BOD Biochemical Oxygen Demand
cfu Colony Forming Unit
µg/L Microgram per liter
mg/L Milligram per liter
n Number of Samples
NTU Nephelometric Turbidity Unit

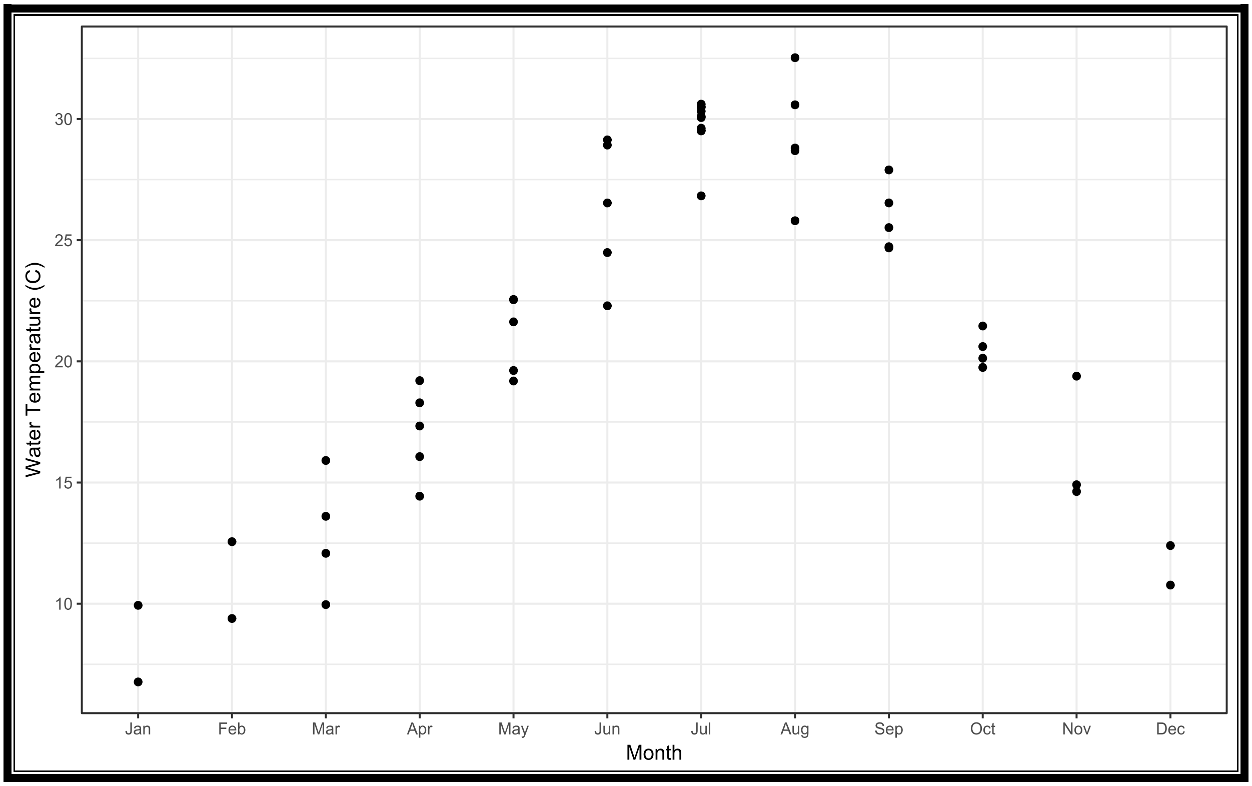


FIGURE 4-6 ADEM WATER TEMPERATURE DATA (2005-2015) FROM TALLAPOOSA RIVER AT HORSESHOE BEND (TART-1)

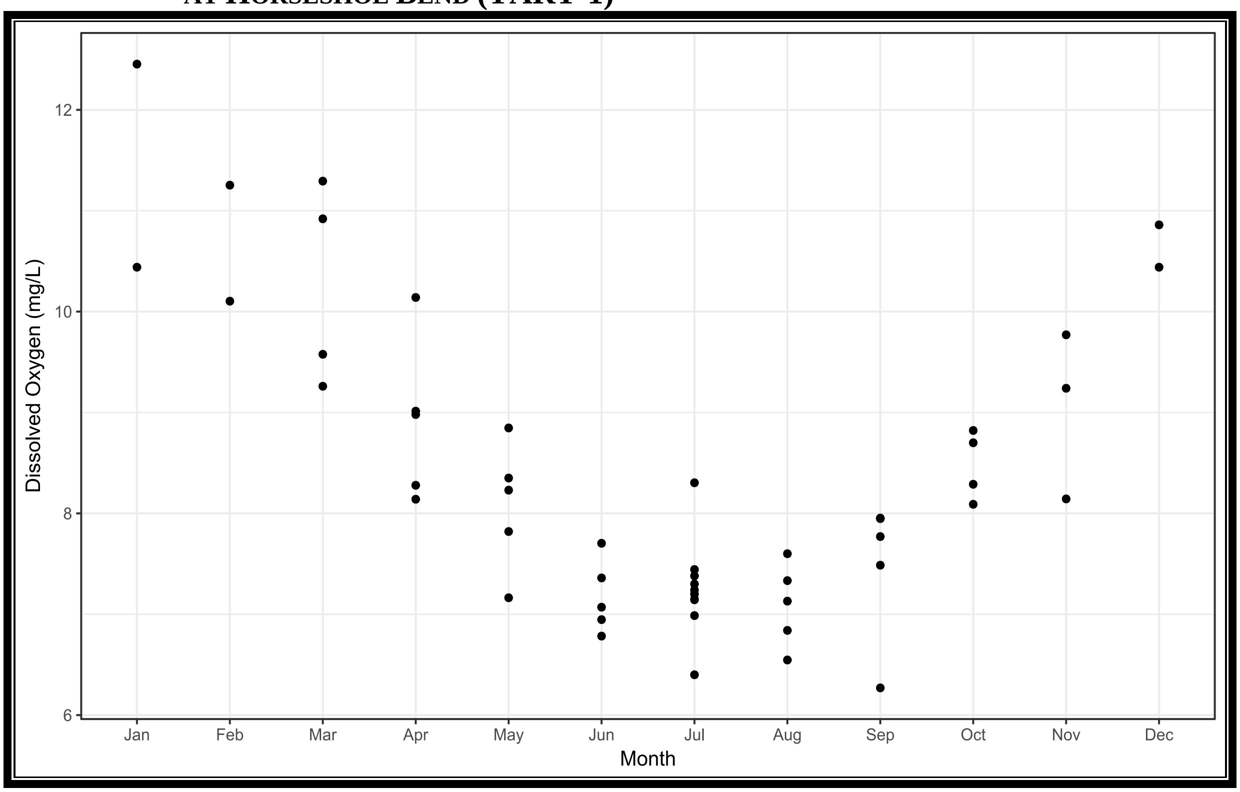


FIGURE 4-7 ADEM DISSOLVED OXYGEN DATA (2005-2015) FROM TALLAPOOSA RIVER AT HORSESHOE BEND (TART-1)

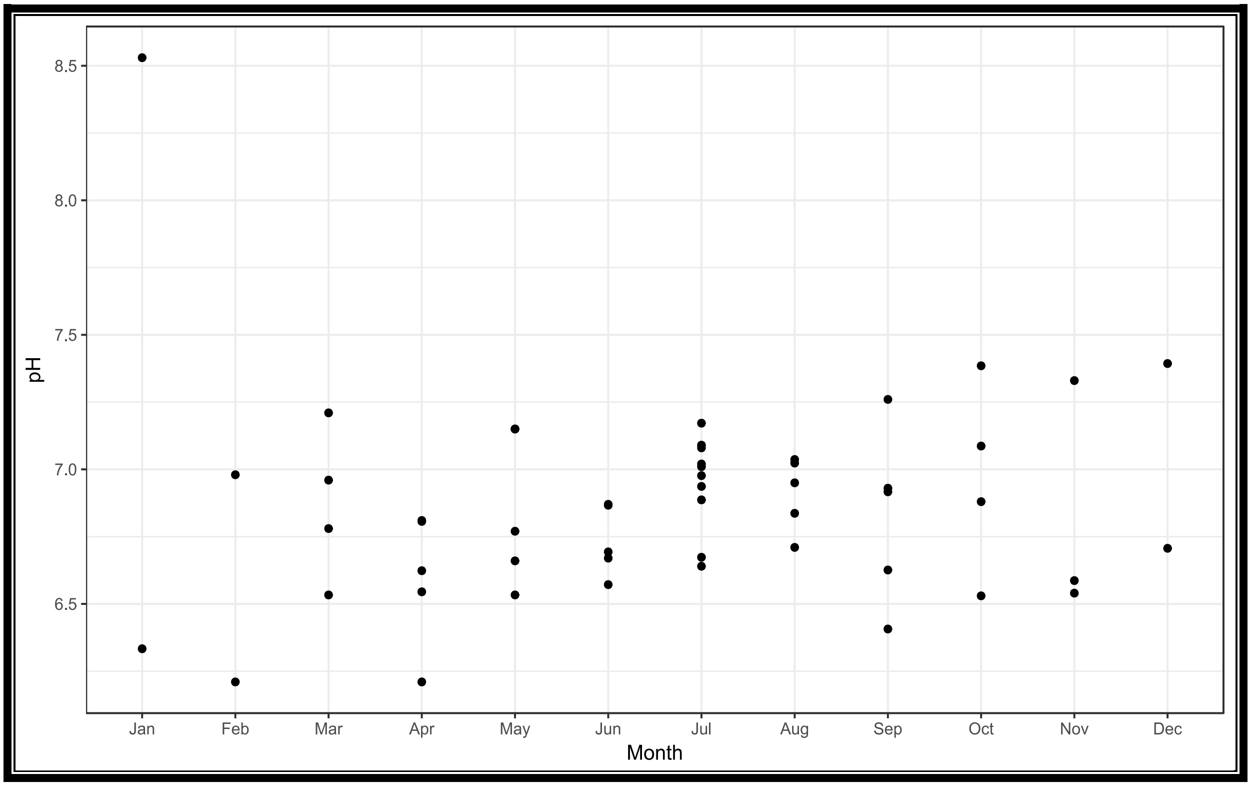


FIGURE 4-8 ADEM PH DATA (2005-2015) FROM TALLAPOOSA RIVER AT HORSESHOE BEND (TART-1)

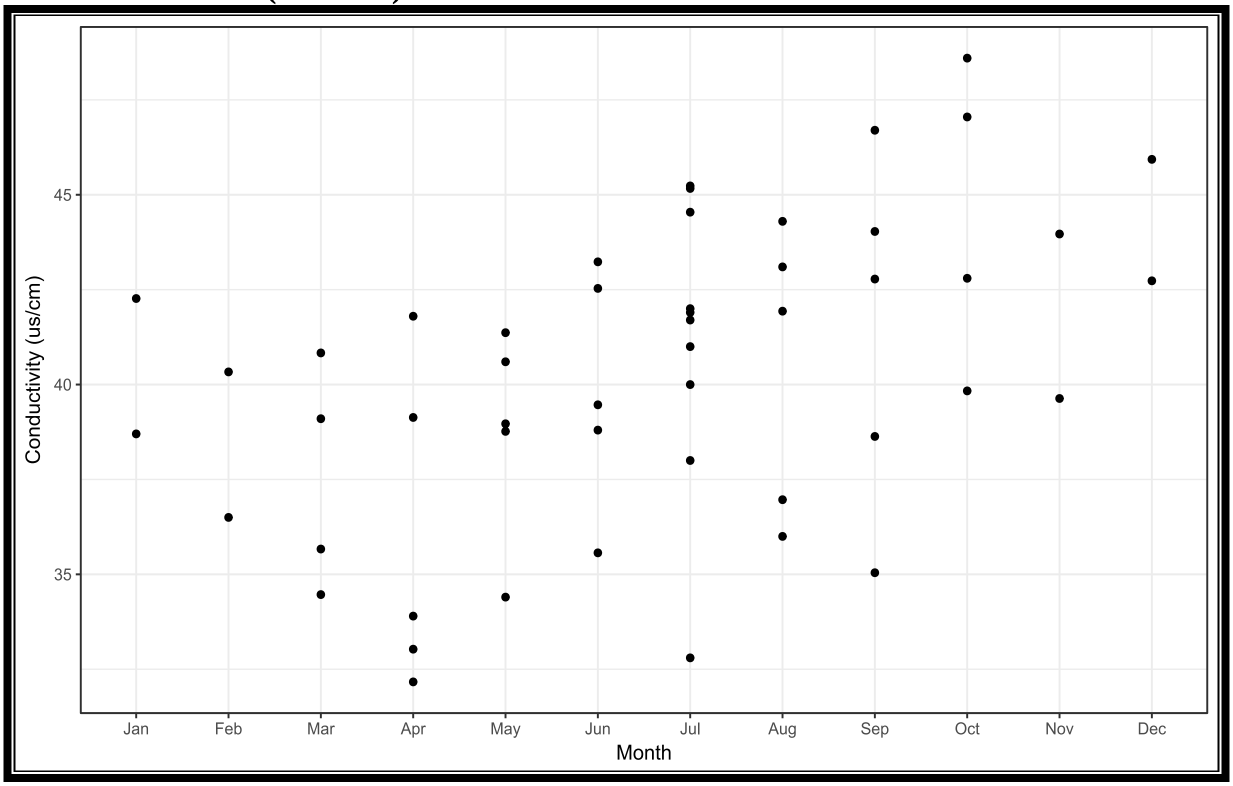
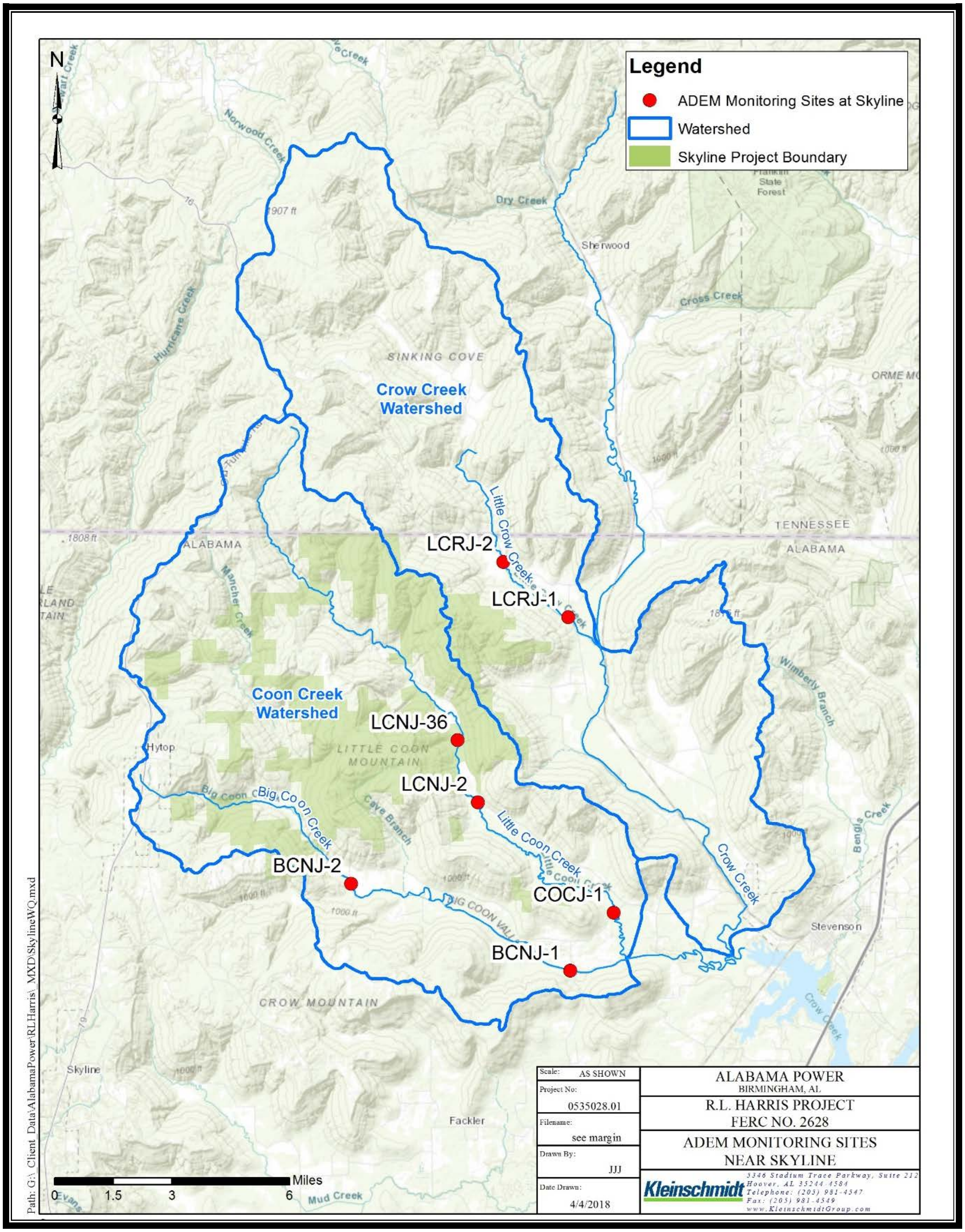


FIGURE 4-9 ADEM CONDUCTIVITY DATA (2005-2015) FROM TALLAPOOSA RIVER AT HORSESHOE BEND (TART-1)

5.0 SKYLINE WATER QUALITY

ADEM performed periodic sampling at six stream sites with watersheds that drain into the Harris Project boundary at Skyline (Figure 5-1). A summary of results from common parameters that were tested at each site is presented in Table 5-1.

In addition to water quality sampling, ADEM performed a macroinvertebrate bioassessment at the lower Big Coon Creek site (BCNJ-1) in May 2013 and the lower Little Coon Creek site (COCJ-1) in June 2013. Macroinvertebrates can be used as bioindicators of water quality and a water body can be listed as impaired based on the results of the macroinvertebrate bioassessment. Assessment results indicated that the macroinvertebrate communities at both sites were in “fair” condition.



Source: Alabama Power, Kleinschmidt 2018

FIGURE 5-1 ADEM MONITORING SITES NEAR SKYLINE

TABLE 5-1 SUMMARY OF ADEM SAMPLING RESULT BY PARAMETER AVERAGE FOR WATER QUALITY STATIONS AT SKYLINE

	Big Coon Creek		Little Coon Creek		Little Crow Creek		
Parameter	**BCNJ-1**	**BCNJ-2**	**COCJ-1**	**LCNJ-36**	**LCRJ-2**	**LCRJ-1**	**Units**
Alkalinity, total	112	126	136	124	75*	101*	mg/L
Ammonia-nitrogen	0.014	-	0.042	-	-	-	mg/L
Calcium	38.06	45.20*	46.04	-	-	-	mg/L
Chloride	3.05	1.97	2.36	1.10	3.53*	3.72*	mg/L
Dissolved oxygen (DO)	8.55	9.66	7.29	9.66	9.40	9.00	mg/L
Escherichia coli	150.3	53.5	205.8	-	-	-	MPN/100 mL
Fecal Coliform	109.2	33.0*	163.3	-	45.0*	72.0*	CFU/100 mL
Hardness, Ca, Mg	111	138	140	-	112*	112*	mg/L
Nitrate + Nitrite	0.758	0.144	0.380	0.079	0.368*	0.517*	mg/L
Kjeldahl nitrogen	0.249	0.241	0.359	0.187	-	-	mg/L
Magnesium	4.74	6.39	6.72	-	-	-	mg/L
pH	7.70	7.86	7.62	7.87	7.99	7.67	
Phosphorus	0.011	0.015	0.018	0.009	0.018*	0.017*	mg/L
Specific conductance	221.3	257.4	271.4	224.2	251.2	210.8	us/cm
Temperature, water	16.91	16.71	17.89	16.87	17.00	18.00	C
Total dissolved solids	146.5	202.0	166.6	143.0	118.0*	101.0*	mg/L
Total suspended solids	4.4	2.5	5.0	10.8	5.0*	4.0*	mg/L
Turbidity	6.7	3.0	9.2	3.1	3.7	4.4	NTU

Source: ADEM 2018
* Single sample result
Key:

- BOD Biochemical Oxygen Demand
- cfu Colony Forming Unit
- µg/L Microgram per liter
- mg/L Milligram per liter
- n Number of Samples
- NTU Nephelometric Turbidity Unit

6.0 REFERENCES

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APPENDIX A

2010 AND 2013 ADEM MONITORING SUMMARIES

ADEM
Alabama Department of Environmental Management
Special Study

Rivers and Streams Monitoring Program

2010 Monitoring Summary

Tallapoosa River at Alabama Highway 77 in Randolph County (33.11801/-85.56015)

BACKGROUND

The Alabama Department of Environmental Management (ADEM) selected the Tallapoosa River at TA-1 for nutrient criteria development in the Tallapoosa River Basin in 2010. Data collected will be used to develop and implement nutrient criteria in streams in the Tallapoosa River Basin, as well as statewide.

The Tallapoosa River at TA-1 is also one of a network of 94 ambient sites monitored annually to identify long-term trends in water quality and to provide data for the development of Total Maximum Daily Loads (TMDLs) and water quality criteria.

Figure 1. Tallapoosa River at TA-1, July 20, 2010.

Table 2. Physical characteristics of Tallapoosa River at TA-1, July 13, 2010.

Physical Characteristics		
Width (ft)		240
Canopy cover		Open
Depth (ft)		
	Riffle	0.2
	Run	2.7
	Pool	3.2
% of Reach		
	Riffle	7
	Run	37
	Pool	56
% Substrate		
	Bedrock	10
	Boulder	7
	Cobble	33
	Gravel	27
	Sand	23

Table 1. Summary of watershed characteristics.

Watershed Characteristics			
Basin			Tallapoosa R
Drainage Area (mi^2)			1674
Ecoregion[a]			45A
% Landuse[b]			
Open water			2%
Wetland		Woody	2%
		Emergent herbaceous	<1%
Forest		Deciduous	37%
		Evergreen	22%
		Mixed	<1%
Shrub/scrub			7%
Grassland/herbaceous			6%
Pasture/hay			17%
Cultivated crops			<1%
Development		Open space	5%
		Low intensity	2%
		Moderate intensity	<1%
		High intensity	<1%
Barren			<1%
Population/km^2[c]			29
# NPDES Permits[d]	**TOTAL**		536
Construction			463
Industrial General			35
Industrial Individual			8
Mining			10
Municipal			5
Small Mining			3
Underground Injection Control			12

a.Southern Inner Piedmont

b.2011 National Land Cover Dataset

c.2010 US Census

d.#NPDES outfalls downloaded from ADEM's NPDES Management System database, April 1, 2016.

WATERSHED CHARACTERISTICS

Watershed characteristics are summarized in Table 1. Tallapoosa River at TA-1 is a *Fish & Wildlife (F&W)* waterbody located in southwestern Randolph County in Wadley, AL. According to the 2011 National Land Cover Dataset, land use within the watershed is primarily forest (59%) with some pasture land. As of April 1, 2016, there were 536 outfalls active in the area.

REACH CHARACTERISTICS

General observations (Table 2) and a habitat assessment (Table 3) were completed during the macroinvertebrate assessment. In comparison with reference reaches in the same ecoregion, they give an indication of the physical condition of the site and the quality and availability of habitat. The Tallapoosa River at TA-1 is a riffle-run stream located in the Southern Inner Piedmont ecoregion (Figure 1). Bottom substrate consists primarily of cobble, gravel, and sand. Overall habitat quality was rated as *sub-optimal* for supporting a diverse aquatic macroinvertebrate community.

Table 3. Results of the habitat assessment conducted in Tallapoosa River at TA-1, July 13, 2010.

Habitat Assessment	% Maximum Score	Rating
Instream Habitat Quality	79	Sub-optimal (55-79)
Sediment Deposition	75	Sub-Optimal (55-79)
Bank and Vegetative Stability	66	Marginal (60-<74)
Riparian Zone Measurements	50	Marginal (31-<60)
Habitat Assessment Score	**140**	
% Maximum Score	**70**	**Sub-optimal (57-82)**

BIOASSESSMENT RESULTS

The benthic macroinvertebrate community was sampled using ADEM's Nonwadeable Multi-habitat Bioassessment methodology (NWM-I). Measures of taxonomic richness, community composition, and community tolerance are used to assess the overall health of the macroinvertebrate community in comparison to conditions expected in north Alabama streams and rivers. Each site is placed in one of six levels, ranging from 1, or *natural* to 6, or *highly altered.* The macroinvertebrate survey conducted at TA-1 rated the site as a *4-*, or *Fair/Poor.* Relative abundance and numbers of pollution-sensitive taxa are lower than expected for this macroinvertebrate community (Table 4).

Table 4. Results of the macroinvertebrate bioassessment conducted in Tallapoosa River at TA-1, July 13, 2010.

Macroinvertebrate Assessment	Results
Taxa richness and diversity measures	
Total # Taxa	38
# EPT taxa	11
Shannon Diversity	3.59
# Highly-sensitive and Specialized Taxa	1
Taxonomic composition measures	
% EPT minus Baetidae and Hydropsychidae	9
% Non-insect taxa	16
Tolerance measures	
# Sensitive EPT	4
% Sensitive taxa	21
% Tolerant taxa	26
WMB-I Assessment Score	**4-**
WMB-I Assessment Rating	**Fair/Poor**

WATER CHEMISTRY

Results of water chemistry analyses are presented in Table 5. In situ measurements and water samples were collected April through December of 2010 to help identify any stressors to the biological community. All parameters met *F&W* use classification criteria throughout the sampling season. However, water temperature, ammonia-nitrogen, and nitrate-nitrite nitrogen were higher than expected based on reference reach data collected in the Southern Inner Piedmont ecoregion. Turbidity was >50 NTU above ecoregional guidelines during the October sampling date. High flows at the time of collection were likely the cause of the increased turbidity.

SUMMARY

While the habitat assessment conducted in the Tallapoosa River at TA-1 indicated the reach to be *sub-optimal* for supporting a diverse biological community, bioassessment results indicated the macroinvertebrate community in the reach to be in *fair/poor* condition. Results of water chemistry analyses showed that water temperature, ammonia-nitrogen, and nitrate-nitrite nitrogen were higher than expected for ecoregion 45a. Monitoring should continue to ensure that conditions in the stream reach continue to meet current standards.

Table 5. Summary of water quality data collected April-December, 2010. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median, average (Avg), and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Parameter	N	Min	Max	Med	Avg	SD
Physical						
Temperature (°C)	10	12.6	29.2	25.0[M]	22.8	6.0
Turbidity (NTU)	9	1.1	193.0[T]	4.8	29.8	62.2
[J] Total Dissolved Solids (mg/L)	8	16.0	58.0	37.0	37.5	14.8
Total Suspended Solids (mg/L)	8	< 1.0	103.0	3.5	18.9	35.4
Specific Conductance (μmhos)	10	29.6	43.2	39.7	37.7	4.6
Hardness (mg/L)	1				10.1	
Alkalinity (mg/L)	8	7.3	14.4	10.7	10.8	2.8
Monthly Stream Flow (cfs)	10	142.0	8350.0	300.5	1784.4	2740.6
Stream Flow during Sample Collection (cfs)	10	142.0	8350.0	300.5	1784.4	2740.6
Chemical						
Dissolved Oxygen (mg/L)	10	6.6	10.8	7.6	7.9	1.3
pH (su)	10	6.5	7.5	7.0	7.0	0.3
Ammonia Nitrogen (mg/L)	8	< 0.021	0.074	0.010[M]	0.018	0.022
Nitrate+Nitrite Nitrogen (mg/L)	8	0.112	0.365	0.171[M]	0.193	0.082
Total Kjeldahl Nitrogen (mg/L)	8	< 0.080	0.650	0.211	0.247	0.198
Total Nitrogen (mg/L)	8	< 0.152	1.015	0.419	0.440	0.266
[J] Dissolved Reactive Phosphorus (mg/L)	8	0.003	0.014	0.008	0.008	0.003
[J] Total Phosphorus (mg/L)	8	0.009	0.153	0.017	0.037	0.049
CBOD-5 (mg/L)	8	< 2.0	< 2.0	1.0	1.1	0.4
Chlorides (mg/L)	8	1.6	3.0	2.4	2.3	0.5
Total Metals						
Aluminum (mg/L)	1				< 0.033	
Iron (mg/L)	1				0.268	
Manganese (mg/L)	1				< 0.001	
Dissolved Metals						
Aluminum (mg/L)	1				< 0.033	
Antimony (μg/L)	1				< 1.9	
Arsenic (μg/L)	1				< 2.1	
Cadmium (μg/L)	1				< 14.000	
Chromium (μg/L)	1				< 13.000	
Copper (mg/L)	1				< 0.013	
Iron (mg/L)	1				< 0.026	
Lead (μg/L)	1				< 1.7	
Manganese (mg/L)	1				< 0.001	
Mercury (μg/L)	1				< 0.080	
Nickel (mg/L)	1				< 0.019	
Selenium (μg/L)	1				< 1.7	
Silver (μg/L)	1				< 2.000	
Thallium (μg/L)	1				< 0.6	
Zinc (mg/L)	1				< 0.030	
Biological						
Chlorophyll a (ug/L)	8	0.27	5.34	2.22	2.39	1.79
[J] E. coli (col/100mL)	3	16	2420	29	821	1384

J=estimate; M=value >90% of all verified ecoregional reference reach data collected in the ecoregion 45a; N= # of samples; T=value exceeds 50 NTU above the 90th percentile of all verified ecoregional reference reach data collected in ecoregion 45a.

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ADEM
Alabama Department of Environmental Management

Ecological Reference Reach

Rivers and Streams Monitoring Program

2013 Monitoring Summary

™

Big Coon Creek at Jackson County Road 55 (34.85659/-85.92684)

BACKGROUND

The Alabama Department of Environmental Management (ADEM) monitored Big Coon Creek as part of the 2013 Assessment of the Tennessee River Basin (TN). The objectives of the TN Basin Assessments were to assess the biological integrity of each monitoring site and to estimate overall water quality within the TN basin.

Figure 1. Big Coon Creek at BCNJ-1, May 16, 2013.

WATERSHED CHARACTERISTICS

Watershed characteristics are summarized in Table 1. Big Coon Creek is a *Fish & Wildlife (F&W)* stream that drains north-central Jackson County. It runs roughly southeast along Jackson County road 53 towards its confluence with Little Coon Creek and later Crow Creek. Based on the 2011 National Land Cover Dataset, land use within the watershed is primarily forest (85%) with some pasture/hay. As of September 1, 2012, ADEM has issued no NPDES permits in the watershed.

REACH CHARACTERISTICS

General observations (Table 2) and a habitat assessment (Table 3) were completed during the macroinvertebrate assessment. In comparison with reference reaches in the same ecoregion, they give an indication of the physical condition of the site and the quality and availability of habitat. Big Coon Creek at BCNJ-1 is a low-gradient, glide-pool stream. The predominant instream substrate was sand (Figure 1). The overall habitat assessment resulted in a *marginal* rating due to poor bank and vegetative stability. Banks were very steep and root bank habitat was virtually nonexistent.

BIOASSESSMENT RESULTS

Benthic macroinvertebrate communities were sampled using ADEM's Intensive Multi-habitat Bioassessment methodology (WMB-I). Table 4 summarizes results of taxonomic richness, community composition, and community tolerance metrics. Each metric is scored on a 100 point scale. The final score is the average of all individual metric scores. Metric results indicated the macroinvertebrate community in Big Coon Creek at BCNJ-1 to be in *fair* condition.

Table 1. Summary of watershed characteristics.

Watershed Characteristics		
Basin		Tennessee River
Drainage Area (mi^2)		42
Ecoregion[a]		68b
% Landuse		
Open water		<1
Wetland	Woody	<1
Forest	Deciduous	80
	Evergreen	1
	Mixed	4
Shrub/scrub		3
Grassland/herbaceous		1
Pasture/hay		7
Cultivated crops		2
Development	Open space	1
	Low intensity	<1
Barren		<1
Population/km^{2b}		3

a.Sequatchie Valley
b.2000 US Census

Table 2. Physical characteristics of Big Coon Creek at BCNJ-1, May 16, 2013.

Physical Characteristics		
Width (ft)		50
Canopy Cover		Estimate 50/50
Depth (ft)		
	Run	2.0
	Pool	4.0
% of Reach		
	Run	90
	Pool	10
% Substrate		
	Clay	5
	Cobble	1
	Gravel	14
	Sand	60
	Silt	15
	Organic Matter	5

Table 3. Results of the habitat assessment conducted in Big Coon Creek at BCNJ-1, May 16, 2013.

Habitat Assessment	%Maximum Score	Rating
Instream Habitat Quality	40	Poor (<41)
Sediment Deposition	59	Marginal (41-58)
Sinuosity	33	Poor (<45)
Bank and Vegetative Stability	25	Poor (<35)
Riparian Buffer	71	Sub-optimal (70-89)
Habitat Assessment Score	**106**	
% Maximum Score	**48**	**Marginal (41-58)**

Table 4. Results of the macroinvertebrate bioassessment conducted in Big Coon Creek at BCNJ-1, May 16, 2013.

Macroinvertebrate Assessment		
	Results	**Scores**
Taxa richness measures		**(0-100)**
# EPT taxa	9	22
Taxonomic composition measures		
% Non-insect taxa	13	46
% Dominant Taxon	17	86
% EPC taxa	23	42
Functional feeding group measures		
% Predators	5	16
Tolerance measures		
% Taxa as Tolerant	35	41
WMB-I Assessment Score	---	**42**
WMB-I Assessment Rating		**Fair (39-58)**

WATER CHEMISTRY

Results of water chemistry analyses are presented in Table 5. In situ measurements and water samples were collected April, June, August and October 2013 to help identify any stressors to the biological communities. In situ parameters were also measured during the macroinvertebrate assessment on May 16. The *F&W* human health criterion for Arsenic was exceeded on April 10, 2013. ADEM criteria for arsenic are expressed as dissolved trivalent arsenic (arsenite – As III). Presently studies are being conducted in order to provide a better understanding of the prevalence and areal distribution of dissolved trivalent arsenic to total arsenic in the State of Alabama. Upon conclusion of the studies Big Coon Creek will be reassessed for arsenic violations. Values for Total Dissolved Solids, Specific Conductance, Hardness, and Alkalinity were greater than expected for ecoregion 68. No organics samples were collected.

SUMMARY

Bioassessment results indicated the macroinvertebrate community to be in *fair* condition. Overall habitat conditions were *marginal*. Total dissolved solids, specific conductance, hardness and alkalinity condcentrations were greater than expected for ecoregion 68. Monitoring of Big Coon Creek at BCNJ-1 should continue to ensure that water quality and biological conditions remain stable.

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Table 5. Summary of water quality data collected between April, June, August, October 2013. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median, average (Avg), and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

	Parameter	N		Min		Max	Med	Avg	SD	Q
Physical										
	Temperature (°C)	5		12.9		19.2	18.2	16.6	2.9	
	Turbidity (NTU)	5		3.3		6.0	3.9	4.3	1.1	
	Total Dissolved Solids (mg/L)	4		112.0		141.0	129.0 [M]	127.8	12.6	
	Total Suspended Solids (mg/L)	4	<	1.0		8.0	0.8	2.5	3.7	
	Specific Conductance (μmhos)	5		187.5		274.7	237.0 [G]	225.5	37.1	
	Hardness (mg/L)	4		97.9		135.0	118.0 [G]	117.2	15.5	
J	Alkalinity (mg/L)	4		97.3	<	136.0	116.5 [M]	116.6	15.8	
	Stream Flow (cfs)	5		6.2		80.0	23.9	36.3	31.5	
Chemical										
	Dissolved Oxygen (mg/L)	5		7.2		9.7	8.3	8.4	1.0	
	pH (su)	5		7.5		7.7	7.6	7.6	0.1	
J	Ammonia Nitrogen (mg/L)	4	<	0.013	<	0.018	0.011	0.012	0.003	
	Nitrate+Nitrite Nitrogen (mg/L)	4		0.144		0.365	0.296	0.275	0.094	
	Total Kjeldahl Nitrogen (mg/L)	4	<	0.041		0.391	0.178	0.192	0.153	
	Total Nitrogen (mg/L)	4	<	0.164		0.756	0.474	0.467	0.243	
J	Dissolved Reactive Phosphorus (mg/L)	4	<	0.004	<	0.006	0.005	0.004	0.002	
J	Total Phosphorus (mg/L)	4	<	0.007		0.014	0.011	0.011	0.003	
	CBOD-5 (mg/L)	4	<	2.0	<	2.0	1.0	1.0	0.0	
	Chlorides (mg/L)	4		1.1		1.3	1.3	1.2	0.1	
Total Metals										
J	Aluminum (mg/L)	4	<	0.076	<	0.199	0.068	0.094	0.076	
J	Iron (mg/L)	4	<	0.148		0.317	0.266	0.250	0.075	
J	Manganese (mg/L)	4	<	0.020		0.054	0.034	0.035	0.014	
Dissolved Metals										
	Aluminum (mg/L)	4	<	0.076	<	0.076	0.038	0.038	0.000	
	Antimony (μg/L)	4	<	0.1	<	2.6	0.0	0.4	0.6	
J	Arsenic (μg/L)	4	<	0.2	<	1.7 [H]	0.3	0.6	0.7	1
	Cadmium (μg/L)	4	<	0.046	<	0.170	0.085	0.070	0.031	
J	Chromium (μg/L)	4	<	0.918	<	32.000	1.210	4.834	7.446	
J	Copper (mg/L)	4	<	0.0003	<	0.005	0.0003	0.002	0.003	
J	Iron (mg/L)	4		0.033	<	0.109	0.062	0.066	0.033	
	Lead (μg/L)	4	<	0.1	<	1.1	0.0	0.2	0.2	
J	Manganese (mg/L)	4	<	0.018	<	0.041	0.029	0.029	0.009	
	Mercury (μg/L)	1						< 0.057		
J	Nickel (mg/L)	4	<	0.0002	<	0.016	0.001	0.002	0.004	
	Selenium (μg/L)	4	<	0.2	<	1.4	0.1	0.3	0.3	
	Silver (μg/L)	4	<	0.215	<	2.120	1.060	0.822	0.476	
	Thallium (μg/L)	4	<	0.1	<	1.1	0.0	0.2	0.2	
J	Zinc (mg/L)	4	<	0.002	<	0.017	0.003	0.004	0.003	
Biological										
	Chlorophyll a (ug/L)	4	<	0.10	<	0.10	0.05	0.05	0.00	
	E. coli (col/100mL)	4		66		291	117	148	101	

G=value greater than median concentration of all verified reference data collected in ecoregion 68; H=*F&W* human health criterion exceeded; J=estimate; M=value greater than the 90th percentile of all verified reference data collected in ecoregion 68; N=# of samples; Q=#samples where criteria exceedences are uncertain.

Alabama Department of Environmental Management

303(d) TMDL Monitoring Site

Rivers and Streams Monitoring Program

2013 Monitoring Summary

Little Coon Creek at Jackson County Road 53 (34.87425/-85.91075)

BACKGROUND

Little Coon Creek, from its confluence with Coon Creek to the Alabama / Tennessee State Line was placed on Alabama's Clean Water Act (CWA) §303(d) list of impaired waters in 2012. It was listed for siltation (habitat alteration) from non-irrigated crop production and pasture grazing. The Environmental Protection Agency (EPA) requires states to develop Total Maximum Daily Loads (TMDL) for listed water bodies to reduce contaminant concentrations. A Draft TMDL for Little Coon Creek is scheduled for completion in 2015. This report summarizes the results of biological and water quality monitoring activities the Alabama Department of Environmental Management (ADEM) has conducted to support the TMDL process.

Figure 1. Little Coon Creek at COCJ-1, April 30, 2013.

WATERSHED CHARACTERISTICS

Watershed characteristics are summarized in Table 1. Little Coon Creek is a *Fish & Wildlife (F&W)* stream in north-central Jackson County. It runs roughly southeast through the Skyline Wildlife Management Area and then along Jackson County Road 54. It combines with Big Coon Creek to form Crow Creek. Based on the 2006 National Land Cover Dataset, land use within the watershed is primarily forest (86%) with some shrub/scrub. As of May 13, 2013, ADEM has issued one NPDES permits in the watershed.

REACH CHARACTERISTICS

General observations (Table 2) and a habitat assessment (Table 3) were completed during the macroinvertebrate assessment. In comparison with reference reaches in the same ecoregion, they give an indication of the physical condition of the site and the quality and availability of habitat. Little Coon Creek at COCJ-1 is a low-gradient, glide-pool stream. Predominant instream substrates were sand, silt and hard pan clay (Figure 1). The overall habitat assessment resulted in a *marginal* rating.

Table 1. Summary of watershed characteristics.

Watershed Characteristics		
Basin		Tennessee River
Drainage Area (mi^2)		29
Ecoregion[a]		68b
% Landuse		
Open Water		<1
Wetland	Woody	<1
Forest	Deciduous	81
	Evergreen	1
	Mixed	4
Shrub/scrub		4
Grassland/herbaceous		1
Pasture/hay		6
Cultivated crops		1
Development	Open space	1
	Low Intensity	<1
Population/km^2[b]		11
# NPDES Permits[c]	**TOTAL**	1
401 Water Quality Certification		1

a.Sequatchie Valley
b.2000 US Census
c.#NPDES permits downloaded from ADEM's NPDES Management System database, May 13, 2013.

Table 2. Physical characteristics of Little Coon Creek at COCJ-1, June 5, 2013.

Physical Characteristics		
Width (ft)		25
Canopy Cover		Mostly Shaded
Depth (ft)		
	Run	2.0
	Pool	3.0
% of Reach		
	Run	80
	Pool	20
% Substrate		
	Boulder	2
	Clay	10
	Cobble	1
	Gravel	5
	Hard Pan Clay	15
	Sand	45
	Silt	15
	Organic Matter	7

BIOASSESSMENT RESULTS

Benthic macroinvertebrate communities were sampled using ADEM's Intensive Multi-habitat Bioassessment methodology (WMB-I). Table 4 summarizes results of taxonomic richness, community composition, and community tolerance metrics. Each metric is scored on a 100 point scale. The final score is the average of all individual metric scores. Metric results indicated the macroinvertebrate community in Little Coon Creek at COCJ-1 to be in *fair* condition.

Table 3. Results of the habitat assessment conducted in Little Coon Creek at COCJ-1, June 5, 2013.

Habitat Assessment	%Maximum Score	Rating
Instream Habitat Quality	61	Sub-optimal (59-70)
Sediment Deposition	71	Optimal (>70)
Sinuosity	40	Poor (<45)
Bank and Vegetative Stability	36	Marginal (35-59)
Riparian Buffer	63	Marginal (50-69)
Habitat Assessment Score	**128**	
% Maximum Score	**58**	**Marginal (41-58)**

Table 4. Results of the macroinvertebrate bioassessment conducted in Little Coon Creek at COCJ-1, June 5, 2013.

Macroinvertebrate Assessment	Results	Scores (0-100)
Taxa richness and diversity measures		
# EPT taxa	13	39
Taxonomic composition measures		
% Non-insect taxa	15	38
% Dominant Taxon	12	100
% EPC taxa	18	32
Functional feeding group measures		
% Predators	11	42
Tolerance measures		
% Taxa as Tolerant	39	27
WMB-I Assessment Score	---	**46**
WMB-I Assessment Rating		**Fair (39-58)**

WATER CHEMISTRY

Results of water chemistry analyses are presented in Table 5. In situ measurements and water samples were collected March through October 2013 to help identify any stressors to the biological communities. In situ parameters were also measured during the macroinvertebrate assessment on June 5. The *F&W* dissolved oxygen criterion was exceeded one time in October. Total dissolved solids, alkalinity and specific conductance values were greater than expected, as compared to all reference data collected in ecoregion 68. No metals, bacteriological or organics samples were collected.

SUMMARY

Little Coon Creek at COCJ-1 is a slow to medium velocity glide-pool stream. It is located downstream of LCNJ-36 and is located in the Sequatchie Valley sub-ecoregion. Overall habitat quality was rated *marginal*. Sediment loads are high during rain events and streambanks are being eroded, potentially impacting macroinvertebrate populations.

Bioassessment results indicated the macroinvertebrate communities to be in *fair* condition. Monitoring should continue to ensure that water quality and biological conditions meet current standards.

Table 5. Summary of water quality data collected between March and October 2013. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median, average (Avg), and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

	Parameter	N	Min	Max	Med	Avg	SD	E
	Physical							
	Temperature (°C)	9	12.2	22.3	19.0	18.0	3.2	
	Turbidity (NTU)	9	3.8	12.5	8.3	7.9	2.5	
J	Total Dissolved Solids (mg/L)	8	80.0	192.0	148.5 M	145.6	34.1	
J	Total Suspended Solids (mg/L)	8	< 1.0	13.0	3.0	4.4	4.2	
	Specific Conductance (µmhos)	9	200.5	340.4	279.4 G	265.7	44.3	
	Alkalinity (mg/L)	8	104.0	167.0	133.0 M	131.1	21.0	
	Stream Flow (cfs)	6	3.4	55.6	11.7	19.0	19.5	
	Chemical							
	Dissolved Oxygen (mg/L)	9	4.6 C	10.3	7.4	7.4	2.2	1
	pH (su)	9	7.4	7.9	7.6	7.6	0.1	
	Ammonia Nitrogen (mg/L)	8	< 0.008	0.070	0.009	0.019	0.022	
	Nitrate+Nitrite Nitrogen (mg/L)	8	0.083	0.313	0.140	0.158	0.080	
J	Total Kjeldahl Nitrogen (mg/L)	8	< 0.041	0.383	0.159	0.173	0.142	
J	Total Nitrogen (mg/L)	8	< 0.114	0.669	0.330	0.330	0.203	
J	Dissolved Reactive Phosphorus (mg/L)	8	< 0.004	0.014	0.008	0.008	0.003	
J	Total Phosphorus (mg/L)	8	< 0.009	0.029	0.018	0.018	0.007	
	CBOD-5 (mg/L)	8	< 2.0	< 2.0	1.0	1.0	0.0	
	Chlorides (mg/L)	8	1.0	1.7	1.3	1.3	0.3	

C= *F&W* criterion exceeded; E=#samples that exceeded criterion; G=value greater than median concentration of all verified reference data collected in ecoregion 68; ; J=estimate; M=value greater than the 90th percentile of all verified reference data collected in ecoregion 68; N=# of samples.

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Appendix M
Desktop Fish Entrainment and Turbine Mortality Report

Appendix M

HARRIS DAM
RELICENSING

DESKTOP FISH ENTRAINMENT AND TURBINE MORTALITY REPORT

R.L. HARRIS HYDROELECTRIC PROJECT

FERC NO. 2628

Prepared for:

ALABAMA POWER COMPANY

BIRMINGHAM, ALABAMA

Alabama Power

Prepared by:

Kleinschmidt

March 2018

Appendix M

ALABAMA POWER COMPANY
BIRMINGHAM, ALABAMA

R. L. HARRIS HYDROELECTRIC PROJECT
FERC NO. 2628

DESKTOP FISH ENTRAINMENT AND TURBINE MORTALITY REPORT

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DESKTOP FISH ENTRAINMENT AND TURBINE MORTALITY STUDY REPORT

1.0 INTRODUCTION

Alabama Power Company (Alabama Power) is initiating the Federal Energy Regulatory Commission (FERC) relicensing of the 135-megawatt (MW) R.L. Harris Hydroelectric Project (Harris Project), FERC Project No. 2628. The Harris Project consists of a dam, spillway, powerhouse, and those lands and waters necessary for the operation of the hydroelectric project and enhancement and protection of environmental resources. These structures, lands, and water are enclosed within the FERC Project Boundary. Under the existing Harris Project license, the FERC Project Boundary encloses two distinct geographic areas, described below.

Harris Reservoir is the 9,870-acre reservoir (Harris Reservoir) created by the R.L. Harris Dam (Harris Dam). Harris Reservoir is located on the Tallapoosa River, near Lineville, Alabama. The lands adjoining the reservoir total approximately 7,392 acres and are included in the FERC Project Boundary. This includes land to 795 feet mean sea level (msl)[1], as well as natural undeveloped areas, hunting lands, prohibited access areas, recreational areas, and all islands.

The Harris Project also contains 15,063 acres of land within the James D. Martin-Skyline Wildlife Management Area (Skyline WMA) located in Jackson County, Alabama. These lands are located approximately 110 miles north of Harris Reservoir and were acquired and incorporated into the FERC Project Boundary as part of the FERC-approved Harris Project Wildlife Mitigative Plan and Wildlife Management Plan. These lands are leased to, and managed by, the State of Alabama for wildlife management and public hunting and are part of the Skyline WMA (ADCNR 2016b).

For the purposes of this technical report, "Lake Harris" refers to the 9,870-acre reservoir, adjacent 7,392 acres of project land, and the dam, spillway, and powerhouse. "Skyline" refers to the 15,063 acres of Project land within the Skyline WMA in Jackson County. "Harris Project" refers to all the lands, waters, and structures enclosed within the FERC Project Boundary, which includes both Lake Harris and Skyline. "Harris Reservoir" refers to the 9,870-acre reservoir only; Harris Dam refers to the dam, spillway, and powerhouse. The "Project Area" refers to the land and water in the Project Boundary and immediate geographic area adjacent to the Project Boundary (Alabama Power Company 2018).

Lake Harris and Skyline are located within two river basins: the Tallapoosa and Tennessee River Basins, respectively. The only waterbody managed by Alabama Power as part of their FERC license for the Harris Project is the Harris Reservoir.

[1] Also includes a scenic easement (800-feet msl or 50-horizontal-feet from 793-feet msl, whichever is less, but never less than 795-feet msl)

To support the relicensing process and provide baseline information for the Pre-Application Document (PAD), Kleinschmidt Associates (Kleinschmidt) conducted a desktop analysis and prepared this report to address fish entrainment and turbine mortality for the Harris Project.

During operation, most hydropower plants generate electricity by converting the potential energy of water from a reservoir above a dam into mechanical energy as the water spins the blades of a turbine connected to a generator. The amount of electricity generated depends on the head, which is the difference in height between the water in the reservoir above the dam and the elevation of the river below the dam. As hydropower dams operate, some of the fish present in the reservoir are entrained or passed through the turbine. In most cases, these fish are passed into the river below unharmed; however, some may be injured or killed due to strikes from turbine blades or rapid pressure changes.

Numerous field studies during the 1980s and early 1990s documented fish entrainment and turbine mortality trends at hydropower plants throughout the United States. These data were subsequently compiled into a comprehensive database of fish entrainment information by the Electric Power Research Institute (EPRI 1992). Since the mid-1990s, the transfer of fish entrainment rate information from project to project utilizing the EPRI database has been widely accepted by state and federal resource agencies (including FERC, the United States Fish and Wildlife Service, and the National Marine Fisheries Service) as a means of providing desktop estimates of fish entrainment. In a similar fashion, the estimated turbine-induced mortality rates (based on mortality studies for similar type turbines) are applied to the fish entrainment estimates to determine potential fish mortality and project-related impacts to the local fisheries resources (FERC 1995). A few of the agency-accepted examples of these desktop assessments include the:

- *Coosa and Warrior Hydroelectric Projects Desktop Fish Entrainment and Turbine Mortality Analysis* (Kleinschmidt Associates 2003)
- *Claytor Hydroelectric Project Fish Entrainment and Impingement Desktop Assessment* (Normandeau Associates, Inc. 2009)
- *Saluda Hydro Project Desktop Fish Entrainment and Turbine Mortality Report* (Kleinschmidt Associates 2007)

In preparing this report, Alabama Power used the same desktop assessment methodologies that resource agencies have agreed to in previous studies at other hydroelectric projects in the southeast.

2.0 PROJECT DESCRIPTION

Harris Reservoir is located within the Tallapoosa River Basin. The Harris Reservoir extends up the Tallapoosa River approximately 29 miles from the Harris Dam with approximately 367 miles of shoreline. The reservoir surface area is approximately 9,870 acres at normal full pool elevation of 793 feet mean sea level (msl), and has a mandatory 8-foot drawdown to 785 feet msl from December to April. The normal tailwater elevation with one-unit operating is 664.93 feet msl; with two units operating, it is 667.71 feet msl. The gross storage capacity of Harris Reservoir is approximately 425,721 acre-feet and the usable storage capacity is approximately 207,317 acre-feet.

The Harris Dam consists of a concrete gravity dam, powerhouse, and spillway totaling 1,142 feet long with a maximum height of 151.5 feet. The dam has five radial gates for passing floodwaters in excess of turbine capacity and one radial trash gate. Each radial gate measures 40 feet 6 inches high and 40 feet wide.

The Harris powerhouse is a concrete structure and is integral with the intake facilities. It houses two flow units totaling 135 MW. There are two vertical generators each rated at 71,740 Kilovolts (kV) and two vertical Francis turbines each rated at 95,000 horsepower (hp) under a net head of 121 feet and a maximum hydraulic capacity of 8,000 cubic feet per second (cfs). Harris Project intake structures are located at 746 feet msl and are equipped with a skimmer weir that can incrementally raise the effective intake elevation approximately 18 feet to a maximum of approximately 764 feet msl.

3.0 METHODOLOGY

The following sections detail the steps taken to calculate the potential annual estimated fish entrainment and potential turbine-induced mortality for the Harris Project.

3.1 ENTRAINMENT

Fish entrainment for the Harris Project was assessed through a desktop study to provide an order-of-magnitude estimate of potential fish entrainment using existing literature and site-specific information. The primary steps in this analysis are listed below:

- Obtain literature with fish entrainment information that would contribute to a site-specific entrainment database.
- Define the subset of studies that form the entrainment database to be applied to the Harris Project.
- Use the entrainment database to develop potential fish entrainment rates as a function of fish/unit flow volume, species composition, and size classes.
- Estimate the average monthly turbine flows for the Harris Project.
- Estimate the number, species composition, and size of fish potentially entrained through the Harris Project.

3.1.1 DEFINE THE ENTRAINMENT DATABASE

Over 60 site-specific desktop analyses that provide order-of-magnitude estimates of annual resident fish entrainment at hydroelectric sites in the United States have been reported by FERC (1995) (Appendix A). These studies were primarily derived from the 1992 EPRI report entitled *Fish Entrainment and Turbine Mortality Review and Guidelines*. The EPRI Report includes descriptive information gathered from each entrainment study, included below:

1. Project name and FERC project number
2. Location: state and river
3. Project size: discharge capacity and power production
4. Physical project characteristics (e.g., trash rack spacing, intake velocity)
5. Project operation (e.g., peaking, run-of-river)

6. Biological factors: fish species composition
7. Impoundment characteristics: general water quality, impoundment size, and flow regime

Kleinschmidt assembled this information into a screening matrix of data that could potentially be used for this study. Many entrainment reports are available on a national level, but not all studies are applicable to the Harris Project given the differences in project features, fish assemblages, and other parameters. Specific studies were selected from the screening matrix that were most applicable to the Harris Project. Criteria used in selecting specific studies were as follows:

1. Similar geographical location, with preference given to projects located in the same eco-region
2. Similar station hydraulic capacity
3. Similar station operation
4. Biological similarities: fish species, assemblage, and water quality
5. Availability of entrainment data – netting or hydro-acoustics

3.1.2 Fish Entrainment Rates

Monthly fish entrainment rates for the Harris Project were based on monthly entrainment estimates available from the entrainment database studies. Typically, these rates were reported in fish per hour of sampling. To standardize the data from the database projects and apply them to the Harris Project, the fish per hour rates were converted to an entrainment density of fish per million cubic feet (mcf) of water that was passed through the turbine. The conversion was based on turbine size (hydraulic capacity in cfs, adjusted to cubic feet per hour) in the original study and the hours of sampling (fish per hour). Entrainment rates are presented in mcf for ease in comparison.

The total number of fish entrained by month for the Harris Project was calculated by multiplying the monthly fish entrainment rate (fish per mcf of water) by the monthly volume of water estimated to pass through the turbines of the Harris Project (mcf of water per month). The total number of fish entrained by season was the sum of the total number of fish entrained per month for each season.

3.1.3 Species Composition and Length Frequency Analysis

Species composition data for Harris Reservoir, based on existing fisheries surveys, was compared to species composition of potential source studies to identify entrainment data that most closely matched the local fish community. Due to geographic differences among the species present, the species composition data were grouped by family to produce a percentage for each fish family by season. The Centrarchid family was divided into Bass and Sunfish genera because of differences in body morphology type. The total number of entrained fish for each season was multiplied by family percent composition and then converted to a percentage to calculate the total number of fish entrained within each family group by season.

Length frequency data from the selected entrainment study was used to estimate the size of fish potentially entrained at the Harris Project. The size composition data for each entrained family group is represented as a percentage from the selected entrainment study for each season to produce length frequency distributions of observed entrainment. These data were grouped by small (1-149 millimeters [mm]) and large (150-900 mm) size classes, family group, and season to produce length frequency distributions of observed entrainment. The data were then summed across family groups to produce length distribution by season. Length frequency data are summarized in Appendix B. Each seasonal family group entrainment estimate was multiplied by the corresponding length frequency distribution percentage to calculate the estimated number of entrained fish for each length group (small or large).

3.2 Turbine Mortality

Turbine characteristics of the Harris Project were compared to those of source studies to identify appropriate turbine mortality rates. Since the Harris Project is equipped with two vertical Francis units, studies from the turbine mortality database were separated based on whether they were performed at sites with Francis or Kaplan-type turbines. The sites were then sorted based on the following characteristics: head, runner diameter, and runner speed. Information on each turbine mortality study is provided in Appendix C. The study information contained in Appendix C includes (where available): species tested, size class/range tested, number of fish tested (test and control), and survival results. The study information is sorted by species tested. Study sites were initially accepted based on turbine design, availability of sufficient turbine descriptions, and species/family types relevant to the Harris Project. Other screening criteria included operating head and availability of 48-hour post testing survival data.

3.3 Calculation of Turbine Mortality Estimate

For purposes of this report, fish mortality is defined as turbine interaction with a fish that results in death of the fish. Mortality rates selected for the Harris Project were sorted by family groups consistent with those used to estimate entrainment rates. Once sorted, the mortality rate from each family group tested was averaged among source studies to estimate turbine mortality for each family group. Turbine mortality was estimated by multiplying the mortality rate of each family group by the seasonal entrainment estimates for that same family group.

4.0 RESULTS AND DISCUSSION

4.1 Fish Entrainment Rate

Table 3-1 depicts the projects initially considered as study sources for the Harris Project. Although two projects are located north of Alabama, the similarities of the projects' infrastructures justified their initial selection.

TABLE 3-1: SUMMARY OF STUDY PROJECTS CONSIDERED FOR THE HARRIS PROJECT ENTRAINMENT STUDY

PROJECT NAME	STATE	RIVER	TURBINE CAPACITY (cfs)	MODE OF OPERATION	FISHERY TYPE	ENTRAINMENT SAMPLING (Full or Partial Netting)
Harris	**AL**	**Tallapoosa**	**16,000**	**Peaking**	**Warm**	**N/A**
Richard B. Russell	GA/SC	Savannah	60,000	Peaking	Warm	Full
Hawks Nest	OH/KY	New	11,866	Peaking	Warm	Partial
Hardy	MI	Muskegon	37,500	Pulsed	Cool	Partial

Upon further screening, studies were excluded if: (1) peaking was not the primary form of operation, (2) the site lacked similar species composition, or (3) the site lacked full draft-tube netting data; this is generally considered to be a more reliable method to obtain accurate estimates (EPRI 1992). Using these criteria, the Richard B. Russell (RBR) Project was selected as the most appropriate project to use for the Harris Project study (Table 3-2). The RBR Project is a large mainstem storage project located on the Savannah River in Georgia. The lake stratifies annually, has a standard southeastern fisheries species composition (family groups), is operated on a daily peaking basis similar to the Harris Project, and has extensive entrainment information available.

TABLE 3-2: COMPARISON OF STUDY PROJECT CHOSEN COMPARED TO HARRIS PROJECT

PROJECT NAME	STATE	RIVER	TURBINE CAPACITY (cfs)	MODE OF OPERATION	FISHERY TYPE	ENTRAINMENT SAMPLING (Full or Partial Netting)
Harris	**AL**	**Tallapoosa**	**16,000**	**Peaking**	**Warm**	**N/A**
Richard B. Russell	GA/SC	Savannah	60,000	Peaking	Warm	Full

Average monthly entrainment density for the RBR Project ranged from 0.3 fish per mcf (June) to 33.6 fish per mcf (February) (Table 3-3).

TABLE 3-3: MEAN MONTHLY FISH ENTRAINMENT RATES FROM THE RICHARD B. RUSSELL PROJECT USED FOR THE HARRIS PROJECT ENTRAINMENT ANALYSIS

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
6.8	33.6	1.0	1.2	0.5	0.3	0.5	1.3	0.6	0.4	2.6	1.1

Note: Figures are measurements of fish per million cubic feet

4.2 Estimated Total Number of Fish Entrained by Month and Season

Using the average data from the RBR Project entrainment study, the estimated total number of fish entrained annually at the Harris Project is 294,427 fish, with approximately 90 percent of all entrainment occurring in the winter season (Table 3-4). The peak month of entrainment is estimated to be February with 211,878 total fish entrained; this is associated with high Clupeid entrainment at the RBR Project during cold weather. The lowest total entrainment is expected to occur in June with 730 total fish entrained.

Table 3-4: Estimated Number of Fish Entrained at the Harris Project Based on Projected Maximum Project Generation

	Month	Seasonal Entrainment Rate (fish/mcf*)	Total Monthly Project Flows (mcf*)	Total Estimated Fish Entrained by Month	Total Estimated Number of Fish Entrained by Season
Winter	December	1.1	6,361	6,998	
	January	6.8	6,614	44,972	263,848
	February	33.6	6,306	211,878	
Spring	March	1.0	7,747	7,747	
	April	1.2	4,764	5,717	15,573
	May	0.5	4,218	2,109	
Summer	June	0.3	2,433	730	
	July	0.5	2,159	1,080	3,714
	August	1.3	1,465	1,904	
Fall	September	0.6	1,463	863	
	October	0.4	2,600	1,092	11,292
	November	2.6	3,619	9,337	
				Total	**294,427**

*mcf = million cubic feet

4.3 Estimated Total Number of Fish Entrained and Length Frequency for Each Family Group

When comparing family groups between Harris and RBR, a difference in family composition was observed. Gar species, walleye, and yellow perch are not known to occur in the Harris Reservoir; therefore, the percent entrainment for Percids and Lepisosteids (which was very low) was divided proportionally among the other family/genus groups.

Seasonal percent composition information for each family group used in species composition calculations is presented in Table 3-5. The estimated seasonal total number of fish for each family group in the Harris Project is presented in Table 3-6. This calculation applied the seasonal entrainment estimates (Table 3-5) to the seasonal family composition data (Table 3-6) to produce a seasonal total for each family group. For the Harris Project, Clupeids were the most entrained family in all seasons.

The estimated numbers of entrained fish in each length frequency group (small or large) for each family group are presented in Table 3-7. The total number of small and large fish estimated to be entrained annually at the Harris Project was 241,911 and 52,516 fish, respectively. Most Clupeids, Cyprinids, Ictalurids and Sunfish estimated to be entrained were small and most Catostomids and Bass were large.

TABLE 3-5: SEASONAL PERCENT COMPOSITION OF EACH FAMILY OF ENTRAINED FISH AT THE HARRIS PROJECT

Family/Genus Group	Winter	Spring	Summer	Fall
Catostomidae	0.01	0.06	0.03	0.00
Sunfish	0.18	9.50	12.59	1.40
Bass	0.00	0.33	0.06	0.05
Clupeidae	96.17	87.65	83.70	79.04
Cyprinidae	0.11	0.99	0.59	0.60
Ictaluridae	3.53	1.47	3.03	18.91
Total	**100**	**100**	**100**	**100**

TABLE 3-6: ESTIMATED SEASONAL NUMBER OF ENTRAINED FISH BY FAMILY/GENUS GROUP AT THE HARRIS PROJECT

Family/Genus Group	Winter	Spring	Summer	Fall	Total
Catostomidae	18	9	1	0	28
Sunfish	461	1,479	468	158	2566
Bass	5	51	2	5	63
Clupeidae	253,752	13,649	3,108	8,926	279,435
Cyprinidae	287	154	22	68	531
Ictaluridae	9,324	231	113	2,136	11,804
Total	**263,847**	**15,573**	**3,714**	**11,293**	**294,427**

TABLE 3-7: ESTIMATED SEASONAL NUMBER OF FISH ENTRAINED, BY FAMILY/GENUS GROUP FOR LENGTH FREQUENCY AT THE HARRIS PROJECT

Family/Genus Group	Size[1]	Winter	Spring	Summer	Fall	Total
Catostomidae	Small	3	0	0	0	3
Catostomidae	Large	15	9	1	0	25
Sunfish	Small	316	1,346	422	92	2176
Sunfish	Large	145	133	46	66	390
Bass	Small	0	11	1	0	12
Bass	Large	5	40	1	5	51
Clupeidae	Small	214,178	10,930	2,152	5,161	232,421
Clupeidae	Large	39,574	2,719	956	3,765	47,014
Cyprinidae	Small	250	140	15	51	456
Cyprinidae	Large	37	14	7	17	75
Ictaluridae	Small	5,162	82	57	1,542	6,843
Ictaluridae	Large	4,162	149	56	594	4,961
Total		**263,847**	**15,573**	**3,714**	**11,293**	**294,427**

Note: [1]Presented in two length groups:
small 0-150 mm length
large 151-900 mm length

4.4 TURBINE CHARACTERISTICS AND FISH MORTALITY

The most frequently cited significant mortality factors relating to the hydraulic passage environment for Francis and Kaplan runners are runner speed, peripheral runner velocity, and cavitation (Semple 1979; Ruggles and Palmeter 1989; Cada 1990; EPRI 1992). For a given turbine size, the faster the runner rotates, the opening through which the fish must pass is clear less often. Thus, revolutions per minute (rpm) indicate the frequency and duration of the opening between the turbine and the unit housing through which the fish pass. Project head directly affects turbine mortality by dictating Francis turbine design and operating characteristics, such as peripheral runner velocity and cavitation, which in turn are believed to directly affect fish survival. Literature suggests that for large fish, size of wicket gates, number of blades, and guide vane clearances may be the most important mortality factors, along with operating efficiency (EPRI 1992). While larger fish stand the greatest chance of experiencing mortality due to collision with turbine hardware such as blades (Cada 1990), smaller fish are less likely to strike gates and stay vanes but are more prone to runner injury and hydraulically-related mortality, such as cavitation (Eicher 1987).

The Harris Project contains two vertical Francis turbines inside the powerhouse. Each unit has a head of 121 feet[2] and rotation speed of approximately 106 rpm. The runner diameter for each unit is 209 inches. Many studies summarized in the EPRI (1997) database utilize Francis type turbines and were potential source studies for estimating fish mortality for the Harris Project

[2] Net operating head at full pool was used not for calculations but for a screening tool to find similar sites.

(Table 3-8[3]). Of these, five were identified for use in the mortality estimates based on similar turbine parameters (head, runner speed, runner diameter, peripheral runner velocity).

Operating head for source studies applied to the Harris Project ranged from 28 feet to 153 feet (Table 3-9). Turbine sizes ranged in diameter from 51 inches to 135 inches, and runner speeds ranged from 75 rpm to 300 rpm for source studies. The operating head of the Harris Project is relatively low compared to the selected mortality source studies; turbine speeds were intermediate relative to the source studies. These source studies provide reasonable estimates of turbine mortality for this study based on two reasons:

1. The studies selected were based on turbine and biological criteria representative of the Harris Project from prior studies of similar fish and turbines which have been reviewed and accepted by FERC.
2. Multiple test results are available as input for the most dominant entrainment family groups (i.e., Sunfish, Bass, and Clupeids). These tests indicate relatively consistent trends.

[3] Blank cells in Table 3-8 are due to unreported information at the respective project.

TABLE 3-8: TURBINE CHARACTERISTICS OF FRANCIS TYPE TURBINES TESTED FOR ENTRAINMENT MORTALITY

SITE NAME	Unit # Tested	TURBINE TYPE	Head (ft)	Head (m)	Power (MW)	Flow (cfs)	Flow (cms)	Speed (rpm)	Diameter (in)	Diameter (cm)	Runner Blades	Wicket Gates
Peshtigo	4	Francis (vert)	13	4.0	0.36	460	13.0	100	80	203		
Potato Rapids	2	Francis (vert)	17	5.2	0.44	440	12.5	135	80	203		
Potato Rapids	1	Francis (vert)	17	5.2	0.5	500	14.2	123	84	213		
Minetto	3/4	Francis (vert)	17.3	5.3	1.6	1500	42.5	72	139	353	16	28
Stevens Creek	3	Francis (vert)	28	8.5	2.35	1000	28.3	75	135	343	14	20
White Rapids	1	Francis (vert)	29	8.8	3.27	1540	43.6	100	134	340	14	20
Vernon	4	Francis (vert)	34	10.4	2.5	1280	36.2	133.3	62	158	14	16
Vernon	10	Francis (vert)	34	10.4	4.2	1834	51.9	74	156	396	15	20
Rogers	2	Francis (vert)	39.2	11.9	1.7	727	41.2	150	60	152	15	
Sandstone Rapids	1	Francis (vert)	42	12.8	1.9	650	18.4	150	87	220		
Alcona	2	Francis (vert)	43	13.1	4	1600	45.3	90	100	254	16	18
Prickett	1	Francis (vert)	54	16.5	1.1	326	9.2	257	53	136		
Holtwood	3	Francis (vert, double-runner)	61.5	18.7	14.95	3500	99.1	102.8	112	284	17	20
Holtwood	10	Francis (vert)	62	18.9	14.9			94.7			16	
E. J. West	2	Francis (vert)	63	19.2	12.8	2450	69.4	112.5	131	332	15	28
Caldron Falls	1	Francis (vert)	80	24.4	3.2	650	18.4	226	72	182		
Hardy	2	Francis (vert)	100	30.5	10	1500	42.5	163.6	84	213	16	
Hoist	3	Francis (vert)	142	43.3	1.8			360				
Schaghticoke	4	Francis (vert)	153	46.6	4.7	410	11.6	300	51	128	17	28
Bond Falls	1	Francis (vert)	210	64.0	6	450	12.7	300				
Colton	1	Francis (vert)	258	78.6	11.2	450	12.7	360	59	150	19	28

Source: EPRI 1997

Key:

ft	feet
m	meters
MW	megawatts
cfs	cubic feet per second
cms	cubic meters per second
rpm	revolution per minute

TABLE 3-9: TURBINE CHARACTERISTICS OF FRANCIS TYPE UNITS COMPARED TO THE HARRIS PROJECT

Site Name	Turbine Type	Head		Power	Flow		Speed	Diameter		Runner	Wicket
		(ft)	(m)	(MW)	(cfs)	(cms)	(rpm)	(in)	(cm)	Blades	Gates
Harris Project	**Francis (vert)**	**121**	**36.9**	**67.5**	**8,000**	**226.5**	**105.9**	**209**	**531**	**13**	**20**
E. J. West[2]	Francis (vert)	63	19.2	12.8	2450	69.4	112.5	131	332	15	28
Vernon[2]	Francis (vert)	34	10.4	2.5	1280	36.2	133.3	62	158	14	16
Stevens Creek[3]	Francis (vert)	28	8.5	2.35	1000	28.3	75	135	343	14	20
White Rapids[2,3]	Francis (vert)	29	8.8	3.27	1540	43.6	100	134	340	14	20
Schaghticoke[1]	Francis (vert)	153	46.6	4.7	410	11.6	300	51	128	17	28

Key:

Similar Head [1]
Similar Speed [2]
Similar Runner Diameter [3]

ft	feet
m	meters
MW	megawatts
cfs	cubic feet per second
cms	cubic meters per second
rpm	revolution per minute

4.5 Turbine Mortality Calculations

All test data and mortality percentages for each species are presented in Table 3-10. Table 3-11 depicts the average mortality rate for each family and size class for the Harris Project. Small Sunfish had a higher mortality rate than the other family groups, and the large Cyprinids had the lowest mortality rate.

Although literature was not available to estimate turbine mortality for one family (*Ictaluridae*), these fish are a very small component of estimated fish entrainment composition. Consistent with other studies, the Catostomid family group was used as a surrogate for the Ictalurid group due to similar physical characteristics, such as skeletal structure and body shape (FERC 1995). Length frequency turbine mortality estimates are presented in Table 3-12.

TABLE 3-10 SUMMARY OF MORTALITY DATA USED TO CALCULATE MORTALITY RATES FOR THE HARRIS PROJECT

SITE NAME	SPECIES TESTED	LENGTH (mm)	MORTALITY (%)	TEST DURATION	FAMILY/GENUS GROUP REPRESENTED
E.J. West	Largemouth Bass	250	1.4	Latent (48 hrs)	Bass
E.J. West	Largemouth Bass	250	70.0	Latent (48 hrs)	Bass
Schaghticoke	Largemouth Bass	250	8.8	Latent (48 hrs)	Bass
Schaghticoke	Largemouth Bass	250	47.1	Latent (48 hrs)	Bass
Schaghticoke	Largemouth Bass	250	39.2	Latent (48 hrs)	Bass
E.J. West	White Sucker	175	31.1	Latent (48 hrs)	Catostomidae, Ictaluridae
E.J. West	White Sucker	250	12.3	Latent (48 hrs)	Catostomidae, Ictaluridae
E.J. West	White Sucker	250	47.2	Latent (48 hrs)	Catostomidae, Ictaluridae
Schaghticoke	White Sucker	175	40.6	Latent (48 hrs)	Catostomidae, Ictaluridae
Schaghticoke	White Sucker	250	14.1	Latent (48 hrs)	Catostomidae, Ictaluridae
Schaghticoke	White Sucker	250	8.5	Latent (48 hrs)	Catostomidae, Ictaluridae
Schaghticoke	White Sucker	175	13.7	Latent (48 hrs)	Catostomidae, Ictaluridae
Schaghticoke	White Sucker	175	31.4	Latent (48 hrs)	Catostomidae, Ictaluridae
White Rapids	White Sucker	176.5	6.8	Latent (48 hrs)	Catostomidae, Ictaluridae
Stevens Creek	Blueback Herring	165	5.7	Latent (48 hrs)	Clupeidae
E.J. West	Golden Shiner	175	4.5	Latent (48 hrs)	Cyprinidae
Stevens Creek	Spotted Sucker	165	11.7	Latent (48 hrs)	Catostomidae, Ictaluridae
Stevens Creek	Sunfish Spp	154	19.6	Latent (48 hrs)	Sunfish
E.J. West	Largemouth Bass	175	3.4	Latent (48 hrs)	Bass
E.J. West	Largemouth Bass	175	4.8	Latent (48 hrs)	Bass
Schaghticoke	Largemouth Bass	175	11.7	Latent (48 hrs)	Bass
Schaghticoke	Largemouth Bass	175	60.0	Latent (48 hrs)	Bass
E.J. West	White Sucker	100	54.8	Latent (48 hrs)	Catostomidae, Ictaluridae
Schaghticoke	White Sucker	100	10.3	Latent (48 hrs)	Catostomidae, Ictaluridae
White Rapids	White Sucker	114	11.8	Latent (48 hrs)	Catostomidae, Ictaluridae
Vernon	American Shad	95	5.3	Latent (48 hrs)	Clupeidae
E.J. West	Golden Shiner	100	27.0	Latent (48 hrs)	Cyprinidae

SITE NAME	SPECIES TESTED	LENGTH (mm)	MORTALITY (%)	TEST DURATION	FAMILY/GENUS GROUP REPRESENTED
Schaghticoke	Golden Shiner	100	7.7	Latent (48 hrs)	Cyprinidae
E.J. West	Bluegill	100	63.8	Latent (48 hrs)	Sunfish
E.J. West	Bluegill	100	42.4	Latent (48 hrs)	Sunfish
E.J. West	Bluegill	100	38.2	Latent (48 hrs)	Sunfish
Schaghticoke	Bluegill	100	14.8	Latent (48 hrs)	Sunfish
Schaghticoke	Bluegill	100	43.4	Latent (48 hrs)	Sunfish
Stevens Creek	Sunfish Spp	100	22.2	Latent (48 hrs)	Sunfish
White Rapids	Bluegill	82	14.8	Latent (48 hrs)	Sunfish
White Rapids	Bluegill	138	32.4	Latent (48 hrs)	Sunfish

Key:

hrs hours
mm millimeter

TABLE 3-11 MEAN TURBINE MORTALITY RATES FOR FAMILY AND SIZE GROUPS AT THE HARRIS PROJECT

Species	Size	Mortality (%)
Catostomidae	Small	25.61
Catostomidae	Large	22.85
Catostomidae	Average	24.23
Sunfish	Small	34.00
Sunfish	Large	19.64
Sunfish	Average	26.82
Bass	Small	19.95
Bass	Large	33.30
Bass	Average	26.63
Clupeidae	Small	5.30
Clupeidae	Large	5.70
Clupeidae	Average	5.50
Cyprinidae	Small	17.36
Cyprinidae	Large	4.55
Cyprinidae	Average	10.95
Ictaluridae	Small	25.61
Ictaluridae	Large	22.85
Ictaluridae	Average	24.23

TABLE 3-12 ESTIMATED TOTAL ENTRAINMENT FISH LOSS FOR SEASONAL LENGTH FREQUENCY BY FAMILY GROUPS FOR THE HARRIS PROJECT

Family/Genus Group	Size	Winter	Spring	Summer	Fall	Total
Catostomidae	Small	1	0	0	0	**1**
Catostomidae	Large	4	2	0	0	**6**
Sunfish	Small	107	457	144	31	**739**
Sunfish	Large	28	26	8	13	**75**
Bass	Small	1	3	0	0	**4**
Bass	Large	1	13	0	2	**16**
Clupeidae	Small	11,351	579	114	273	**12,317**
Clupeidae	Large	2,255	155	55	215	**2,680**
Cyprinidae	Small	43	24	3	9	**79**
Cyprinidae	Large	2	1	0	1	**4**
Ictaluridae	Small	1,322	21	15	395	**1,753**
Ictaluridae	Large	951	34	13	136	**1,134**
Total		**16,066**	**1,315**	**352**	**1,075**	**18,808**

Key:
- Small 0 mm-150 mm
- Large 151 mm-900 mm

5.0 SUMMARY

The total number of small and large fish estimated to be entrained annually at the Harris Project was 241,911 and 52,516 fish, respectively. Most Clupeids, Cyprinids, Ictalurids and Sunfish estimated to be entrained were small and most Catostomids and Bass were large.

A total of 18,808 fish were estimated to be killed annually by turbine entrainment at the Harris Project. Estimated fish entrainment loss is highest for Clupeids, representing 80 percent of the projected fish loss at the Harris Project. Estimated fish loss is greatest for the small Clupeids relative to the other family size groups.

6.0 REFERENCES

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APPENDIX A

FISH ENTRAINMENT DATABASE

FISH ENTRAINMENT DATABASE																		
PROJECT	**LOCATION**			**TURBINE CONFIGURATION**			**INTAKE PARAMETERS**			**OPERATION**	**IMPOUNDMENT/ POWER CANAL DATA**				**BIOLOGICAL DATA AVAILABLE**			
															Baseline	**Fishery**		
Name	**State**	**River**	**Capacity**	**Turbine**	**Number**	**Rated**	**Intake**	**Bar Rack**	**Depth**	**Peaking or**	**Impoundment /**	**Surface**	**Volume**	**Ave.**	**Survey**	**Type**	**Entrainment Sampling**	
FERC NO.			**(MW)**	**Type**	**of Turbines**	**Head**	**Velocity**	**Spacing**	**of Intake**	**Run of River**	**Power Canal**	**Acres**	**(acre/ ft.)**	**Depth**			**Netting**	**Hydroacoustics**
			(CFS)			**(ft)**	**(ft/s)**	**(in)**	**(ft)**					**(ft)**				
Ninety-nine Islands	SC	Broad	18 MW	Horizontal	6 @ 3000 kW	72	2.3		Bottom oriented	Modified	Impoundment	433	2300	> 6	YES	Warm	Full Recovery	YES
No. 2331			3992 cfs	Francis			70% clear		11.5 ft. below the	Peaking							Netting on Unit 4	
									water surface									
Neals Shoals	SC	Broad	4.42 MW	Horizontal	4 @ 1100 kW	24	3.4		Intake pulls	Run of River	Impoundment	600	1500		YES	Warm	Full Recovery	YES
No. 2315			4000 cfs	Francis			70% clear		from entire								Netting on Unit 3	
									water column									
Hollidays Bridge	SC	Saluda	3.5 MW	Horizontal	3 @ 1250 kW	41.5	1.2	2	Bottom oriented	Modified	Impoundment	466	6000	> 6	YES	Warm	Full Recovery	YES
No. 2465			1850 cfs	Francis			70% clear		18 ft. below the	Peaking							Netting on Unit 3	
				Vertical	1 @ 600 kW				water surface		Power Canal	1.5						
				Francis														
Saluda Station	SC	Saluda	2.4 MW	Horizontal	4 @ 600 kW	38	2.0		Bottom oriented	Modified	Impoundment	556	7228	6	YES	Warm	Full Recovery	YES
No. 2406			1280 cfs	Francis			70% clear		14 ft. below the	Peaking							Netting on Unit 1	
									water surface									
Gaston Shoals	SC	Broad	9.1 MW	Horizontal	1 @ 2320 kW	43 .	0.7	2.5	Bottom oriented	Modified	Impoundment	300	2500	> 30	YES	Warm	Full Recovery	YES
No. 2332			2800 cfs	Francis	3 @ 1440 kW		70% clear		13.5 ft below the	Peaking							Netting on Unit 6	
				Vertical	1 @ 2500 kW	51			water surface									
				Francis														
Richard B. Russell	GA/SC	Savannah	648 MW	Francis	4@ 80MW	144		8	Mid-depth	peaking	Impoundment	26,653	#######		YES	Warm	Full Recovery	
			60,000 cfs		4@ 82MW				100 ft. below normal pool								Netting on 1 unit	YES
Hawks Nest	OH/KY	New	102 MW	Semi-Kaplan						Peaking	Impoundment	n/a	n/a	n/a	YES	Warm	Partial	YES
			11,866	Runners	3 @ 23 MW			4									Recovery Net	
High Falls	NC	Deep	0.66 MW	Francis	3 units	17		2.375			Impoundment				YES	Warm	Partial	NO

FISH ENTRAINMENT DATABASE																		
PROJECT	**LOCATION**			**TURBINE CONFIGURATION**			**INTAKE PARAMETERS**			**OPERATION**	**IMPOUNDMENT/ POWER CANAL DATA**				**BIOLOGICAL DATA AVAILABLE**			
Steven's Creek	GA	Savannah	18.9 MW	Vertical		28				Run-ofRiver	Impoundment				YES	Warm	Full Recovery	YES
No. 2535				Francis						contraolled by								
										upstream releases								
King Mill	GA	Augusta Canal	2.05 MW	Horizontal	1 @ 650 kW	30	1.5 ft/s	2	Intake pulls	Run of River	Power Canal			7	YES	Warm	Partial	NO
No. 9988		Savannah	950 cfs	Francis	1 @ 1400 kW				from entire								Recovery Net	
									water column					11			in tailrace	
Four Mile	MI	Thunder Bay	1.8 MW	Horizontal	3 @ 600 kW	29	n/a	n/a	n/a	n/a	Impoundment	n/a	n/a	n/a	n/a	Warm/Co ol	Full Recovery	NO
			1,800 cfs														on Unit 1	
Moore's Park	MI	Grand	1.8 MW	Horizontal	2 @ 540 kW	15	3.67	1.62	17	Run of river	Impoundment	240	2,000	n/a	YES	Warm/co ol	Full recovery	YES
			1,200 cfs	Francis														
Belding	MI	Flat	n/a	Kaplan	2	11	n/a	2	n/a	Run of River	Impoundment	n/a	n/a	n/a	n/a	Cool	Full Recovery	NO
			416 cfs															
La Barge	MI	Thornapple	1.6 MW	Horizontal	2 @ 800 kW	15	n/a	n/a	n/a	Run of River	Impoundment	100	n/a	n/a	n/a	Warm	Full Recovery	NO
				Francis														
Mio	MI	Au Sable	5 MW	tbd	n/a	35	2.3	2.94	20	Run of River	Impoundment	880	12,000	n/a	n/a	Cool	Partial	YES
			4950 cfs														Recovery Net	
Alcona	MI	Au Sable	8.0 MW	Vertical	n/a	43	2.2	3.12	25	Pulsed	Impoundment	1075	25,000	n/a	n/a	Cool	Partial	YES
			8000 cfs	Francis													Recovery Net	
Loud	MI	Au Sable	4.0 MW	tbd	n/a	40	1.5	1.69	22.6	Pulsed	Impoundment	780	12,600	n/a	n/a	Cool	Partial	YES
			4444 cfs														Recovery Net	
Five Channels	MI	Au Sable	6 MW	Horizontal	n/a	36	1.4	1.75	22.2	Pulsed	Impoundment	250	4,000	n/a	n/a	Cool	Partial	YES
			3,000 cfs	Francis													Recovery Net	
Cooke	MI	Au Sable	9 MW	tbd	n/a	50	1.7	1.75	28.5	Pulsed	Impoundment	1800	30,000	n/a	n/a	Cool	Partial	YES
			3,600 cfs														Recovery Net	
Foote	MI	Au Sable	9 MW	tbd	n/a	40	22	2.87	22	Pulsed	Impoundment	1800	30,000	n/a	n/a	Cool	Partial	YES

FISH ENTRAINMENT DATABASE																		
PROJECT	**LOCATION**			**TURBINE CONFIGURATION**			**INTAKE PARAMETERS**			**OPERATION**	**IMPOUNDMENT/ POWER CANAL DATA**				**BIOLOGICAL DATA AVAILABLE**			
			4,050 cfs														Recovery Net	
Rogers	MI	Muskegon	8.8 MW	Vertical	n/a	39.2	n/a	1.75	23	Run of River	Impoundment	810	10,000	n/a	n/a	Cool	Full/Partial	YES
			2,400 cfs	Francis													Recovery Net	
Hardy	MI	Muskegon	30 MW	Vertical	n/a	100	n/a	n/a	n/a	Pulsed	Impoundment	3902	134,973	n/a	n/a	Cool	Partial	YES
			37,500 cfs	Francis													Recovery Net	
Croton	MI	Muskegon	8.8 MW	tbd	n/a	50	n/a	1.75	21	Run of River	Impoundment	1209	21,932			Cool	Partial	YES
			10,510 cfs														Recovery Net	
Morrow	MI	Kalamazoo		rim-drive	4	13	n/a	n/a	n/a	Run of River	Impoundment	1000	n/a	n/a	n/a	Cool	Full Recovery	NO
			880 cfs														on one unit	
Kleber	MI	Black	1.2 MW	Vertical	2 @ 600kW	44	1.41	3	15	Run of River	Impoundment	270	3,000	n/a	n/a	Warm/cool	Full Recovery	YES
			1,200	Kaplan													on one Unit	
Constantine	MI	St. Josephs	1.2 MW	n/a	4	11	1.3	3	13.74	Run of River	Impoundment	525	n/a	n/a	n/a	Cool	Full Recovery	No
			1,200 cfs															
Buchanan	MI	St. Josephs	4.1 MW	Vertical	10	12.8	0.7	3	13.87	Run of River	Impoundment	525	3,895	n/a	YES	Cool	Partial	NO
			4,569 cfs	Francis													Recovery Net	
Mc Clure	MI	Dead	460 cfs	Pelton	2	410	tbd	3	tbd	Run of River	Impoundment	tbd	tbd	tbd	Yes	Warm/cool	Full recovery	No
Ninth Street	MI	Thunder Bay		tbd	3 @ 460 kW	tbd	tbd	1.0	tbd	Run of rier	Impoundment	tbd	tbd	n/a	n/a	Warm	Full recovery	NO
			1650 cfs															
Hillman	MI	Thunder Bay		tbd	1 @ 460 kW	tbd	tbd	tbd	tbd	Run of River	Impoundment	tbd	tbd	n/a	n/a	Warm	Full recovery	NO
			550 cfs														1 Unit	
Hoist	MI	Dead	760 cfs	Francis	2	84	tbd	3	tbd	Run of river	Impoundment	tbd	tbd	tbd	Yes	Warm/cool	Full Recovery	No
Prickett	MI	Sturgeon	2.2 MW	Vertical	2 @ 1100 kW	54	1.6	2	17	Modified ROR	Impoundment	773	13,987	n/a	n/a	Warm/cool	Full Recovery	NO
			2220 cfs	Francis														

FISH ENTRAINMENT DATABASE																		
PROJECT	**LOCATION**			**TURBINE CONFIGURATION**			**INTAKE PARAMETERS**			**OPERATION**	**IMPOUNDMENT/ POWER CANAL DATA**				**BIOLOGICAL DATA AVAILABLE**			
Escanaba Dam 3	MI	Escanaba	2.5 MW	n/a	2	30.5	3	1.62	16.5	Run of River	Impoundment	182	1,100	n/a	n/a	Cool	Full Recovery	NO
			3400 cfs															
Escanaba Dam 1	MI	Escanaba	1.95 MW	n/a	3	23.2	3	1.62	18.2	Run of River	Impoundment	75	375	n/a	n/a	Cool	Full Recovery	NO
			1,600 cfs															
Stewart's Bridge	NY	Sacandaga	36 MW		1 @ 5400 cfs						Impoundment	480	18,600	n/a	YES	n/a	n/a	n/a
No. 2047			5,400	Francis			n/a	n/a	n/a									
E.J. West	NY	Sacandaga		Vertical	2 @ 2700 cfs	63	2.8 fps	4.5		Peaking	Impoundment	25,940	681,000	n/a	YES	n/a	Full Netting	NO
No. 2318			5400	Francis											State		Unit 2	
															Agency			
Sherman Island	NY	Hudson	6600 cfs	Vertical	4 @ 1650 cfs	69	2.2 fps	3.13		Peaking	Impoundment	305	6,960	n/a	YES	n/a	Full Netting	NO
No. 2482			30 MW	Francis							Power Canal						Units 2,3, & 5	
Feeder Dam	NY	Hudson	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Impoundment	n/a	n/a	n/a	-------	n/a	Full Netting	NO
																	Units 1,3, & 5	
Minetto	NY	Oswego	7500 cfs	Vertical	5 @ 1500 cfs	17.3	2.6 fps	2		Peaking	Impoundment	350	4,730	n/a	YES	Cool/cold	Full Netting	NO
				Francis													Units 3, 4, & 5	
Schagticoke	NY	Hoosic	1640 cfs	Vertical	4 @ 410 cfs	153	1.6 fps	2.25		Peaking	Impoundment	164	1,150	n/a	YES	Warm/cool	Full Netting	NO
				Francis							Power Canal						Unit 4	
Johnsonville	NY	Hoosic	1288 cfs	Horizontal	2 @ 644 cfs	38	0.9 fps	2		Peaking	Impoundment	450	6,430	n/a	YES	Warm/cool	Full Netting	NO
				Francis													Units 1 & 2	
Higley	NY	Middle	2045 cfs	Horizontal	2 @ 675 cfs	46	1.5 fps	3.63		Peaking	Impoundment	742	4,496	n/a	YES	Cool/cold	Full Netting	NO
		Racquette		Francis	1@ 695 cfs	45					Power Canal						Units 1, 2, & 3	
Colton	NY	Middle	1503 cfs	Vertical	2 @ 497 cfs	285	2.7 fps	2		Peaking	Impoundment	195	620	n/a	YES	Cool/cold	Full Netting	NO
		Racquette		Francis	1 @ 509 cfs	285											Unit 1	
Raymondville	NY	Lower	1640 cfs	Fixed	1 @ 1640 cfs	21.5	1.9 fps	3		Peaking	Power Canal	50	264	n/a	YES	Cool/cold	Full Netting	NO
		Racquette		Propeller													Unit 1	
East Norfolk	NY	Lower	1635 cfs	Fixed	1 @ 1635 cfs	31.4	4.2 fps	8.75		Peaking	Impoundment	135	287.9	n/a		Cool/cold	Full Netting	NO
		Racquette		Propeller							Power Canal						Power Canal	
High Falls	NY	Beaver	900 cfs	Vertical	3 @ 300 cfs	100	0.9 fps	1.81		Peaking	Impoundment	290	1,059	n/a	YES	Cool/cold	Full Netting	NO
				Francis													Unit 1	

FISH ENTRAINMENT DATABASE																		
PROJECT	**LOCATION**			**TURBINE CONFIGURATION**			**INTAKE PARAMETERS**			**OPERATION**	**IMPOUNDMENT/ POWER CANAL DATA**				**BIOLOGICAL DATA AVAILABLE**			
Moshier	NY	Beaver	660 cfs	Vertical	2 @ 330 cfs	196	1.3 fps	1.5		Peaking	Impoundment	690	7,339	n/a	YES	Cool/cold	Full Netting	NO
				Francis													Unit 2	
Herrings	NY	Black	3609 cfs	Fixed	3 @ 1203 cfs	19.5	2.3 fps	3.5		Run-of-River	Impoundment	140	n/a	n/a	YES	Cool	Full Netting	NO
				Propeller													Unit 2	
Station 26	NY	Genessee	3.0 MW	n/a	n/a	n/a	n/a	n/a	n/a	N/a	Impoundment	n/a	n/a	n/a	n/a	Cool	n/a	n/a
Little Quinnesec	WI	Menominee	9.1 MW	Francis	5	65	n/a	2	n/a	Peaking	Impoundment	349	3,000	n/a	n/a	Warm	No	n/a
			2,176	Horizontal	1@1,00 hp													
					2@1,400 hp													
					1 @ 2600 hp													
					1 @ 2800 hp													
				Vertical	1 @ 3240 hp													
Chalk Hill	WI	Menominee	7.8 MW	Kaplan	3	28	n/a	4.5	n/a	Peaking	Impoundment	n/a	n/a	n/a	n/a	Warm/cold	No	No
			3993 cfs															
Grand Rapids	WI	Menominee	7.02 MW	Francis	5	28	n/a	1.75	n/a	Peaking	Canal	n/a	n/a	n/a	n/a	Warm/cold	Partial	n/a
			3870 cfs		3 @1,700													
					1 @ 2,500													
					1 @ 2,400													
White Rapids	WI	Menominee	8.0 MW	Francis	3 units	29	1.9	2.5	23.9	Run of river	Impoundment	435	5,155	n/a	Yes	Warm/cold	Partial	YES
			3,994		2 @ 4,385													
					1 @ 3,100													
Park Mill	WI	Menominee	4.6 MW	V. Francis		16	2.06	3	16	Run of river	Impoundment	539	3788		n/a	Cool	Partial	YES
			2543 cfs														Netting of	
				H. Francis							Power Canal						Power Canal	
											2400 ft. long						for species	
Brule	WI	Brule	5.3 MW	Francis	3 @ 1760 kW	63	1	1.375	22 ft	Run of river	Impoundment	545	8,800		YES	Cool	Full Recovery	YES
			1500 cfs														on Two Units	
Upper	WI	Flambeau	0.9 MW	n/a	n/a		2	1.75	13.6	Run of River	Impoundment	431	3280	n/a	n/a	n/a	NO	Yes
			720 cfs															
Lower	WI	Flambeau	1.2 MW	n/a	n/a	n/a	1.7	3.5	12.2	Run of River	Impoundment	71	570	570	n/a	n/a	NO	Yes
			930 cfs															
Pixley	WI	Flambeau	.96 MW	n/a	n/a	n/a	2	1.75	16	Run of River	Impoundment	193	1757	n/a	n/a	n/a	NO	Yes
			675 cfs															

FISH ENTRAINMENT DATABASE																		
PROJECT	LOCATION			TURBINE CONFIGURATION			INTAKE PARAMETERS			OPERATION	IMPOUNDMENT/ POWER CANAL DATA				BIOLOGICAL DATA AVAILABLE			
Crowley	WI	Flambeau	1.74 MW	n/a	n/a	n/a	1.4	2.38	20.7	Run of River	Impoundment	422	3539	n/a	YES	Warm	Full Recovery	YES
			1480 cfs															
Thornapple	WI	Flambeau	1.4 MW	Propeller	2 @ 700 kW	15	1.22	1.69	13.1	Run of River	Impoundment	295	1000	n/a	YES	Warm	Full Recovery	NO
			1400 cfs														on One Unit	
Rothschild	WI	Wisconsin	3.64 MW	H. Francis	6 units	n/a	2.15	1.38	15	Run of River	Impoundment	1,604	13,900	n/a	YES	Warm	Full Recovery	NO
			3386 cfs														on Two Units	
				Vert. Propeller	1 unit													
Wis. River Div.	WI	Wisconsin	1.8 MW	Horizontal	9 units	20	n/a	n/a	19	Run of River	Impoundment	240	1,120	n/a	n/a	Warm	Full Recovery	NO
			5141 cfs	Francis	hydromechani cal						Mainstem of						Netting in	
											the Wisconsin						Tailrace	
				Tube	1 unit	22					River							
				Turbine	hydroelectric													
Centralia	WI	Wisconsin	3.2 MW	Vertical	4 @ 400 kW	15.5	n/a	3.5	n/a	Run of River	Impoundment	250	n/a	n/a	n/a	Warm/ cold	Full Recovery	NO
			3900 cfs	Francis													on Unit # 2	
											Power Canal						Vertical	
				Vertical	2 @ 800 kW	15.5					200 ft. long						Francis	
				Propeller														
Shawano	WI	Wolf	0.7 MW		1	18.5	1.48	5	16	Run of River	Impoundment	155	1,090	n/a	n/a	n/a	YES	YES
			835 cfs															
Townsend	PA	Beaver	5.0 MW								Impoundment	n/a	n/a	n/a			Full Recovery	
Youghiogheny	PA	Youghioghe ny									Impoundment	n/a	n/a	n/a			Full Recovery	
Dam #4	WV	Potomac	1.0 MW	Horizontal	2 @ 500 kW	17.3					Impoundment	n/a	n/a	n/a			Full Recovery	NO
			1082 cfs	Francis													on Unit # 1	
Millville	WV	Shenandoah	2.8 MW	Francis	1 @ 840 kW	22.4					Impoundment						Full Recovery	NO
			1970 cfs	Propeller	1 @ 1000 kW	24											on Unit # 1	
				Kaplan	1 @ 1000 kW	24											Francis	

APPENDIX B

SPECIES COMPOSITION OF ENTRAINED FISH
FROM
THE RICHARD B. RUSSELL ENTRAINMENT STUDY

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
						Based on number released			Based on number recovered			Based on number recovered		
Test		Species	Fish Size (mm)			Immediate	24 Hour	48 Hour	Immediate	24 Hour	48 Hour	Control Survival		
ID No.	Site Name	Tested	Min.	Max.	Avg.	Survival	Survival	Survival	Survival	Survival	Survival	Immediate	24 hour	48 hour
AC-01	Alcona	bluegill	122	206		1.028	1.028	1.000	1.000	1.000	0.973	1.000	1.000	1.000
AC-02	Alcona	bluegill	77	154		1.000	0.886	0.831	1.000	0.886	0.831	1.000	1.000	0.957
AC-03	Alcona	rainbow trout	223	345		1.182	1.182	1.136	0.929	0.929	0.893	1.000	1.000	1.000
AC-04	Alcona	rainbow trout	103	147		1.333	1.333	1.333	1.000	1.000	1.000	1.000	1.000	1.000
AC-05	Alcona	spottail shiner	81	128		0.825	0.871	0.520	0.943	0.995	0.594	1.000	0.775	0.625
AC-06	Alcona	yellow perch	74	171		1.008	1.120	0.968	1.008	1.120	0.968	0.909	0.818	0.818
AC-07	Alcona	bluegill	95	205		0.772	0.711	0.631	0.863	0.795	0.705	1.000	0.839	0.806
AC-08	Alcona	bluegill	58	133		0.736	0.855	0.842	0.780	0.906	0.893	1.000	0.817	0.717
AC-09	Alcona	golden shiner	101	188		0.837	0.805	0.995	0.909	0.874	1.080	0.973	0.946	0.730
AC-10	Alcona	golden shiner	65	129		0.902	0.837	0.777	0.939	0.871	0.809	1.000	0.984	0.984
AC-11	Alcona	northern pike	295	456		0.545	0.500	0.500	0.558	0.512	0.512	1.000	1.000	1.000
AC-12	Alcona	grass pickerel	177	293		0.967	0.900	0.867	0.967	0.900	0.867	1.000	1.000	1.000
AC-13	Alcona	walleye	132	361		1.106	0.922	0.447	0.956	0.796	0.386	1.000	0.921	0.921
AC-14	Alcona	walleye	99	254		0.951	1.839	1.404	0.899	1.739	1.328	0.615	0.135	0.096
AC-15	Alcona	white sucker	161	395		1.037	0.996	0.975	0.963	0.924	0.905	1.000	0.962	0.962
AC-16	Alcona	white sucker	111	278		0.883	0.897	0.962	0.883	0.897	0.962	1.000	0.967	0.883
AC-17	Alcona	yellow perch	75	241		0.581	0.641	0.513	0.625	0.689	0.551	1.000	0.907	0.907
AC-18	Alcona	yellow perch	68	171		0.565	0.484	0.484	0.452	0.387	0.387	1.000	0.083	0.083
BF-01	Bond Falls	rainbow trout	127	292					0.829	0.666	0.645	1.000	1.000	1.000
BF-02	Bond Falls	yellow perch	64	140					0.798	0.771	0.768	0.995	0.991	0.991
BF-03	Bond Falls	golden shiner	38	102					0.744	0.615	0.579	0.967	0.924	0.890
BF-04	Bond Falls	bluegill	38	191					0.816	0.752	0.781	0.984	0.959	0.900
BR-01	Buzzards Roost	bluegill	100	149					0.931	0.759	0.759	1.000	1.000	1.000
BR-02	Buzzards Roost	bluegill	150			1.000	0.870	0.870	1.000	0.870	0.870	1.000	1.000	1.000
BR-03	Buzzards Roost	bullhead spp	150	224		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
BR-04	Buzzards Roost	bullhead spp	225	300		0.774	0.774	0.774	0.774	0.774	0.774	1.000	1.000	1.000
BR-05	Buzzards Roost	bluegill	100	149		0.960	1.189	2.704	0.960	1.189	2.704	1.000	0.538	0.192
BR-06	Buzzards Roost	bluegill	150			0.893	0.771	3.375	0.893	0.771	3.375	1.000	0.741	0.148
BR-07	Buzzards Roost	white perch	150			0.923	1.615		0.923	1.615		1.000	0.500	
BR-08	Buzzards Roost	bluegill	100	149		0.931	3.966	1.970	0.931	3.966	1.970	1.000	0.200	0.280
BR-09	Buzzards Roost	bluegill	150			0.931	0.828	1.634	0.931	0.828	1.634	1.000	1.000	0.464
BR-10	Buzzards Roost	bullhead spp	150	224		0.963	0.963	0.963	0.963	0.963	0.963	1.000	1.000	1.000
CF-01	Caldron Falls	bluegill, bluegill x green sunfish hybrid	50	100		1.413	1.386	1.386	0.981	0.962	0.962	1.000	1.000	1.000
CF-02	Caldron Falls	bluegill, bluegill x green sunfish hybrid	50	100		0.935	0.947	1.038	0.924	0.936	1.026	0.769	0.731	0.615
CF-03	Caldron Falls	bluegill, bluegill x green sunfish hybrid	50	100		1.048	1.048	1.048	1.048	1.048	1.048	0.935	0.935	0.935
CF-04	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.820	0.794	0.741	0.883	0.855	0.798	0.900	0.900	0.900
CF-05	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.515	0.515	0.515	0.613	0.613	0.613	0.971	0.971	0.971
CF-06	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.956	0.956	0.969	0.991	0.991	1.005	0.964	0.964	0.929
CF-07	Caldron Falls	bluegill, bluegill x green sunfish hybrid	100	150		1.132	1.153	1.131	0.999	1.018	0.999	0.966	0.931	0.931
CF-08	Caldron Falls	bluegill, bluegill x green sunfish hybrid	100	150		0.803	0.843	0.890	0.906	0.951	1.004	1.000	0.920	0.840
CF-09	Caldron Falls	bluegill, bluegill x green sunfish hybrid	100	150		0.744	0.744	0.744	0.941	0.941	0.941	1.000	1.000	1.000
CF-10	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		1.191	1.191	1.108	0.945	0.945	0.879	0.875	0.875	0.875
CF-11	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.555	0.579	0.588	0.572	0.596	0.605	0.926	0.889	0.778
CF-12	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.934	0.934	0.912	0.974	0.974	0.951	0.939	0.939	0.939
CF-13	Caldron Falls	bluegill, bluegill x green sunfish hybrid	150	200		0.867	0.800	0.800	0.867	0.800	0.800	1.000	1.000	1.000
CF-14	Caldron Falls	bluegill, bluegill x green sunfish hybrid	150	200		0.934	0.934	0.885	0.934	0.934	0.885	1.000	1.000	1.000
CF-15	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.792	0.771	0.911	0.884	0.860	1.017	1.000	1.000	0.824
CF-16	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.320	0.320	0.200	0.333	0.333	0.208	1.000	1.000	1.000

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
CF-17	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.723	0.751	0.729	0.723	0.751	0.729	0.931	0.897	0.897
CF-18	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.800	0.783	0.767	0.800	0.783	0.767	1.000	1.000	1.000
CF-19	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.494	0.494	0.378	0.465	0.465	0.356	0.938	0.938	0.938
CF-20	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.784	0.757	0.730	0.784	0.757	0.730	1.000	1.000	1.000
CF-21	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.857	0.829	0.829	0.811	0.784	0.784	1.000	1.000	1.000
CF-22	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.675	0.675	0.638	0.450	0.450	0.425	0.909	0.909	0.909
CF-23	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.597	0.597	0.597	0.597	0.597	0.597	1.000	1.000	1.000
CF-24	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.530	0.507	0.461	0.469	0.449	0.408	1.000	1.000	1.000
CF-25	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.367	0.341	0.301	0.259	0.241	0.213	1.000	1.000	0.958
CF-26	Caldron Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.455	0.455	0.455	0.465	0.465	0.465	1.000	1.000	1.000
CH-01	Chalk Hill	bluegill	87	119	105.5	0.909		0.909	0.969		0.969	0.976		0.976
CH-02	Chalk Hill	bluegill	120	185	133.5	0.984		1.125	0.974		1.113	0.985		0.862
CH-03	Chalk Hill	white sucker/rainbow trout	78	159	131.5	0.854		0.864	0.912		0.923	0.985		0.910
CH-04	Chalk Hill	white sucker/rainbow trout	160	362	225.5	0.974		0.896	0.974		0.896	1.000		0.822
CT-01	Colton	white sucker	88	114					1.319			0.158		
CT-02	Colton	white sucker	115	148					0.635	0.721	0.641	1.000	0.720	0.540
CT-03	Colton	white sucker	152	344					0.567	0.376	0.232	1.000	0.842	0.719
CT-04	Colton	bluegill	74	189					0.044	0.000	0.000	0.707	0.244	0.171
CT-05	Colton	largemouth bass	96	199					0.956	0.077	0.042	0.981	0.404	0.250
CT-06	Colton	largemouth bass	200	257					0.356	0.337	0.000	1.000	0.653	0.286
CT-07	Colton	brook trout	71	113					0.670	0.678	0.667	1.000	0.941	0.941
CT-08	Colton	rainbow trout	164	254					0.339	0.321	0.250	1.000	1.000	1.000
CT-09	Colton	rainbow trout	262	358					0.065	0.059	0.061	0.958	0.792	0.771
CT-10	Colton	white sucker	70	119					0.536	0.686	0.802	0.957	0.532	0.404
CT-11	Colton	white sucker	120	263					0.284	0.280	0.292	1.000	0.960	0.920
CT-12	Colton	white sucker	225	333					0.128	0.118	0.118	1.000	0.980	0.980
CT-13	Colton	bluegill	56	108					0.082	0.028	0.000	0.938	0.458	0.438
CT-14	Colton	largemouth bass	146	199					0.000	0.000	0.000	1.000	0.900	0.880
CT-15	Colton	largemouth bass	225	334					0.000	0.000	0.000	0.960	0.800	0.780
CT-16	Colton	yellow perch	49	87					0.499	0.567	0.433	0.882	0.706	0.647
CT-17	Colton	walleye	136	219					0.092	0.084	0.099	0.940	0.820	0.700
CT-18	Colton	brook trout	75	117					0.735	0.699	0.687	1.000	1.000	1.000
CT-19	Colton	rainbow trout	152	250					0.472	0.404	0.363	0.978	0.913	0.804
CT-20	Colton	rainbow trout	270	355					0.302	0.180	0.084	1.000	0.971	0.941
CT-21	Colton	white sucker	69	102					0.966	1.097	1.185	0.810	0.643	0.595
CT-22	Colton	bluegill	67	106					0.296	0.104	0.056	0.980	0.620	0.580
CT-23	Colton	largemouth bass	150	202					0.111	0.014	0.014	1.000	1.000	1.000
CT-24	Colton	largemouth bass	177	295					0.025	0.025	0.000	1.000	1.000	0.980
CT-25	Colton	yellow perch	46	104					0.855	0.899	0.860	0.594	0.406	0.406
CT-26	Colton	walleye	141	205					0.323	0.269	0.176	1.000	1.000	0.979
CW-01	Conowingo	American shad	100	149	117.0	0.949		0.929	0.949		0.929	0.917		0.917
CD-01	Craggy Dam	channel catfish	145	220		0.889	0.889	0.873	0.903	0.903	0.887	1.000	1.000	1.000
CD-02	Craggy Dam	channel catfish	221	345		0.692	0.692	0.692	0.794	0.794	0.794	1.000	1.000	1.000
CD-03	Craggy Dam	channel catfish	103	220		0.860	0.860	0.860	0.925	0.925	0.925	1.000	1.000	1.000
CD-04	Craggy Dam	channel catfish	221	323		0.875	0.875	0.875	0.933	0.933	0.933	1.000	1.000	1.000
CD-05	Craggy Dam	bluegill	77	120		0.928			0.943			1.000		
CD-06	Craggy Dam	bluegill	121	210		0.801			0.864			1.000		
CS-01	Crescent	blueback herring	77	105	85.5	0.944	0.990	1.000	0.960	1.006	1.017	0.878	0.789	0.707
CL-01	Crowley	white sucker	86	132	109.2	0.979	1.024	1.100	1.000	1.046	1.124	1.000	0.894	0.638
CL-02	Crowley	white sucker	158	201	182.9	0.892	0.563	0.300	1.019	0.643	0.343	0.981	0.741	0.556
CL-03	Crowley	walleye	51	122	83.8	1.200	0.867	2.080	1.200	0.867	2.080	0.750	0.115	0.038
CL-04	Crowley	walleye	127	259	170.2	0.833	0.639	0.519	1.000	0.767	0.623	1.000	0.575	0.425
CL-05	Crowley	largemouth bass	69	102	86.4	0.941	0.980	0.980	0.980	1.020	1.020	1.000	0.800	0.380
EJW-01	E.J. West	bluegill		100		1.261		1.714	1.108		1.506	0.793		0.362
EJW-02	E.J. West	yellow perch		100		1.098		3.000	1.117		3.051	0.850		0.217
EJW-03	E.J. West	rainbow trout	100	250		1.020		1.000	0.945		0.927	1.000		1.000
EJW-04	E.J. West	rainbow trout		100		1.429		0.818	0.870		0.498	1.000		0.786
EJW-05	E.J. West	golden shiner	100	250		0.813		0.667	0.925		0.759	0.970		0.955

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
EJW-06	E.J. West	golden shiner		100		1.171		0.630	0.850		0.457	0.946		0.730
EJW-07	E.J. West	rainbow trout	250			0.746		0.746	0.932		0.932	0.983		0.983
EJW-08	E.J. West	largemouth bass	250			0.802		0.664	0.870		0.720	1.000		0.986
EJW-09	E.J. West	largemouth bass	100	250		0.800		0.750	0.955		0.896	1.000		0.966
EJW-10	E.J. West	bluegill		100		0.436		0.412	0.696		0.657	0.932		0.576
EJW-11	E.J. West	bluegill		100		0.209		0.238	0.592		0.675	0.985		0.618
EJW-12	E.J. West	largemouth bass	100	250		1.929		1.924	0.816		0.814	1.000		0.952
EJW-13	E.J. West	largemouth bass	250			0.944		0.427	1.053		0.476	0.950		0.300
EJW-14	E.J. West	yellow perch		100		0.952		1.261	0.856		1.133	0.792		0.434
EJW-15	E.J. West	yellow perch		100		1.810		2.000	1.329		1.469	0.583		0.361
EJW-16	E.J. West	rainbow trout		100		1.517		1.800	0.971		1.152	0.906		0.625
EJW-17	E.J. West	rainbow trout		100		0.854		1.000	0.874		1.024	0.953		0.721
EJW-18	E.J. West	rainbow trout	100	250		1.625		1.581	0.909		0.884	0.970		0.939
EJW-19	E.J. West	rainbow trout	250			1.526		1.600	0.935		0.981	1.000		0.789
EJW-20	E.J. West	white sucker		100		0.695		0.162	0.813		0.189	0.738		0.452
EJW-21	E.J. West	white sucker	100	250		0.625		0.541	0.773		0.668	0.984		0.689
EJW-22	E.J. West	white sucker	250			0.684		0.680	0.722		0.718	1.000		0.877
EJW-23	E.J. West	white sucker	250			0.799		1.250	0.767		1.200	1.000		0.528
FPU4-01	Finch Pruyn	smallmouth bass	101	190		0.939			0.949			1.000		
FPU4-02	Finch Pruyn	smallmouth bass	191	229		0.838			0.909			1.000		
FPU4-03	Finch Pruyn	smallmouth bass	230	305		0.954			0.926			1.000		
FPU5-01	Finch Pruyn	smallmouth bass	108	190		0.655			0.941			1.000		
FPU5-02	Finch Pruyn	smallmouth bass	191	229		0.706			0.815			1.000		
FPU5-03	Finch Pruyn	smallmouth bass	230	305		0.720			0.707			1.000		
FC-01	Five Channels	bluegill	120	192		0.583	0.530	0.401	0.944	0.859	0.649	1.000	0.971	0.941
FC-02	Five Channels	bluegill	72	131		1.762	1.850	1.875	1.000	1.050	1.064	1.000	0.952	0.762
FC-03	Five Channels	rainbow trout	275	360		1.775	1.775	1.775	0.700	0.700	0.700	1.000	1.000	1.000
FC-04	Five Channels	rainbow trout	69	137		0.852	0.852	0.852	0.958	0.958	0.958	1.000	1.000	1.000
FC-05	Five Channels	spottail shiner	68	132		0.411	0.274	0.822	1.030	0.687	2.061	0.971	0.529	0.088
FC-06	Five Channels	yellow perch	131	263		0.818	1.058	1.455	0.818	1.058	1.455	1.000	0.688	0.250
FC-07	Five Channels	yellow perch	68	187		0.919	4.960	9.920	0.943	5.091	10.182	0.964	0.179	0.071
FC-08	Five Channels	bluegill	113	244		1.002	1.002	0.984	0.967	0.967	0.950	1.000	1.000	1.000
FC-09	Five Channels	bluegill	73	189		0.964	0.927	0.944	0.930	0.895	0.911	1.000	1.000	0.982
FC-10	Five Channels	golden shiner	111	207		0.782	0.778	0.808	0.827	0.823	0.854	1.000	0.982	0.945
FC-11	Five Channels	golden shiner	62	153		0.900	0.846	0.752	0.980	0.921	0.818	1.000	0.958	0.958
FC-12	Five Channels	walleye	231	384		0.862	0.844	0.809	0.817	0.800	0.767	1.000	1.000	1.000
FC-13	Five Channels	walleye	62	153		0.896	0.734	0.764	0.836	0.685	0.713	1.000	0.982	0.893
FC-14	Five Channels	white sucker	209	442		0.770	0.770	0.748	0.735	0.735	0.714	1.000	1.000	1.000
FC-15	Five Channels	white sucker	81	241		0.791	0.791	0.801	0.875	0.875	0.886	1.000	1.000	0.964
FC-16	Five Channels	yellow perch	61	192		0.895	0.942	0.720	0.944	0.994	0.760	1.000	0.950	0.950
FC-17	Five Channels	northern pike	299	415		1.258	1.258	1.258	0.941	0.941	0.941	0.952	0.952	0.952
FL-01	Fourth Lake	alewife			96.4	1.333			0.873			0.879		
FL-02	Fourth Lake	alewife			97.2	0.676			0.897			0.943		
FL-03	Fourth Lake	alewife			95.6	0.770			0.845			0.913		
FL-04	Fourth Lake	alewife			95.2	0.675			0.802			0.943		
FL-05	Fourth Lake	alewife			96.1	0.539			0.707			0.900		
FL-06	Fourth Lake	alewife			97.5	0.506			0.851			0.340		
FL-07	Fourth Lake	alewife			96.4	0.583			0.875			0.833		
FL-08	Fourth Lake	Atlantic salmon			154.7	0.758			0.868			0.985		
FL-09	Fourth Lake	Atlantic salmon			152.2	0.944			0.849			0.987		
FL-10	Fourth Lake	Atlantic salmon			173.2	0.565			0.814			1.000		
FL-11	Fourth Lake	Atlantic salmon			169.2	0.669			0.695			0.986		
FL-12	Fourth Lake	Atlantic salmon			172.0	0.967			0.777			1.000		
FL-13	Fourth Lake	Atlantic salmon			170.5	0.747			0.754			0.943		
FL-14	Fourth Lake	Atlantic salmon			178.6	0.753			0.709			0.813		
FL-15	Fourth Lake	Atlantic salmon			178.7	0.628			0.691			0.971		
FL-16	Fourth Lake	Atlantic salmon			173.2	0.930			0.871			0.963		
FL-17	Fourth Lake	Atlantic salmon			170.1	0.691			0.705			0.955		
FL-18	Fourth Lake	Atlantic salmon			169.4	1.031			1.407			0.484		
GR-U1-01	Grand Rapids	bluegill	50	100					1.000	1.000	0.999	1.000	1.000	0.975
GR-U1-02	Grand Rapids	bluegill	101	150					0.982	0.930	0.929	1.000	1.000	0.982
GR-U1-03	Grand Rapids	bluegill	151	200					0.905	0.931	0.815	1.000	0.818	0.818
GR-U1-04	Grand Rapids	white sucker	50	100					0.980	0.980	0.980	1.000	1.000	1.000
GR-U1-05	Grand Rapids	white sucker	101	150					0.976	1.040	1.040	1.000	0.939	0.939
GR-U1-06	Grand Rapids	white sucker	151	200					0.978	1.000	1.000	1.000	0.933	0.911
GR-U1-07	Grand Rapids	white sucker	201	250					1.000	1.061	1.065	1.000	0.897	0.872
GR-U1-08	Grand Rapids	white sucker	251	325					1.000	1.000	0.994	1.000	1.000	0.958
GR-U1-09	Grand Rapids	white sucker	326						1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-10	Grand Rapids	bluegill	50	100					0.980	0.980	0.978	1.000	1.000	0.960
GR-U1-11	Grand Rapids	bluegill	101	150					1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-12	Grand Rapids	white sucker	50	100					1.000	1.000	0.955	1.000	1.000	1.000
GR-U1-13	Grand Rapids	white sucker	101	150					1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-14	Grand Rapids	white sucker	151	200					1.000	1.000	1.000	1.000	1.000	1.000
GR-U1-15	Grand Rapids	white sucker	201	250					1.000	0.979	0.958	1.000	1.000	1.000
GR-U1-16	Grand Rapids	white sucker	251	325					1.000	0.980	0.980	1.000	1.000	1.000
GR-U1-17	Grand Rapids	white sucker	326						1.000	0.933	0.911	1.000	1.000	1.000
GR-U1-18	Grand Rapids	bluegill	50	100					1.133	1.075	1.053	0.653	0.633	0.551
GR-U1-19	Grand Rapids	bluegill	101	150					1.343	1.419	1.870	0.686	0.608	0.451
GR-U1-20	Grand Rapids	bluegill	151	200					0.929	0.961	0.957	1.000	0.967	0.933
GR-U1-21	Grand Rapids	white sucker	50	100					1.121	1.101	1.071	0.737	0.711	0.711

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GR-U1-22	Grand Rapids	white sucker	101	150					0.999	1.020	1.042	0.980	0.960	0.940
GR-U1-23	Grand Rapids	white sucker	151	200					0.980	0.980	0.980	1.000	0.980	0.959
GR-U1-24	Grand Rapids	white sucker	201	250					0.907	0.888	0.829	0.980	0.939	0.939
GR-U1-25	Grand Rapids	white sucker	251	325					0.846	0.846	0.846	1.000	1.000	1.000
GR-U1-26	Grand Rapids	white sucker	326						0.913	0.913	0.913	1.000	1.000	1.000
GR-U2-01	Grand Rapids	bluegill	50	100					0.974	0.974	0.974	1.000	1.000	1.000
GR-U2-02	Grand Rapids	bluegill	101	150					0.981	0.981	0.925	1.000	1.000	1.000
GR-U2-03	Grand Rapids	bluegill	151	200					0.950	0.960	0.960	1.000	0.833	0.833
GR-U2-04	Grand Rapids	white sucker	50	100					1.000	2.182	2.343	1.000	0.458	0.417
GR-U2-05	Grand Rapids	white sucker	101	150					1.026	1.002	1.002	0.975	0.975	0.975
GR-U2-06	Grand Rapids	white sucker	151	200					1.029	0.957	0.987	0.971	0.943	0.914
GR-U2-07	Grand Rapids	white sucker	201	250					1.000	1.000	0.920	1.000	1.000	1.000
GR-U2-08	Grand Rapids	white sucker	251	325					0.974	1.035	1.041	1.000	0.941	0.912
GR-U2-09	Grand Rapids	white sucker	326						1.000	0.957	0.957	1.000	1.000	1.000
GR-U2-10	Grand Rapids	bluegill	50	100					0.978	0.978	0.957	1.000	1.000	1.000
GR-U2-11	Grand Rapids	bluegill	101	150					1.000	1.000	1.146	1.000	1.000	0.872
GR-U2-12	Grand Rapids	white sucker	50	100					1.000	1.000	0.978	1.000	1.000	0.957
GR-U2-13	Grand Rapids	white sucker	101	150					1.000	1.001	0.981	1.000	0.980	0.959
GR-U2-14	Grand Rapids	white sucker	151	200					1.000	1.000	1.000	1.000	1.000	1.000
GR-U2-15	Grand Rapids	white sucker	201	250					1.000	1.000	1.020	1.000	1.000	0.980
GR-U2-16	Grand Rapids	white sucker	251	325					1.000	1.000	1.000	1.000	1.000	1.000
GR-U2-17	Grand Rapids	bluegill	50	100					1.071	1.048	1.024	0.894	0.894	0.894
GR-U2-18	Grand Rapids	bluegill	101	150					0.980	1.048	0.933	1.000	0.896	0.875
GR-U2-19	Grand Rapids	bluegill	151	200					0.978	0.977	0.950	0.979	0.958	0.896
GR-U2-20	Grand Rapids	white sucker	50	100					0.974	0.879	0.900	0.918	0.898	0.878
GR-U2-21	Grand Rapids	white sucker	101	150					0.956	0.975	0.975	1.000	0.980	0.980
GR-U2-22	Grand Rapids	white sucker	151	200					0.957	0.936	0.996	1.000	1.000	0.940
GR-U2-23	Grand Rapids	white sucker	201	250					1.000	1.000	0.957	1.000	1.000	1.000
GR-U2-24	Grand Rapids	white sucker	326						0.689	0.623	0.556	0.978	0.978	0.978
GRU4-01	Grand Rapids	bluegill	50	100					0.840	0.758	0.712	0.900	0.880	0.780
GRU4-02	Grand Rapids	bluegill	101	150					0.960	0.940	0.940	1.000	1.000	1.000
GRU4-03	Grand Rapids	bluegill	151	200					0.884	0.884	0.952	0.980	0.980	0.840
GRU4-04	Grand Rapids	white sucker	50	100					1.067	1.091	1.116	0.938	0.917	0.896
GRU4-05	Grand Rapids	white sucker	101	150					1.000	1.000	0.980	1.000	1.000	1.000
GRU4-06	Grand Rapids	white sucker	151	200					0.979	0.958	0.978	1.000	1.000	0.980
GRU4-07	Grand Rapids	white sucker	201	250					0.961	0.960	0.960	1.000	0.980	0.980
GRU4-08	Grand Rapids	white sucker	251	325					0.827	0.750	0.731	1.000	1.000	1.000
GRU4-09	Grand Rapids	white sucker	326						0.783	0.739	0.674	1.000	1.000	1.000
GRU4-10	Grand Rapids	bluegill	50	100					1.053	0.994	0.877	0.380	0.380	0.380
GRU4-11	Grand Rapids	bluegill	101	150					1.103	0.923	0.789	0.796	0.796	0.776
GRU4-12	Grand Rapids	bluegill	151	200					0.938	0.872	0.810	1.000	0.980	0.900
GRU4-13	Grand Rapids	white sucker	50	100					1.097	1.059	1.100	0.563	0.563	0.542
GRU4-14	Grand Rapids	white sucker	101	150					0.895	0.895	0.895	0.980	0.980	0.980
GRU4-15	Grand Rapids	white sucker	151	200					0.848	0.865	0.865	1.000	0.980	0.980
GRU4-16	Grand Rapids	white sucker	201	250					0.860	0.816	0.816	1.000	0.980	0.980
GRU4-17	Grand Rapids	white sucker	251	325					0.900	0.900	0.900	1.000	1.000	1.000
GRU4-18	Grand Rapids	white sucker	326						0.880	0.796	0.829	1.000	0.980	0.941
HAFU1-01	Hadley Falls	American shad	55	110		1.039	1.333	1.714	1.039	1.333	1.714	0.770	0.390	0.140
HAFU1-02	Hadley Falls	American shad	55	110		0.973	0.816	0.286	0.973	0.816	0.286	0.750	0.380	0.140
HAFU2-01	Hadley Falls	American shad	55	110		0.890	0.659	0.750	0.890	0.659	0.750	0.833	0.342	0.233
HD-01	Hardy	bluegill	120	186		0.979	0.915	0.935	0.958	0.896	0.915	1.000	1.000	0.979
HD-02	Hardy	bluegill	79	149		0.769	0.673	0.709	0.971	0.850	0.896	1.000	0.975	0.925
HD-03	Hardy	golden shiner	113	204		1.219	1.128	1.128	0.958	0.886	0.886	1.000	0.846	0.846
HD-04	Hardy	golden shiner	74	165		1.067	0.909	0.930	0.980	0.835	0.854	1.000	0.978	0.956
HD-05	Hardy	largemouth bass	80	162		0.784	0.638	0.629	0.949	0.773	0.762	1.000	0.896	0.875
HD-06	Hardy	northern pike	319	437		0.820	0.708	0.708	0.880	0.760	0.760	1.000	1.000	1.000
HD-07	Hardy	rainbow trout	280	410		0.667	0.667	0.686	0.667	0.667	0.686	1.000	1.000	0.972
HD-08	Hardy	rainbow trout	81	135		0.634	0.654	0.620	0.731	0.754	0.715	1.000	0.969	0.969
HD-09	Hardy	walleye	148	638		0.833	0.833	0.806	0.800	0.800	0.773	0.969	0.938	0.938
HD-10	Hardy	white sucker	137	375		0.752	0.527	0.527	0.909	0.637	0.637	1.000	0.964	0.964
HD-11	Hardy	white sucker	96	237		1.180	1.180	1.180	0.769	0.769	0.769	1.000	1.000	1.000
HD-12	Hardy	yellow perch	123	293		0.855	0.852	0.834	0.980	0.976	0.955	1.000	0.983	0.983
HD-13	Hardy	yellow perch	85	173		0.900	0.842	0.789	0.947	0.886	0.831	1.000	0.950	0.950
HR-01	Herrings	bluegill	70	115		0.502		0.032	1.046		0.066	0.803		0.303
HR-02	Herrings	largemouth bass	163	343		0.471		0.333	0.611		0.432	1.000		0.900
HR-03	Herrings	yellow perch	72	115		1.751		1.832	1.081		1.130	0.872		0.821
HR-04	Herrings	walleye	162	258		0.616		0.556	0.752		0.678	0.903		0.710
HR-05	Herrings	golden shiner	85	175		4.174		4.749	1.381		1.571	0.600		0.200
HR-06	Herrings	white sucker	181	275		2.602		3.045	0.922		1.078	1.000		0.818
HR-07	Herrings	white sucker	271	370		0.432		0.370	0.610		0.522	0.911		0.821
HR-08	Herrings	rainbow trout	92	195		0.789		0.789	1.005		1.005	0.946		0.946
HR-09	Herrings	rainbow trout	118	281		0.767		0.743	0.873		0.846	1.000		0.976
HR-10	Herrings	rainbow trout	287	410		0.967		1.191	0.809		0.996	0.867		0.600
HR-11	Herrings	bluegill	83	139		0.833		1.046	1.017		1.277	0.983		0.712
HR-12	Herrings	largemouth bass	148	221		0.935		0.818	0.973		0.851	1.000		0.952
HR-13	Herrings	largemouth bass	186	251		1.201		1.096	0.932		0.850	1.000		0.935
HR-14	Herrings	walleye	83	137		0.973		1.260	1.013		1.311	0.911		0.489
HR-15	Herrings	rainbow trout	43	78		1.273		1.273	0.900		0.900	1.000		1.000
HR-16	Herrings	rainbow trout	178	217		17.878		17.878	0.875		0.875	1.000		1.000

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
HR-17	Herrings	bluegill	58	124		0.812		0.769	1.003		0.949	0.982		0.745
HR-18	Herrings	largemouth bass	136	246		0.403		0.370	1.000		0.919	1.000		0.961
HR-19	Herrings	largemouth bass	257	346		0.705		0.408	0.935		0.541	1.000		0.321
HR-20	Herrings	yellow perch	53	85		1.113		0.945	0.818		0.694	1.000		0.917
HR-21	Herrings	yellow perch	53	95		2.333		2.400	0.947		0.974	0.964		0.893
HR-22	Herrings	white sucker	73	93		0.846		0.517	0.814		0.497	1.000		0.889
HR-23	Herrings	white sucker	67	115		2.691		2.258	1.067		0.895	0.900		0.700
HR-24	Herrings	white sucker	139	260		0.904		0.672	0.966		0.719	1.000		0.707
HR-25	Herrings	white sucker	133	252		1.001		1.072	0.888		0.950	1.000		0.750
HR-26	Herrings	white sucker	147	355		0.710		0.583	0.884		0.726	1.000		0.839
HR-27	Herrings	white sucker	140	331		0.669		0.643	0.883		0.849	1.000		0.805
HR-28	Herrings	rainbow trout	63	160		1.446		1.929	0.783		1.043	1.000		0.625
HR-29	Herrings	rainbow trout	173	273		0.429		0.383	0.848		0.758	1.000		0.880
HR-30	Herrings	rainbow trout	280	365		0.325		0.233	1.000		0.718	1.000		0.750
HR-31	Herrings	American eel	466	690		0.591		0.554	0.821		0.769	1.000		1.000
HR-32	Herrings	bluegill	62	131		0.995		1.007	0.981		0.994	0.984		0.613
HR-33	Herrings	largemouth bass	150	235		0.915		1.013	0.964		1.067	1.000		0.836
HR-34	Herrings	largemouth bass	231	398		0.844		0.753	0.925		0.825	1.000		1.000
HR-35	Herrings	yellow perch	80	109		0.902		0.779	0.947		0.817	1.000		0.636
HR-36	Herrings	yellow perch	150	196		0.938		0.910	0.976		0.946	1.000		0.881
HR-37	Herrings	yellow perch	150	231		0.959		0.850	0.987		0.875	1.000		0.969
HR-38	Herrings	yellow perch	215	345		0.874		0.816	0.974		0.910	1.000		0.983
HR-39	Herrings	yellow perch	211	340		0.844		0.812	0.962		0.925	1.000		0.986
HR-40	Herrings	white sucker	60	96		0.748		0.644	0.982		0.846	1.000		0.912
HR-41	Herrings	white sucker	59	97		0.736		0.787	0.969		1.036	1.000		0.742
HR-42	Herrings	white sucker	149	200		0.791		0.702	0.900		0.798	1.000		0.710
HR-43	Herrings	white sucker	150	229		0.671		0.588	0.933		0.816	1.000		0.551
HR-44	Herrings	white sucker	230	403		0.878		0.809	0.878		0.809	1.000		0.783
HR-45	Herrings	white sucker	225	384		0.836		0.715	0.909		0.777	1.000		0.953
HR-46	Herrings	rainbow trout	60	78		1.220		1.220	0.955		0.955	1.000		1.000
HR-47	Herrings	rainbow trout	127	337		1.058		1.058	0.987		0.987	1.000		1.000
HR-48	Herrings	rainbow trout	221	355		0.867		0.934	0.986		1.062	1.000		0.929
HR-49	Herrings	alewife	69	116		0.966		4.337	0.907		4.070	1.000		0.043
HR-50	Herrings	alewife	67	133		0.889		1.136	0.946		1.209	0.988		0.100
HIF-01	High Falls	bluegill, bluegill x green sunfish hybrid	50	100		1.044	0.992	0.977	0.967	0.919	0.904	0.880	0.880	0.800
HIF-02	High Falls	bluegill, bluegill x green sunfish hybrid	50	100		0.931	0.931	0.931	0.955	0.955	0.955	0.963	0.963	0.963
HIF-03	High Falls	bluegill, bluegill x green sunfish hybrid	50	100		0.874	0.874	0.845	0.721	0.721	0.698	1.000	1.000	1.000
HIF-04	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.801	0.874	0.736	0.830	0.904	0.762	0.964	0.821	0.750
HIF-05	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.637	0.637	0.637	0.861	0.861	0.861	1.000	1.000	1.000
HIF-06	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		1.171	1.171	1.230	0.891	0.891	0.936	1.000	1.000	0.952
HIF-07	High Falls	bluegill, bluegill x green sunfish hybrid	100	150		0.735	0.735	0.724	0.745	0.745	0.733	1.000	1.000	0.929
HIF-08	High Falls	bluegill, bluegill x green sunfish hybrid	100	150		0.653	0.653	0.653	0.824	0.824	0.824	1.000	1.000	1.000
HIF-09	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.708	0.707	0.761	0.665	0.663	0.714	0.967	0.933	0.833
HIF-10	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.717	0.717	0.686	0.717	0.717	0.686	0.788	0.758	0.697
HIF-11	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.610	0.610	0.610	0.571	0.571	0.571	1.000	1.000	1.000
HIF-12	High Falls	bluegill, bluegill x green sunfish hybrid	150	200		1.350	1.250	1.150	0.614	0.568	0.523	1.000	1.000	1.000
HIF-13	High Falls	bluegill, bluegill x green sunfish hybrid	150	200		1.120	1.120	1.120	0.622	0.622	0.622	1.000	1.000	1.000
HIF-14	High Falls	bluegill, bluegill x green sunfish hybrid	150	200		0.974	0.974	0.974	0.613	0.613	0.613	1.000	1.000	1.000
HIF-15	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.429	0.395	0.406	0.481	0.442	0.455	1.000	1.000	0.973
HIF-16	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.601	0.578	0.511	0.528	0.508	0.449	1.000	0.966	0.966
HIF-17	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.511	0.523	0.535	0.511	0.523	0.535	0.978	0.957	0.935
HIF-18	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.473	0.798	0.468	0.585	0.987	0.580	0.964	0.571	0.929
HIF-19	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.436	0.410	0.427	0.378	0.356	0.370	1.000	1.000	0.962

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HIF-20	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.392	0.392	0.403	0.444	0.444	0.457	1.000	1.000	0.972
HIF-21	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.175	0.180	0.160	0.160	0.165	0.147	0.970	0.939	0.939
HIF-22	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.280	0.280	0.290	0.255	0.255	0.264	1.000	1.000	0.967
HIF-23	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.235	0.216	0.196	0.235	0.216	0.196	1.000	1.000	1.000
HIF-24	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.029	0.029	0.029	0.026	0.026	0.026	1.000	1.000	1.000
HIF-25	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.043	0.043	0.043	0.018	0.018	0.018	1.000	1.000	1.000
HIF-26	High Falls	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.089	0.089	0.089	0.063	0.063	0.063	1.000	1.000	1.000
HL-01	Higley	brook trout	67	116					0.915	0.734	0.707	1.000	1.000	0.978
HL-02	Higley	rainbow trout	160	260					0.746	1.124	1.124	1.000	0.263	0.263
HL-03	Higley	rainbow trout	255	378					0.354	0.927	0.829	1.000	0.250	0.250
HL-04	Higley	rainbow trout	255	336					0.386	0.381	0.381	1.000	0.525	0.525
HL-05	Higley	white sucker	72	110					0.907	0.630	0.644	1.000	0.979	0.957
HL-06	Higley	yellow perch	47	93					0.919	0.410	0.385	0.927	0.561	0.561
HL-07	Higley	walleye	134	205					0.531	0.459	0.448	0.857	0.690	0.619
HL-08	Higley	walleye	142	207					0.501	0.403	0.418	0.714	0.592	0.571
HL-09	Higley	brook trout	71	110					0.765	0.721	0.691	1.000	0.979	0.894
HL-10	Higley	rainbow trout	145	250					0.511	0.444	0.582	1.000	1.000	0.688
HL-11	Higley	white sucker	73	90					0.714	0.549	0.549	1.000	0.953	0.953
HL-12	Higley	white sucker	140	211					0.690	0.633	0.713	0.980	0.939	0.796
HL-13	Higley	white sucker	187	326					0.429	0.446	0.373	1.000	0.960	0.920
HL-14	Higley	bluegill	49	79					0.851	0.877	0.828	1.000	0.783	0.739
HL-15	Higley	largemouth bass	92	216					0.392	0.342	0.234	1.000	1.000	0.974
HL-16	Higley	largemouth bass	182	312					0.375	0.304	0.277	1.000	1.000	0.967
HL-17	Higley	yellow perch	56	71					0.966	0.859	0.795	1.000	0.963	0.889
HL-18	Higley	golden shiner	63	106					0.416	0.000	0.000	0.233	0.163	0.163
HL-19	Higley	white sucker	110	147					0.901	0.709	0.734	0.745	0.723	0.681
HL-20	Higley	white sucker	150	267					0.543	0.503	0.430	0.950	0.833	0.800
HL-21	Higley	bluegill	81	147					0.697	0.899	0.801	0.763	0.395	0.342
HL-22	Higley	largemouth bass	121	194					0.073	0.059	0.045	0.830	0.811	0.811
HL-23	Higley	largemouth bass	195	269					0.127	0.116	0.068	0.604	0.264	0.226
HL-24	Higley	yellow perch	72	107					0.913	0.000	0.000	0.095	0.048	0.048
HOI-01	Hoist	brown trout	61	110		0.255			0.452			1.000		
HOI-02	Hoist	brook trout	111	160		0.320			0.436			1.000		
HOI-03	Hoist	brown trout	161	281		0.207			0.228			1.000		
HOI-04	Hoist	bluegill	51	80		0.075			0.168			0.993		
HOI-05	Hoist	bluegill	81	150		0.500			0.765			1.000		
HB-01	Hollidays Bridge	bluegill	102	152		1.000	1.007	0.860	1.000	1.007	0.860	1.000	0.840	0.760
HB-02	Hollidays Bridge	bluegill	153			1.000	0.880	0.840	1.000	0.880	0.840	1.000	1.000	1.000
HB-03	Hollidays Bridge	catfish spp	152	228		1.000	1.042	1.087	1.000	1.042	1.087	1.000	0.960	0.920
HB-04	Hollidays Bridge	catfish spp	229	305		1.000	1.042	1.087	1.000	1.042	1.087	1.000	0.960	0.920
HB-05	Hollidays Bridge	catfish spp	152	228		1.000	0.929	0.929	1.000	0.929	0.929	1.000	1.000	1.000
HB-06	Hollidays Bridge	catfish spp	229	305		1.000	0.960	0.960	1.000	0.960	0.960	1.000	1.000	1.000
HWU10-01	Holtwood	American shad	93	163	113.7	0.875	0.764	0.600	0.894	0.780	0.613	0.926	0.758	0.526
HWU3-01	Holtwood	American shad	85	144	109.7	0.768	0.629	0.550	0.835	0.683	0.598	0.938	0.875	0.800
LG-01	Lower Granite	chinook salmon	107	188	134.0	0.946		0.940	0.957		0.951	0.983		0.966
LG-02	Lower Granite	chinook salmon	110	238	150.0	0.952			0.949			0.994		
LG-03	Lower Granite	chinook salmon	110	238	150.0	0.956			0.953			0.994		
LG-04	Lower Granite	chinook salmon	110	238	150.0	0.978			0.978			0.994		
LG-05	Lower Granite	chinook salmon	110	238	150.0	0.984			0.975			0.994		
LG-06	Lower Granite	chinook salmon	110	238	150.0	0.968			0.972			0.996		
LG-07	Lower Granite	chinook salmon	110	238	150.0	0.946			0.946			1.000		
MNU3-01	Minetto	bluegill	60	116		0.720		0.680	0.881		0.832	1.000		0.789
MNU3-02	Minetto	largemouth bass	141	310		0.864		0.802	0.988		0.918	1.000		0.988
MNU3-03	Minetto	largemouth bass	165	348		1.035		0.909	0.965		0.847	1.000		0.889
MNU3-04	Minetto	yellow perch	64	119		1.076		0.809	0.944		0.710	1.000		0.821
MNU3-05	Minetto	white sucker	65	102		1.857		2.217	1.029		1.229	0.900		0.467
MNU3-06	Minetto	white sucker	110	215		0.539		0.590	0.906		0.991	1.000		0.800
MNU3-07	Minetto	white sucker	170	280		1.107		0.913	0.988		0.815	1.000		0.767
MNU3-08	Minetto	rainbow trout	52	87		0.857		0.840	0.944		0.926	1.000		1.000
MNU3-09	Minetto	rainbow trout	157	224		0.868		0.893	0.989		1.018	1.000		0.931
MNU3-10	Minetto	rainbow trout	240	404		1.004		0.671	0.895		0.598	1.000		0.323
MNU3-11	Minetto	alewife	121	149		0.722		0.402	0.871		0.485	0.988		0.679

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MNU3-12	Minetto	alewife	67	115		0.634		0.135	0.728		0.155	0.853		0.293
MNU3-13	Minetto	alewife	63	176		0.813		0.498	0.750		0.459	0.667		0.118
MNU3-14	Minetto	alewife	110	174		0.809		0.736	0.853		0.775	0.955		0.478
MNU3-15	Minetto	alewife	112	144		1.022		0.860	0.972		0.818	0.951		0.617
MNU4-01	Minetto	bluegill	52	102		0.623		0.267	0.974		0.417	1.000		0.758
MNU4-02	Minetto	largemouth bass	150	217		0.970		0.806	0.887		0.737	0.984		0.969
MNU4-03	Minetto	largemouth bass	236	323		0.783		0.653	1.000		0.834	1.000		0.985
MNU4-04	Minetto	yellow perch	47	93		0.714		0.668	0.957		0.894	1.000		0.778
MNU4-05	Minetto	walleye	132	216		0.620		0.631	1.000		1.018	1.000		0.757
MNU4-06	Minetto	walleye	135	210		1.087		1.030	1.000		0.948	1.000		0.851
MNU4-07	Minetto	white sucker	69	111		0.638		0.620	0.933		0.907	1.000		0.857
MNU4-08	Minetto	white sucker	68	105		0.953		0.802	0.880		0.740	1.000		1.000
MNU4-09	Minetto	white sucker	141	260		0.816		0.758	0.961		0.893	0.970		0.924
MNU4-10	Minetto	white sucker	212	302		0.856		0.844	0.885		0.874	1.000		1.000
MNU4-11	Minetto	rainbow trout	50	81		0.582		0.527	1.000		0.906	1.000		1.000
MNU4-12	Minetto	rainbow trout	145	274		0.857		0.780	0.957		0.871	1.000		1.000
MNU4-13	Minetto	rainbow trout	239	334		0.898		0.873	0.943		0.917	1.000		0.966
MNU4-14	Minetto	rainbow trout	243	327		1.025		0.978	0.961		0.917	0.980		0.980
MNU4-15	Minetto	American eel	400	705		0.662		0.620	1.000		0.936	1.000		1.000
NNI-01	Ninety-Nine Islands	bluegill	102	152		1.000	0.916	0.759	1.000	0.916	0.759	1.000	0.840	0.760
NNI-02	Ninety-Nine Islands	bluegill	153			1.000	0.964	0.929	1.000	0.964	0.929	1.000	1.000	1.000
NNI-03	Ninety-Nine Islands	catfish spp	152	228		1.000	0.889	0.889	1.000	0.889	0.889	1.000	1.000	1.000
NNI-04	Ninety-Nine Islands	catfish spp	229	305		0.962	0.923	0.885	0.962	0.923	0.885	1.000	1.000	1.000
NNI-05	Ninety-Nine Islands	bluegill	102	152		1.000	0.962	1.183	1.000	0.962	1.183	1.000	0.680	0.520
NNI-06	Ninety-Nine Islands	bluegill	153			0.893	0.714	0.643	0.893	0.714	0.643	1.000	1.000	1.000
NNI-07	Ninety-Nine Islands	catfish spp	152	228		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
NNI-08	Ninety-Nine Islands	catfish spp	229	305		1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
PTG-01	Peshtigo	bluegill, bluegill x green sunfish hybrid	50	100		0.962	0.962	0.974	0.957	0.957	0.970	1.000	1.000	0.966
PTG-02	Peshtigo	bluegill, bluegill x green sunfish hybrid	50	100		0.979	0.979	0.979	1.048	1.048	1.048	0.955	0.955	0.955
PTG-03	Peshtigo	bluegill, bluegill x green sunfish hybrid	50	100		0.930	0.930	0.930	1.000	1.000	1.000	1.000	1.000	1.000
PTG-04	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.767	0.767	0.715	0.862	0.862	0.803	0.897	0.897	0.846
PTG-05	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		1.001	1.001	1.009	1.036	1.036	1.044	0.944	0.944	0.917
PTG-06	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.762	0.770	0.779	0.971	0.982	0.994	1.000	0.960	0.920
PTG-07	Peshtigo	bluegill, bluegill x green sunfish hybrid	100	150		1.122	1.122	1.122	1.000	1.000	1.000	1.000	1.000	1.000
PTG-08	Peshtigo	bluegill, bluegill x green sunfish hybrid	100	150		0.991	1.027	0.978	0.977	1.013	0.965	1.000	0.964	0.964
PTG-09	Peshtigo	bluegill, bluegill x green sunfish hybrid	100	150		0.811	0.811	0.811	1.000	1.000	1.000	1.000	1.000	1.000
PTG-10	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.848	0.848	0.789	0.915	0.915	0.852	0.939	0.939	0.939
PTG-11	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.964	0.924	1.094	0.920	0.881	1.043	0.969	0.938	0.750
PTG-12	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.672	0.672	0.672	0.962	0.962	0.962	1.000	1.000	1.000
PTG-13	Peshtigo	bluegill, bluegill x green sunfish hybrid	150	200		1.070	1.044	1.044	1.000	0.976	0.976	1.000	1.000	1.000
PTG-14	Peshtigo	bluegill, bluegill x green sunfish hybrid	150	200		0.840	0.907	0.993	0.909	0.982	1.075	1.000	0.895	0.789
PTG-15	Peshtigo	bluegill, bluegill x green sunfish hybrid	150	200		1.123	1.123	1.123	1.000	1.000	1.000	1.000	1.000	1.000
PTG-16	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.940	0.926	0.851	0.940	0.926	0.851	1.000	0.972	0.917
PTG-17	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.990	0.941	0.933	1.009	0.959	0.951	0.972	0.944	0.833
PTG-18	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.988	0.988	1.102	0.993	0.993	1.108	0.967	0.967	0.867
PTG-19	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		1.138	1.138	1.129	1.012	1.012	1.004	0.968	0.968	0.935
PTG-20	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.981	0.962	0.967	0.981	0.962	0.967	1.000	1.000	0.957

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
PTG-21	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.864	0.864	0.864	0.896	0.896	0.896	1.000	1.000	1.000
PTG-22	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.684	0.703	0.684	0.765	0.785	0.765	0.974	0.949	0.949
PTG-23	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.996	0.972	1.065	0.894	0.872	0.955	1.000	1.000	0.913
PTG-24	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.938	0.938	0.938	0.864	0.864	0.864	1.000	1.000	1.000
PTG-25	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.700	0.700	0.700	0.708	0.708	0.708	1.000	1.000	1.000
PTG-26	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			1.211	1.339	1.413	0.825	0.912	0.962	0.955	0.864	0.818
PTG-27	Peshtigo	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.604	0.604	0.604	0.806	0.806	0.806	1.000	1.000	1.000
PRU1-01	Potato Rapids	bluegill, bluegill x green sunfish hybrid	50	100		1.319	1.477	1.204	1.322	1.480	1.206	0.545	0.424	0.424
PRU1-02	Potato Rapids	bluegill, bluegill x green sunfish hybrid	50	100		0.947	0.929	0.924	0.842	0.826	0.821	0.625	0.542	0.417
PRU1-03	Potato Rapids	bluegill, bluegill x green sunfish hybrid	50	100		1.031	1.031	1.071	1.123	1.123	1.166	0.871	0.871	0.839
PRU1-04	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.632	0.615	0.631	0.860	0.837	0.859	1.000	1.000	0.975
PRU1-05	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		1.098	1.025	1.001	1.023	0.955	0.932	0.880	0.880	0.880
PRU1-06	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		1.150	1.145	1.049	1.048	1.044	0.957	0.742	0.710	0.677
PRU1-07	Potato Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.727	0.706	0.876	0.728	0.707	0.877	0.865	0.838	0.676
PRU1-08	Potato Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.432	0.432	0.425	0.800	0.800	0.788	1.000	1.000	0.964
PRU1-09	Potato Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.694	0.723	0.680	0.919	0.957	0.901	1.000	0.960	0.960
PRU1-10	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.598	0.598	0.567	0.676	0.676	0.640	0.938	0.938	0.938
PRU1-11	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.713	0.618	0.738	0.713	0.618	0.738	0.957	0.957	0.739
PRU1-12	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.800	0.776	0.822	0.818	0.793	0.841	0.897	0.897	0.793
PRU1-13	Potato Rapids	bluegill, bluegill x green sunfish hybrid	150	200		0.475	0.475	0.459	0.853	0.853	0.824	1.000	1.000	1.000
PRU1-14	Potato Rapids	bluegill, bluegill x green sunfish hybrid	150	200		0.371	0.371	0.361	0.857	0.857	0.835	1.000	1.000	0.970
PRU1-15	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.621	0.669	0.669	0.611	0.658	0.658	0.966	0.897	0.897
PRU1-16	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.569	0.525	0.554	0.553	0.511	0.538	1.000	1.000	0.909
PRU1-17	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.543	0.598	0.642	0.747	0.822	0.883	0.971	0.882	0.765
PRU1-18	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.498	0.498	0.496	0.591	0.591	0.588	1.000	1.000	0.966
PRU1-19	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.606	0.586	0.587	0.588	0.569	0.569	1.000	1.000	0.964
PRU1-20	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.679	0.743	0.658	0.692	0.757	0.671	1.000	0.889	0.889
PRU1-21	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.563	0.343	0.314	0.788	0.480	0.440	0.889	0.833	0.833
PRU1-22	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.545	0.545	0.583	0.558	0.558	0.597	1.000	1.000	0.897

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
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PRU1-23	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.500	0.500	0.514	0.521	0.521	0.536	1.000	1.000	0.972
PRU1-24	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.383	0.342	0.350	0.362	0.324	0.331	0.902	0.882	0.863
PRU1-25	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.394	0.375	0.357	0.389	0.370	0.352	1.000	1.000	1.000
PRU1-26	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.234	0.256	0.227	0.333	0.364	0.323	1.000	0.917	0.917
PRU2-01	Potato Rapids	bluegill, bluegill x green sunfish hybrid	50	100		0.964	0.964	0.946	0.982	0.982	0.964	1.000	1.000	1.000
PRU2-02	Potato Rapids	bluegill, bluegill x green sunfish hybrid	50	100		0.845	0.854	0.808	0.986	0.997	0.943	0.906	0.875	0.813
PRU2-03	Potato Rapids	bluegill, bluegill x green sunfish hybrid	50	100		0.871	0.812	0.812	0.947	0.882	0.882	0.941	0.912	0.912
PRU2-04	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.840	0.779	0.553	0.915	0.848	0.603	0.974	0.974	0.974
PRU2-05	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		1.455	1.499	1.548	0.930	0.958	0.990	0.947	0.895	0.842
PRU2-06	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.999	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000
PRU2-07	Potato Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.901	0.901	0.735	0.925	0.925	0.755	1.000	1.000	1.000
PRU2-08	Potato Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.395	0.378	0.378	1.030	0.983	0.983	0.971	0.971	0.971
PRU2-09	Potato Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.881	0.857	0.857	0.881	0.857	0.857	1.000	1.000	1.000
PRU2-10	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.590	0.629	0.297	0.697	0.744	0.352	1.000	0.897	0.690
PRU2-11	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.614	0.592	0.310	0.741	0.714	0.374	0.900	0.833	0.700
PRU2-12	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.904	0.888	0.986	0.904	0.888	0.986	0.914	0.857	0.771
PRU2-13	Potato Rapids	bluegill, bluegill x green sunfish hybrid	150	200		1.019	0.983	0.948	0.983	0.948	0.914	1.000	1.000	1.000
PRU2-14	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.855	0.912	0.805	0.855	0.912	0.805	0.970	0.909	0.727
PRU2-15	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.734	0.537	0.496	0.780	0.571	0.527	0.885	0.846	0.654
PRU2-16	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.778	0.738	0.747	0.778	0.738	0.747	0.969	0.938	0.906
PRU2-17	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.730	0.730	0.496	0.730	0.730	0.496	0.971	0.971	0.882
PRU2-18	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.640	0.620	0.500	0.769	0.745	0.602	0.929	0.821	0.679
PRU2-19	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.804	0.760	0.738	0.820	0.776	0.753	0.914	0.886	0.857
PRU2-20	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.435	0.435	0.435	0.513	0.513	0.513	1.000	1.000	0.800
PRU2-21	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.681	0.709	0.689	0.762	0.794	0.771	1.000	0.900	0.833
PRU2-22	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.617	0.467	0.466	0.627	0.475	0.474	1.000	1.000	0.966
PRU2-23	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.287	0.287	0.280	0.280	0.280	0.273	0.893	0.893	0.500
PRU2-24	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.575	0.521	0.461	0.542	0.492	0.435	1.000	1.000	0.935
PRU2-25	Potato Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.714	0.595	0.625	0.714	0.595	0.625	1.000	1.000	0.952
PK-01	Prickett	bluegill	25	75		0.889	0.919	1.063	0.976	1.010	1.168	0.968	0.691	0.287
PK-02	Prickett	bluegill	76	125		0.935	0.818	1.686	0.925	0.809	1.667	1.000	0.583	0.153

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PK-03	Prickett	bluegill	126			0.947	0.529	0.545	0.857	0.479	0.494	1.000	0.895	0.579
PK-04	Prickett	white sucker	125	200		0.707	0.653	0.617	0.699	0.645	0.610	0.969	0.917	0.490
PK-05	Prickett	white sucker	201			0.476	0.267	0.222	0.357	0.200	0.167	1.000	0.714	0.429
PK-06	Prickett	golden shiner	50	100		1.471	1.369	1.538	0.929	0.865	0.972	0.867	0.867	0.600
RRU3-01	Rocky Reach	chinook salmon	99	201		0.939		0.927	0.939		0.927	0.989		0.977
RRU3-02	Rocky Reach	chinook salmon	99	201		0.947		0.951	0.947		0.951	0.988		0.984
RRU5-01	Rocky Reach	chinook salmon			182.0	0.973		0.973	0.973		0.973	1.000		1.000
RRU5-02	Rocky Reach	chinook salmon			180.0	0.982		0.977	0.986		0.982	1.000		0.991
RRU5-03	Rocky Reach	chinook salmon			182.3	0.987		1.009	0.976		0.998	0.989		0.955
RRU5-04	Rocky Reach	chinook salmon			180.7	0.915		0.931	0.899		0.913	1.000		0.984
RRU5-05	Rocky Reach	chinook salmon			181.2	0.978		0.978	0.976		0.976	0.987		0.987
RRU5-06	Rocky Reach	chinook salmon			182.6	0.941		0.929	0.952		0.940	1.000		1.000
RRU6-01	Rocky Reach	chinook salmon			182.2	0.912		0.888	0.912		0.888	1.000		1.000
RRU6-02	Rocky Reach	chinook salmon			180.6	0.984		0.981	0.976		0.972	1.000		0.991
RRU6-03	Rocky Reach	chinook salmon			182.7	0.983		1.010	0.962		0.988	1.000		0.966
RRU6-04	Rocky Reach	chinook salmon			180.0	0.965		0.980	0.932		0.948	1.000		0.984
RRU6-05	Rocky Reach	chinook salmon			180.6	0.978		0.978	0.965		0.965	0.987		0.987
RRU6-06	Rocky Reach	chinook salmon			182.7	0.960		0.960	0.973		0.973	1.000		1.000
RRU8-01	Rocky Reach	chinook salmon	90	170	114.0	0.962		0.953	0.932		0.924	0.933		0.933
RG-01	Rogers	bluegill	112	185		0.906	0.865	1.031	0.906	0.865	1.031	1.000	0.867	0.667
RG-02	Rogers	bluegill	46	85		0.870	0.932	0.932	0.932	0.999	0.999	1.034	0.966	0.966
RG-03	Rogers	rainbow trout	228	401					0.800		0.720	1.000		1.000
RG-04	Rogers	rainbow trout	57	158					0.967		0.900	1.000		1.000
RG-05	Rogers	spottail shiner	58	174					0.806		1.262	1.000		0.563
RG-06	Rogers	yellow perch	27	156					0.933		0.929	1.000		0.969
RG-07	Rogers	bluegill	108	178		0.898	0.847	0.831	0.962	0.908	0.890	0.983	0.983	0.983
RG-08	Rogers	bluegill	84	155		1.343	1.377	1.278	0.989	1.014	0.941	0.976	0.952	0.952
RG-09	Rogers	golden shiner	103	173		0.583	0.583	0.549	0.984	0.984	0.926	0.960	0.960	0.960
RG-10	Rogers	golden shiner	68	114		1.118	0.996	0.643	0.932	0.830	0.536	1.000	0.980	0.980
RG-11	Rogers	largemouth bass	76	139		0.813	0.795	0.786	0.800	0.782	0.774	1.000	1.000	0.964
RG-12	Rogers	northern pike	248	420		1.049	1.049	0.942	0.929	0.929	0.833	1.000	1.000	1.000
RG-13	Rogers	walleye	155	600					0.947		0.862	1.000		0.946
RG-14	Rogers	white sucker	162	413					0.940		0.860	1.000		1.000
RG-15	Rogers	white sucker	82	219					0.875		0.812	1.000		0.955
RG-16	Rogers	yellow perch	131	310					0.929		0.881	1.000		1.000
RG-17	Rogers	yellow perch	98	169					0.956		0.911	1.000		1.000
SHU7-01	Safe Harbor	American shad	95	140	113.0	0.980	0.980	1.024	0.980	0.980	1.024	1.000	1.000	0.838
SHU9-01	Safe Harbor	American shad	99	129	111.0	0.978	1.000	1.106	0.978	1.000	1.106	1.000	0.685	0.511
SHU9-02	Safe Harbor	American shad	100	138	117.0	0.948	0.967	0.667	0.958	0.978	0.674	1.000	0.724	0.541
SS-01	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	50	100		0.759	0.689	0.668	0.886	0.804	0.779	1.000	0.960	0.880
SS-02	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	50	100		0.895	0.895	0.930	0.962	0.962	1.001	1.000	1.000	0.943
SS-03	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	50	100		1.044	1.044	1.044	1.044	1.044	1.044	0.941	0.941	0.941
SS-04	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.676	0.676	0.417	0.818	0.818	0.504	1.000	1.000	0.767
SS-05	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.481	0.401	0.342	0.777	0.647	0.552	0.966	0.966	0.793
SS-06	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	50	100		0.535	0.535	0.515	0.994	0.994	0.958	0.971	0.971	0.971
SS-07	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.877	0.704	0.580	0.896	0.719	0.593	0.808	0.769	0.538
SS-08	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.885	0.885	0.879	0.920	0.920	0.914	1.000	1.000	0.941
SS-09	Sandstone Rapids	bluegill, bluegill x green sunfish hybrid	100	150		0.706	0.706	0.706	0.878	0.878	0.878	1.000	1.000	1.000
SS-10	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.936	0.887	0.455	0.959	0.908	0.466	0.967	0.967	0.733
SS-11	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.369	0.403	0.422	0.600	0.655	0.686	0.867	0.733	0.467
SS-12	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	100	150		0.901	0.879	0.879	0.901	0.879	0.879	0.971	0.971	0.971
SS-13	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.833	0.817	0.755	0.833	0.817	0.755	1.000	0.952	0.810
SS-14	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.840	0.840	0.816	0.814	0.814	0.791	1.000	1.000	1.000
SS-15	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.745	0.686	0.504	0.745	0.686	0.504	1.000	1.000	0.778
SS-16	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.753	0.816	0.906	0.842	0.912	1.013	0.839	0.710	0.581

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
SS-17	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	150	200		0.839	0.843	0.828	0.839	0.843	0.828	1.000	0.974	0.949
SS-18	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.603	0.580	0.538	0.619	0.595	0.552	1.000	1.000	0.862
SS-19	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.864	0.818	0.832	0.905	0.857	0.872	1.000	1.000	0.929
SS-20	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	200	250		0.743	0.743	0.758	0.717	0.717	0.731	1.000	1.000	0.929
SS-21	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.292	0.243	0.233	0.273	0.227	0.218	1.000	1.000	0.833
SS-22	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.659	0.659	0.659	0.794	0.794	0.794	1.000	1.000	1.000
SS-23	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	250	325		0.519	0.519	0.534	0.583	0.583	0.601	1.000	1.000	0.971
SS-24	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.579	0.521	0.516	0.545	0.491	0.486	1.000	1.000	0.973
SS-25	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.405	0.381	0.357	0.424	0.399	0.374	0.955	0.955	0.955
SS-26	Sandstone Rapids	fathead minnow, creek chub, white sucker, golden/shorthead redhorse	325			0.584	0.584	0.611	0.537	0.537	0.562	0.957	0.957	0.913
STC-01	Schaghticoke	brook trout	250			0.228		0.245	0.170		0.182	0.983		0.914
STC-02	Schaghticoke	brook trout	100	250		0.000		0.000	0.000		0.000	0.905		0.703
STC-03	Schaghticoke	largemouth bass	100	250		0.418		0.415	0.314		0.311	0.917		0.883
STC-04	Schaghticoke	brook trout		100		0.506		0.486	0.433		0.416	0.966		0.862
STC-05	Schaghticoke	golden shiner		100		0.531		0.483	0.617		0.561	0.985		0.923
STC-06	Schaghticoke	white sucker	100	250		0.503		0.405	0.516		0.415	0.928		0.594
STC-07	Schaghticoke	white sucker		100		0.471		0.492	0.615		0.643	1.000		0.897
STC-08	Schaghticoke	bluegill		100		0.382		0.294	0.414		0.318	0.984		0.852
STC-09	Schaghticoke	largemouth bass	250			0.268		0.250	0.254		0.238	0.982		0.912
STC-10	Schaghticoke	yellow perch		100		0.508		0.540	0.501		0.532	0.913		0.725
STC-11	Schaghticoke	brook trout	250			0.061		0.063	0.045		0.047	0.846		0.821
STC-12	Schaghticoke	white sucker	250			0.328		0.309	0.349		0.330	0.906		0.859
STC-13	Schaghticoke	white sucker	250			0.115		0.118	0.137		0.140	0.936		0.915
STC-14	Schaghticoke	largemouth bass	250			0.154		0.108	0.189		0.133	0.743		0.529
STC-15	Schaghticoke	largemouth bass	250			0.000		0.000	0.000		0.000	0.824		0.608
STC-16	Schaghticoke	brook trout	100	250		0.209		0.197	0.224		0.211	0.882		0.868
STC-17	Schaghticoke	white sucker	100	250		0.319		0.175	0.295		0.161	0.945		0.863
STC-18	Schaghticoke	white sucker	100	250		0.265		0.223	0.296		0.249	0.756		0.686
STC-19	Schaghticoke	largemouth bass	100	250		0.692		0.900	0.666		0.865	0.520		0.400
STC-20	Schaghticoke	walleye	100	250		0.436		0.444	0.382		0.389	0.786		0.257
STC-21	Schaghticoke	brook trout		100		0.806		0.770	0.737		0.704	0.969		0.953
STC-22	Schaghticoke	brook trout	100	250		0.500		0.397	0.427		0.338	0.969		0.906
STC-23	Schaghticoke	bluegill		100		0.420		0.233	0.491		0.272	0.908		0.566
STC-24	Schaghticoke	yellow perch		100		0.758		0.751	0.791		0.784	0.900		0.800
STC-25	Schaghticoke	yellow perch		100		0.585		0.549	0.764		0.717	0.828		0.797
SC-01	Stevens Creek	blueback herring	131	203	165.0	1.019	1.010	0.993	0.967	0.959	0.943	1.000	1.000	1.000
SC-02	Stevens Creek	sunfish spp	85	115		0.974	1.053	1.057	0.974	1.053	1.057	0.981	0.907	0.778
SC-03	Stevens Creek	sunfish spp	116	192		0.938	0.909	0.976	0.938	0.909	0.976	1.000	0.964	0.804
SC-04	Stevens Creek	yellow perch/spotted sucker	80	245	165.0	0.983	0.966	0.972	0.983	0.966	0.972	0.983	0.975	0.883
TS-01	Townsend	largemouth bass	76	127		1.000	1.000	1.000	1.000	1.000	1.000	0.980	0.980	0.980
TS-02	Townsend	largemouth bass	203	229		0.860	0.860	0.860	0.860	0.860	0.860	1.000	1.000	1.000
TS-03	Townsend	rainbow trout	127	152		0.944			0.944			1.000		
TS-04	Townsend	rainbow trout	330	356		0.919	0.919	0.919	1.000	1.000	1.000	1.000	1.000	1.000
TBU1-01	Twin Branch	bluegill	81	171		1.231		1.202	0.973		0.950	1.000		0.971
TBU5-01	Twin Branch	chinook/channel catfish	81	161		0.986		0.963	1.000		0.976	1.000		1.000
TBU5-02	Twin Branch	chinook/channel catfish	81	161		0.970		0.815	0.986		0.829	1.000		0.903
TBU5-03	Twin Branch	steelhead/channel catfish	141	231		0.703		0.656	0.862		0.804	1.000		0.950
VNU10-01	Vernon	Atlantic salmon	110	214	153.0	0.959		0.949	1.000		0.989	1.000		1.000
VNU10-02	Vernon	Atlantic salmon	110	208	156.0	1.013		1.013	1.000		1.000	1.000		1.000
VNU4-01	Vernon	Atlantic salmon	110	208	148.0	0.851		0.851	0.840		0.840	1.000		1.000
WNP-01	Wanapum	coho salmon	120	200	156.5	0.897		0.897	0.897		0.897	0.988		0.981
WNP-02	Wanapum	coho salmon	120	200	156.0	0.949		0.955	0.949		0.955	0.988		0.981
WNP-03	Wanapum	coho salmon	120	200	154.2	0.935		0.942	0.924		0.930	0.994		0.987
WNP-04	Wanapum	coho salmon	120	200	154.0	0.981		0.987	0.968		0.975	0.994		0.987
WNP-05	Wanapum	coho salmon	120	200	151.9	0.942		0.942	0.948		0.948	0.987		0.987
WNP-06	Wanapum	coho salmon	120	200	151.2	1.006		1.006	1.000		1.000	0.987		0.987
WNP-07	Wanapum	coho salmon	120	200	155.2	0.868		0.873	0.885		0.890	1.000		0.994

Fish Mortality Studies From Other Hydroelectric Projects (EPRI 1997)														
TEST ID INFO						SURVIVAL ESTIMATES								
WNP-08	Wanapum	coho salmon	120	200	154.3	0.962		0.962	0.968		0.968	1.000		0.994
WR-01	White Rapids	bluegill	60	119	82.0	0.944		1.022	0.945		1.024	1.000		0.852
WR-02	White Rapids	bluegill	120	190	138.0	0.957		0.967	1.000		1.011	1.000		0.676
WR-03	White Rapids	white sucker	74	149	114.0	1.018		1.000	1.009		0.992	0.941		0.882
WR-04	White Rapids	white sucker	150	257	176.5	0.991		1.023	0.930		0.960	1.000		0.932
WD-01	Wilder	Atlantic salmon	162	220	187.1	0.960	0.943	0.943	0.960	0.943	0.943	1.000	0.984	0.984

Appendix M

APPENDIX C

FISH MORTALITY STUDIES FROM OTHER HYDROELECTRIC PROJECTS

Species Composition of Entrained Fish From the Richard B. Russel Entrainment Study												
Common Name	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
Northern Hogsucker	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Silver Redhorse	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Black Crappie	0.02	0.00	0.11	0.37	5.29	17.49	1.87	0.71	0.00	0.00	0.06	0.04
Coosa Bass	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Largemouth Bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.00	0.00
Smallmouth Bass	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spotted Bass	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.08	0.00	0.00	0.01	0.00
White Crappie	0.00	0.00	0.00	1.15	0.07	1.61	0.06	0.13	0.00	0.00	0.00	0.00
Blueback Herring	10.09	3.52	21.22	29.50	41.18	30.84	8.51	24.18	5.22	24.15	0.79	1.07
Gizzard Shad	0.01	0.00	0.06	0.04	0.00	0.07	0.50	0.07	0.16	0.37	0.02	0.04
Threadfin Shad	86.80	95.52	17.05	17.03	1.70	15.14	64.41	66.44	78.33	28.02	94.99	83.70
Carp	0.00	0.00	0.00	0.06	0.03	0.24	0.94	0.05	0.09	1.71	0.00	0.03
Golden Shiner	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spottail Shiner	0.06	0.01	0.58	0.41	0.31	0.19	0.00	0.00	0.00	0.00	0.00	0.23
Whitefin Shiner	0.00	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Walleye	0.00	0.00	0.00	0.01	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
Black Bullhead	0.00	0.00	0.02	0.10	0.00	0.21	0.00	0.26	0.00	0.00	0.00	0.00
Brown Bullhead	0.00	0.00	0.02	0.00	0.13	0.08	2.37	0.00	5.81	0.93	0.03	6.14
Channel Catfish	0.01	0.00	0.00	0.03	0.53	0.08	0.08	0.23	0.21	0.10	0.84	0.11
Flathead Catfish	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.10	0.09	0.05
Snail Bullhead	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05
White Catfish	0.11	0.02	0.40	0.22	0.72	1.01	1.11	1.50	5.02	39.81	2.65	3.80
Yellow Bullhead	0.02	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00
Longnose Gar	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
Hybrid Bass	0.00	0.00	0.11	0.08	0.13	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Striped Bass	0.00	0.00	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Bass	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Perch	0.00	0.01	0.83	4.70	9.14	0.94	0.07	0.00	0.04	0.00	0.04	0.00
Blackbanded Darter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tesselated Darter	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Yellow Perch	2.78	0.90	59.09	41.45	38.70	28.76	15.68	3.16	2.68	3.13	0.34	4.36
Bluegill	0.07	0.01	0.48	4.35	1.73	2.97	3.41	3.12	2.36	1.60	0.12	0.32
Green Sunfish	0.00	0.00	0.00	0.01	0.02	0.11	0.06	0.00	0.00	0.00	0.00	0.00
Redbreast Sunfish	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00
Warmouth	0.01	0.00	0.00	0.13	0.12	0.00	0.00	0.04	0.06	0.00	0.00	0.03
Total	**100.00**	**100.00**	**100.00**	**99.82**	**100.00**	**100.00**	**99.93**	**100.00**	**100.00**	**100.00**	**100.00**	**99.99**

Winter Size Composition of Entrained Fish From the Richard B. Russell Entrainment Study																		
Name	1 in. 0-25 mm	2 26-50	3 51-75	4 76-100	5 101-125	6 126-150	7 151-175	8 176-200	9 201-225	10 226-250	10-12 251-300	12-16 301-400	16-20 401-500	20-24 501-600	24-28 601-700	28-32 701-800	32-36 801-900	Total Percent
black bullhead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
black crappie	0.00	0.00	13.37	37.43	10.70	6.68	0.00	13.37	11.76	0.00	6.68	0.00	0.00	0.00	0.00	0.00	0.00	99.99
blackbanded darter	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
blueback herring	0.00	0.00	2.16	35.92	28.21	13.68	15.31	4.45	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
bluegill	0.00	9.67	13.93	20.51	25.90	16.44	12.57	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
brown bullhead	0.00	0.00	7.14	35.71	14.29	7.14	0.00	14.29	0.00	7.14	14.29	0.00	0.00	0.00	0.00	0.00	0.00	100.00
common carp	0.00	40.00	0.00	0.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	100.00
channel catfish	0.00	4.37	5.72	7.70	5.46	5.43	11.00	20.54	27.87	5.13	5.13	1.64	0.00	0.00	0.00	0.00	0.00	99.99
Coosa bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
flathead catfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
gizzard shad	0.00	0.00	1.41	5.63	25.35	40.85	5.63	7.04	1.41	0.00	5.63	5.63	1.41	0.00	0.00	0.00	0.00	99.99
golden shiner	0.00	0.00	34.40	42.66	11.47	0.00	0.00	11.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
green sunfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hybrid bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	100.00
largemouth bass	0.00	0.00	0.00	48.19	0.00	0.00	0.00	0.00	0.00	0.00	24.10	0.00	27.71	0.00	0.00	0.00	0.00	100.00
longnose gar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	100.00
northern hogsucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00	33.33	33.33	0.00	0.00	0.00	0.00	0.00	0.00	99.99
redbreast sunfish	0.00	14.63	4.88	14.63	29.27	2.44	29.27	4.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
silver redhorse	0.00	0.00	25.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	100.00
smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
snail bullhead	0.00	0.00	1.54	15.38	36.92	21.54	9.23	6.15	1.54	6.15	1.54	0.00	0.00	0.00	0.00	0.00	0.00	99.99
spottail shiner	0.00	0.00	3.42	78.81	17.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
spotted bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
striped bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
tesselated darter	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
threadfin shad	0.30	80.30	18.74	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
walleye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	100.00
warmouth	0.00	0.00	44.44	0.00	0.00	27.78	27.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00
white catfish	0.00	11.57	21.61	20.61	10.65	12.99	12.92	2.47	4.04	0.52	2.62	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white crappie	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white perch	0.00	0.00	0.00	74.27	0.00	18.60	0.00	0.00	0.00	0.00	0.00	7.13	0.00	0.00	0.00	0.00	0.00	100.00
whitefin shiner	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
yellow bullhead	0.00	0.00	0.00	31.06	0.00	0.00	0.00	31.06	0.00	37.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.01
yellow perch	0.00	1.92	15.21	43.72	31.57	5.53	1.19	0.56	0.11	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	99.98

Spring Size Composition of Entrained Fish From the Richard B. Russell Entrainment Study																	
Name	1 in. 0-25 mm	2 26-50	3 51-75	4 76-100	5 101-125	6 126-150	7 151-175	8 176-200	9 201-225	10 226-250	10-12 251-300	12-16 301-400	16-20 401-500	20-24 501-600	24-28 601-700	28-32 701-800	32-36 801-900	Total Percent
black bullhead	0.00	0.00	0.00	44.39	0.00	0.00	55.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
black crappie	0.00	0.00	54.84	30.45	8.82	2.98	0.88	0.93	0.00	0.86	0.23	0.00	0.00	0.00	0.00	0.00	0.00	99.99
blackbanded darter	0.00	33.33	66.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
blueback herring	0.00	0.00	0.74	3.30	10.60	93.71	0.79	0.40	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	109.55
bluegill	0.00	28.61	43.49	14.93	4.32	4.34	3.01	1.01	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
brown bullhead	0.00	0.00	4.10	20.50	8.20	4.10	0.00	16.69	10.00	4.10	32.31	0.00	0.00	0.00	0.00	0.00	0.00	100.00
common carp	0.00	19.42	0.00	0.00	9.71	0.00	0.00	0.00	9.71	0.00	0.00	0.00	41.75	19.42	0.00	0.00	0.00	100.01
channel catfish	9.62	11.32	13.53	11.29	3.09	9.27	12.43	16.56	7.66	3.09	0.00	2.13	0.00	0.00	0.00	0.00	0.00	99.99
Coosa bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00
flathead catfish	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
gizzard shad	0.00	1.29	0.00	11.22	15.44	11.58	9.01	9.01	14.15	6.43	1.29	18.01	2.57	0.00	0.00	0.00	0.00	100.00
golden shiner	0.00	0.00	17.28	21.13	19.25	15.40	7.70	15.40	3.85	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.01
green sunfish	0.00	33.33	33.33	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
hybrid bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.61	10.83	67.98	17.59	0.00	0.00	0.00	100.01
largemouth bass	0.00	50.00	10.00	30.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
longnose gar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
northern hogsucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
redbreast sunfish	0.00	15.53	8.63	19.31	22.43	5.18	25.47	3.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
silver redhorse	0.00	0.00	9.09	0.00	0.00	0.00	0.00	9.09	0.00	0.00	0.00	36.36	36.36	9.09	0.00	0.00	0.00	99.99
smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25.00	25.00	0.00	25.00	25.00	0.00	0.00	0.00	0.00	100.00
snail bullhead	0.00	0.00	1.32	14.47	36.84	21.05	14.47	3.95	1.32	5.26	1.32	0.00	0.00	0.00	0.00	0.00	0.00	100.00
spottail shiner	0.00	1.74	10.63	39.68	45.16	2.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
spotted bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
striped bass	0.00	0.00	0.00	0.00	21.62	11.68	0.00	0.00	0.00	0.00	0.00	9.53	57.17	0.00	0.00	0.00	0.00	100.00
tesselated darter	0.00	44.71	55.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
threadfin shad	0.15	30.06	43.65	21.87	4.05	0.18	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
walleye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
warmouth	0.00	0.00	13.62	50.00	13.62	6.81	10.64	5.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.01
white bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	100.00
white catfish	1.73	10.73	37.41	16.43	9.66	6.63	3.85	3.92	4.82	0.96	3.85	0.00	0.00	0.00	0.00	0.00	0.00	99.99
white crappie	0.00	0.00	64.16	15.92	15.83	2.16	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white perch	0.00	0.00	0.44	10.38	32.27	15.09	34.28	5.98	0.37	0.86	0.23	0.11	0.00	0.00	0.00	0.00	0.00	100.01
whitefin shiner	0.00	34.97	17.48	47.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
yellow bullhead	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
yellow perch	0.00	0.02	27.96	30.48	21.28	15.46	2.88	1.69	0.18	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	100.00

Summer Size Composition of Entrained Fish From the Richard B. Russell Entrainment Study																	
Name	1 in. 0-25 mm	2 26-50	3 51-75	4 76-100	5 101-125	6 126-150	7 151-175	8 176-200	9 201-225	10 226-250	10-12 251-300	12-16 301-400	16-20 401-500	20-24 501-600	24-28 601-700	28-32 701-800	32-36 801-900	Total Percent
black bullhead	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
black crappie	0.00	0.00	17.88	69.97	9.18	2.35	0.31	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
blackbanded darter	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
blueback herring	0.00	0.71	43.19	9.78	3.39	24.34	8.71	7.73	2.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
bluegill	1.94	17.52	40.61	14.97	4.88	7.55	6.50	4.97	0.74	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.00	100.00
brown bullhead	0.00	0.98	15.19	11.10	11.48	3.36	7.14	6.72	2.02	3.36	36.29	2.38	0.00	0.00	0.00	0.00	0.00	100.02
common carp	0.00	6.13	0.00	0.00	3.06	0.00	0.00	0.00	3.06	0.00	0.00	49.39	34.83	0.00	3.52	0.00	0.00	99.99
channel catfish	0.00	2.62	8.64	10.79	8.84	4.37	13.11	13.11	22.49	7.28	5.83	1.46	0.00	1.46	0.00	0.00	0.00	100.00
Coosa bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
flathead catfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
gizzard shad	0.00	1.45	0.00	10.14	7.25	7.25	11.59	1.45	5.80	7.25	21.74	21.74	4.35	0.00	0.00	0.00	0.00	100.01
golden shiner	0.00	0.00	22.22	22.22	11.11	0.00	11.11	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
green sunfish	0.00	0.00	66.67	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
hybrid bass	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
largemouth bass	3.70	70.37	11.11	11.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	99.99
longnose gar	0.00	0.00	0.00	0.00	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
northern hogsucker	0.00	0.00	0.00	0.00	0.00	59.35	0.00	0.00	0.00	40.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
redbreast sunfish	0.00	11.42	9.51	20.09	24.73	3.81	26.64	3.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.01
silver redhorse	0.00	0.00	25.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	100.00
smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
snail bullhead	0.00	0.00	4.46	14.26	34.22	22.81	8.56	4.28	1.43	5.70	2.85	1.43	0.00	0.00	0.00	0.00	0.00	100.00
spottail shiner	0.00	6.40	55.44	30.79	7.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.01
spotted bass	0.00	65.04	34.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
striped bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
tesselated darter	0.00	16.67	83.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
threadfin shad	0.00	3.93	73.41	22.53	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.01
walleye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
warmouth	0.00	0.00	0.00	88.88	0.00	0.00	11.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
white catfish	0.00	2.12	23.32	14.27	20.06	16.19	8.88	4.64	5.81	0.59	3.53	0.59	0.00	0.00	0.00	0.00	0.00	100.00
white crappie	0.00	5.03	32.76	39.33	19.74	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white perch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
whitefin shiner	0.00	29.76	29.76	40.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
yellow bullhead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
yellow perch	0.00	0.00	3.16	53.36	28.56	13.06	1.60	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	99.99

Fall Size Composition of Entrained Fish From the Richard B. Russell Entrainment Study																	
Name	1 in. 0-25 mm	2 26-50	3 51-75	4 76-100	5 101-125	6 126-150	7 151-175	8 176-200	9 201-225	10 226-250	10-12 251-300	12-16 301-400	16-20 401-500	20-24 501-600	24-28 601-700	28-32 701-800	32-36 801-900	Total Percent
black bullhead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
black crappie	0.00	0.00	0.00	10.83	22.69	0.00	5.41	0.00	35.30	16.24	9.53	0.00	0.00	0.00	0.00	0.00	0.00	100.00
blackbanded darter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
blueback herring	0.00	0.00	5.74	3.65	0.45	18.26	50.41	20.03	1.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
bluegill	0.49	12.75	8.33	9.31	11.76	22.06	22.55	11.27	1.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
brown bullhead	0.00	0.00	9.74	9.04	40.39	20.55	7.96	7.10	2.17	1.02	1.31	0.72	0.00	0.00	0.00	0.00	0.00	100.00
common carp	0.00	20.83	0.00	0.00	10.42	0.00	0.00	0.00	10.42	0.00	0.00	0.00	22.40	0.00	23.96	11.98	0.00	100.01
channel catfish	0.00	2.16	6.80	7.18	32.87	15.19	10.56	10.56	6.61	4.80	2.03	1.24	0.00	0.00	0.00	0.00	0.00	100.00
Coosa bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
flathead catfish	0.00	0.00	0.00	0.00	0.00	60.03	0.00	19.98	0.00	19.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
gizzard shad	0.00	0.00	3.93	4.43	23.65	13.30	0.00	8.87	14.78	7.39	16.26	5.91	1.48	0.00	0.00	0.00	0.00	100.00
golden shiner	0.00	7.69	30.77	23.08	7.69	0.00	0.00	23.08	7.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
green sunfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hybrid bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
largemouth bass	0.00	0.00	0.00	32.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.26	51.22	0.00	0.00	0.00	0.00	100.00
longnose gar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
northern hogsucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
redbreast sunfish	0.00	19.35	6.45	9.68	22.58	8.06	25.81	8.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
silver redhorse	0.00	0.00	25.00	0.00	0.00	0.00	0.00	25.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	100.00
smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
snail bullhead	0.00	0.00	1.43	15.71	34.29	21.43	11.43	4.29	1.43	8.57	1.43	0.00	0.00	0.00	0.00	0.00	0.00	100.01
spottail shiner	0.00	0.00	0.00	50.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
spotted bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
striped bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
tesselated darter	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
threadfin shad	0.00	54.84	37.05	8.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.96
walleye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
warmouth	0.00	0.00	76.19	0.00	0.00	0.00	23.81	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white bass	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	66.67	0.00	0.00	0.00	0.00	0.00	100.00
white catfish	0.00	0.98	6.87	15.51	19.51	23.01	17.30	10.30	5.12	1.02	0.31	0.08	0.00	0.00	0.00	0.00	0.00	100.01
white crappie	0.00	0.00	50.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
white perch	0.00	0.00	0.00	0.00	0.00	0.00	20.85	36.82	15.97	7.99	18.37	0.00	0.00	0.00	0.00	0.00	0.00	100.00
whitefin shiner	0.00	36.36	18.18	36.36	9.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	99.99
yellow bullhead	0.00	0.00	6.32	10.16	40.28	34.32	7.17	0.00	0.41	0.87	0.47	0.00	0.00	0.00	0.00	0.00	0.00	100.00
yellow perch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Average Size Composition of Entrained fish from the Richard B. Russell Entrainment Study																	
Name	1 in. 0-25 mm	2 26-50	3 51-75	4 76-100	5 101-125	6 126-150	7 151-175	8 176-200	9 201-225	10 226-250	10-12 251-300	12-16 301-400	16-20 401-500	20-24 501-600	24-28 601-700	28-32 701-800	32-36 801-900
black bullhead	0.00	0.00	0.00	35.36	20.33	0.00	44.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
black crappie	0.00	0.00	15.68	17.47	10.86	5.53	7.96	2.99	14.99	17.62	6.90	0.00	0.00	0.00	0.00	0.00	0.00
blackbanded darter	0.00	10.00	90.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
blueback herring	0.00	5.51	11.08	15.31	3.08	41.27	23.36	0.35	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
bluegill	0.43	14.95	18.64	10.36	12.56	16.78	15.84	9.29	1.01	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brown bullhead	0.00	12.50	4.55	10.83	12.16	6.01	2.04	5.30	0.71	2.08	43.54	0.29	0.00	0.00	0.00	0.00	0.00
common carp	0.00	13.33	0.00	0.00	6.67	0.00	0.00	0.00	6.67	0.00	0.00	16.06	19.63	33.33	3.24	1.08	0.00
channel catfish	0.00	2.49	16.72	20.82	10.80	3.88	3.88	8.92	9.43	3.52	10.05	0.63	0.53	8.33	0.00	0.00	0.00
Coosa bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
flathead catfish	0.00	0.00	0.00	0.00	0.00	13.01	3.75	4.33	0.00	4.33	44.39	30.18	0.00	0.00	0.00	0.00	0.00
gizzard shad	0.00	0.42	8.24	13.79	22.29	20.63	5.26	6.00	7.59	4.15	2.86	6.69	2.08	0.00	0.00	0.00	0.00
golden shiner	0.00	4.00	25.96	26.23	7.14	3.81	11.90	19.05	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
green sunfish	44.05	39.29	8.33	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
hybrid bass	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	1.75	5.25	34.48	8.52	0.00	0.00	0.00
largemouth bass	0.65	19.84	2.58	21.29	0.65	0.00	0.00	0.00	0.00	0.00	6.67	5.00	43.33	0.00	0.00	0.00	0.00
longnose gar	0.00	0.00	0.00	0.00	25.00	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00
northern hogsucker	0.00	0.00	0.00	0.00	0.00	25.00	0.00	25.00	0.00	25.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00
redbreast sunfish	0.00	8.96	14.22	18.22	8.80	14.37	31.68	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
silver redhorse	0.00	0.00	8.33	0.00	0.00	0.00	0.00	8.33	0.00	0.00	0.00	50.00	26.67	6.67	0.00	0.00	0.00
smallmouth bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.67	16.67	0.00	33.33	33.33	0.00	0.00	0.00	0.00
snail bullhead	0.00	0.00	20.31	14.13	11.50	18.38	8.88	20.94	0.31	3.25	2.31	0.00	0.00	0.00	0.00	0.00	0.00
spottail shiner	0.00	0.80	33.04	48.67	16.68	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
spotted bass	0.00	54.51	29.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.20	0.00	0.00	0.00	0.00	0.00	0.00
striped bass	0.00	0.00	0.00	0.00	9.76	5.27	0.00	0.00	0.00	4.86	50.00	4.30	25.80	0.00	0.00	0.00	0.00
tesselated darter	0.00	21.43	78.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
threadfin shad	0.07	24.53	24.58	21.78	28.69	0.30	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
walleye	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00
warmouth	0.00	0.00	16.02	21.01	10.22	2.75	41.67	8.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
white bass	0.00	0.00	0.00	0.00	0.00	0.00	33.33	0.00	0.00	0.00	0.00	66.67	0.00	0.00	0.00	0.00	0.00
white catfish	0.02	0.50	2.11	21.23	10.45	12.25	13.72	7.38	14.97	1.88	9.94	5.56	0.00	0.00	0.00	0.00	0.00
white crappie	0.00	0.55	53.86	10.72	8.56	0.88	25.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
white perch	0.00	0.00	0.21	5.50	15.92	7.83	16.62	28.00	25.18	0.41	0.22	0.10	0.00	0.00	0.00	0.00	0.00
whitefin shiner	0.00	31.25	16.07	49.11	3.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
yellow bullhead	0.00	0.00	0.00	4.25	0.00	50.00	4.25	0.00	5.18	36.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
yellow perch	0.00	1.06	9.30	10.52	11.28	28.62	9.46	18.24	10.52	0.49	0.51	0.00	0.00	0.00	0.00	0.00	0.00

Appendix N
Representative Wildlife in the Harris Project Vicinity

Table 1: BIRD SPECIES POTENTIALLY OCCURRING IN THE HARRIS PROJECT VICINITY

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Anatidae	Canada Goose	*Branta Canadensis*	X	Fairly common in all seasons	Freshwater marshes, agricultural fields, and on lakes
Anatidae	Wood Duck	*Aix sponsa*	X	Common in all seasons	Wooded swamps, beaver ponds, bottomlands, creeks, and lakes
Anatidae	Gadwall	*Anas strepera*		Fairly common in winter and uncommon in fall and spring	Shallow freshwater ponds and lakes with abundant aquatic vegetation
Anatidae	American Wigeon	*Anas Americana*		Fairly common in winter, spring, and fall	Shallow freshwater ponds and lakes with abundant aquatic vegetation
Anatidae	Mallard	*Anas platyrhynchos*	X	Common in winter, fairly common in spring and fall, and uncommon in summer	Shallow water of ponds, lakes, and flooded fields
Anatidae	Blue-winged Teal	*Anas discors*		Common to fairly common in spring and fall	Shallow freshwater ponds, sloughs, creeks, and on lake mudflats
Anatidae	Northern Shoveler	*Anas clypeata*		Common in winter, spring and fall	Freshwater ponds, swamps, and on lakes
Anatidae	Northern Pintail	*Anas acuta*		Fairly common in winter, spring, and fall	Freshwater marshes, agricultural fields, and shallow portions of lakes, ponds, and rivers
Anatidae	Green-winged Teal	*Anas cerci*		Common in winter, spring, and fall	Shallow freshwater marshes, and on creeks, lakes, and mudflats
Anatidae	Ring-necked Duck	*Aythya collaris*		Common in winter, early spring, and late fall	Shallow, wooded, freshwater ponds, swamps, and lakes
Anatidae	Lesser Scaup	*Aythya affinisthrus*		Fairly common in winter, spring, and fall	Larger lakes and rivers
Anatidae	Bufflehead	*Bucephala albeola*		Common in winter, early spring, and late fall	Larger lakes and slow-moving rivers
Anatidae	Hooded Merganser	*Lophodytes cucullatus*	X	Fairly common in winter, spring, and fall, and rare in summer	Wooded freshwater ponds, lakes, and slow water river systems
Anatidae	Ruddy Duck	*Oxyura jamaicensis*		Fairly common in winter	Freshwater ponds, lakes, and slow-moving rivers
Phasianidae	Wild Turkey	*Meleagris gallopavo*	X	Fairly common in all seasons	Forested and partially forested habitats

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Odontophoridae	Northern Bobwhite	*Colinus virginianus*	X	Fairly common in all seasons in early successional habitats	Farms, along woodland edges, recently cut-over forest land, and in open country habitats dominated by old fields
Podicipedidae	Pied-billed Grebe	*Podilymbus podiceps*	X	Fairly common in spring, winter, and fall	Lakes and marshy ponds
Phalacrocoracidae	Double-crested Cormorant	*Phalacrocorax auritus*		Fairly common in fall, winter, and spring and uncommon in summer	Larger lakes, ponds, and rivers
Ardeidae	Great Blue Heron	*Ardea herodias*	X	Common in all seasons	Shallow water of ponds, lakes, and rivers
Ardeidae	Great Egret	*Ardea alba*	X	Common to fairly common in spring, summer, but uncommon to rare in winter	Shallow water of ponds, lakes, and rivers
Ardeidae	Little Blue Heron	*Egretta caerulea*	X	Rare to uncommon in spring to mid-summer, but fairly common in late summer and early fall	Shallow water of ponds, lakes, and rivers
Ardeidae	Green Heron	*Butorides virescens*	X	Common in spring, summer, and fall, but rare in winter	Edge of ponds, lakes, and rivers
Cathartidae	Black Vulture	*Coragyps atratus*	X	Common throughout year	Agricultural and livestock areas
Cathartidae	Turkey Vulture	*Cathartes aura*	X	Common in all seasons and regions	Wooded as well as open areas
Accipitridae	Osprey	*Pandion haliaetus*	X	Fairly common in spring and fall, and uncommon in summer	Large lakes and rivers
Accipitridae	Northern Harrier	*Circus cyaneus*		Fairly common in winter, spring, and fall	In and over old fields, marshes, meadows, and grasslands
Accipitradae	Red-shouldered Hawk	*Buteo lineatus*	X	Fairly common in all seasons	Moist woodlands and swamps
Accipitradae	Broad-winged Hawk	*Buteo platypterus*	X	Fairly common in spring and summer, common in fall, but rare in winter	Deciduous woodlands; during migration can be seen overhead of any habitat type
Accipitradae	Red-tailed Hawk	*Buteo jamaicensis*	X	Common winter and fairly common in spring, summer, and fall	Open country and woodland edges
Falconidae	American Kestrel	*Falco sparverius*	X	Common in winter, fairly common in spring and fall, but rare in summer	Open fields and woodland edges.
Rallidae	American Coot	*Fulica Americana*		Common in winter, common to uncommon in spring and fall, and rare in summer	Rivers, ponds, lakes, and swamps

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Charadriidae	American Golden-Plover	*Pluvialis dominica*		Fairly common in spring and uncommon to rare in fall	Short grasslands, flooded fields and on mudflats of lakes, ponds, and rivers
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*		Fairly common in spring and fall, and occasional in early winter	Mudflats of lakes, ponds, and rivers
Charadriidae	Killdeer	*Charadrius vociferous*	X	Common in all seasons	Short-grass fields, and mudflats and shorelines of lakes, ponds, and rivers
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*		Fairly common in spring and fall, but uncommon in winter and late summer	Along shorelines of shallow ponds and lakes, marsh edges, in flooded fields, and on mudflats
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*		Common in spring and fall, rare in winter, uncommon to rare in summer	Along shorelines of shallow ponds and lakes, marsh edges, in flooded fields and on mudflats
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	X	Common in spring, late summer and fall, but rare in winter	Along pond and lake margins, stream banks, and on mudflats
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*		Common in spring, late summer, and fall	Along lake borders, stream banks, ponds, and marsh edges
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*		Fairly common in spring and fall, and uncommon in late summer	On mudflats, and along pond edges and lakeshores
Scolopacidae	Least Sandpiper	*Calidris minutilla*		Common in spring, fairly common in fall, uncommon in winter and late summer, and occasional in early summer	On mudflats, and along pond edges and lakeshores
Scolopacidae	Pectoral Sandpiper	*Calidris melanotos*		Common in spring and fall, and uncommon in late summer	Wet meadows, flooded fields, on mudflats, and along shores of ponds, pools, and lakes
Scolopacidae	Common Snipe	*Gallinago*		Common in winter, spring, and fall	Marshes and wet grassy areas
Scolopacidae	American Woodcock	*Scolopax minor*	X	Fairly common in fall and winter, and occasional in spring	Moist shrubby woods, floodplains, thickets, and at edges of swamps
Laridae	Ring-billed Gull	*Larus delawarensis*		Fairly common in winter, spring and fall, and occasional in summer	Summer rivers, lakes, irrigated and plowed fields, and garbage dumps
Columbidae	Rock Pigeon	*Columba livia Exotic*	X	Common in all seasons	In cities, and on farms, bridges, cliffs
Columbidae	Mourning Dove	*Zenaida macroura*	X	Common in all seasons	Farms, and in towns, woodlots, agricultural fields, and grasslands
Cuculidae	Yellow-billed Cuckoo	*Coccyzus americanus*	X	Common in spring, summer, and fall	Woodlands, and on farmlands with scattered trees and orchards

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Strigidae	Eastern Screech-Owl	*Megascops asio*	X	Common in all seasons	Woodlands, especially near open areas
Strigidae	Great Horned Owl	*Bubo virginianus*	X	Fairly common in all seasons	Woodlands, parklands, and occasionally In wooded suburbs
Strigidae	Barred Owl	*Strix varia*	X	Common in all seasons	Moist woodlands and wooded swamps
Caprimulgidae	Chuck-will's-widow	*Anstrostomus carolinensis*	X	Common in spring, summer, and fall	Deciduous and pine woodlands
Caprimulgidae	Whip-poor-will	*Caprimulgus vociferous*	X	Locally common in spring, summer, and fall	Open and mix-forest woodlands
Apodidae	Chimney Swift	*Chaetura pelagica*	X	Common in spring, summer, and fall	Open areas, especially around human habitations
Trochilidae	Ruby-throated Hummingbird	*Archilochus colubris*	X	Common in spring, summer, and fall	Woodlands, gardens, along forest edges, and at feeders
Alcedinidae	Belted Kingfisher	*Ceryle alcyon*	X	Common in all seasons	Along wooded rivers, streams, lakes, ponds, and in marshes
Picidae	Red-headed Woodpecker	*Melanerpes erythrocephalus*	X	Fairly common in spring, summer, and fall, but uncommon in winter	Open woods, especially those containing numerous snags
Picidae	Red-bellied Woodpecker	*Melanerpes carolinus*	X	Common in all seasons	Woodlands
Picidae	Yellow-bellied Sapsucker	*Sphyrapicus varius*		Fairly common in winter, spring, and fall	Mixed hardwood and conifer forests
Picidae	Downy Woodpecker	*Picoides pubescens*	X	Common in all seasons	Woodlands, orchards, suburban areas, parks, and farm woodlots
Picidae	Red-cockaded Woodpecker	*Picoides borealis*	X	Rare and isolated in all seasons	Old growth pine with open mid-story
Picidae	Northern Flicker	*Colaptes auratus*	X	Fairly common in all seasons and regions	Open woodlands and fields, and on lawns and open meadows with large trees
Picidae	Pileated Woodpecker	*Dryocopus pileatus*	X	Fairly common in all	Mature woodlands with coniferous and hardwood trees
Tyrannidae	Eastern Wood-Pewee	*Contopus virens*	X	Common to fairly common in spring, summer, and fall	Open woodlands, parks, and along forest edges
Tyrannidae	Acadian Flycatcher	*Empidonax virescens*	X	Common in spring, summer, and fall	Moist deciduous woods, dense woodlands, and wooded swamps
Tyrannidae	Eastern Phoebe	*Sayornis phoebe*	X	Common in winter, spring, and fall	Open deciduous woodlands near bridges, cliffs, and eaves

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Tyrannidae	Great Crested Flycatcher	*Myiarchus crinitus*	X	Common in spring, summer, and fall	Woodlands, open country with scattered trees, and parks
Tyrannidae	Eastern Kingbird	*Tyrannus*	X	Common in spring, summer, and fall	Open rural areas with scattered trees and shrubs, along woodland edges, and in agricultural fields with hedgerows, especially near ponds or rivers
Laniidae	Loggerhead Shrike	*Lanius ludovicianus*	X	Fairly common in winter, spring, and fall, and uncommon in summer	Open country with scattered trees and shrubs, and in hedgerows along agricultural fields
Vireonidae	White-eyed Vireo	*Vireo griseus*	X	Common in spring, summer, and fall	Undergrowth, early successional fields, streamside thickets, and along woodland edges
Vireonidae	Yellow-throated Vireo	*Vireo flavifrons*	X	Common in spring, summer, and fall	Tall, open woodlands, especially near water
Vireonidae	Red-eyed Vireo	*Vireo olivaceus*	X	Common in spring, summer, and fall	Deciduous woods, mixed forests, shade trees, and woodlots
Corvidae	Blue Jay	*Cyanocitta cristata*	X	Common in all seasons	Forests, open woodlands, wooded residential areas, and parks
Corvidae	American Crow	*Corvus brachyrhynchos*	X	Common	All woodlands, farmlands, and suburban areas
Corvidae	Fish Crow	*Corvus ossifragus*	X	Fairly common to locally common in all seasons	Around swamplands, riverine areas, large lakes, urban and suburban areas, and farmlands
Hirundinidae	Purple Martin	*Progne subis*	X	Common in spring, summer, and early fall	Open rural and suburban areas and open farmlands, especially near water
Hirundinidae	Tree Swallow	*Tachycineta bicolor*	X	Common in fall, fairly common in spring, and rare in winter and summer	Open areas, and over ponds and lakes; nests in cavities in dead, standing timber and boxes
Hirundinidae	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	X	Common in spring, summer, and fall	Open areas, fields, swamps, and over ponds and lakes; nests in burrows in road cuts and steep banks
Hirundinidae	Bank Swallow	*Riparia*		Fairly common in spring and fall, and occasional	Summer in open habitats, especially near water
Hirundinidae	Cliff Swallow	*Petrochelidon pyrrhonota*	X	Fairly common in spring, summer, and fall	Open habitats near water; nests on dams and bridges

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Hirundinidae	Barn Swallow	*Hirundo rustica*	X	Common in spring, summer, and fall	Open habitats, under bridges and culverts, and in barns
Paridae	Carolina Chickadee	*Poecile carolinensis*	X	Common in all seasons	Woodlands and wooded suburbs
Paridae	Tufted Titmouse	*Baeolophus bicolor*	X	Common in all seasons	Woodlands and wooded suburbs
Sittidae	Brown-headed Nuthatch	*Sitta pusilla*	X	Locally common in all seasons	Open pine forests
Troglodytidae	Carolina Wren	*Thryothorus ludovicianus*	X	Common in all seasons	Thickets in woodlands, farmlands, and suburbs
Troglodytidae	House Wren	*Troglodytes aedon*	X	Fairly common in fall, uncommon in spring, and rare in winter and summer	Farmlands, thickets, and suburban yards with dense hedgerows
Regulidae	Golden-crowned Kinglet	*Regulus satrapa*		Common in winter, spring, and fall	Woodlands, especially with conifers
Regulidae	Ruby-crowned Kinglet	*Regulus calendula*		Common in winter, spring, and fall	Woodlands
Sylviidae	Blue-gray Gnatcatcher	*Polioptila caerulea*	X	Common in spring, summer, and fall, and rare in winter	Open woodlands, forest edges, and tree-lined fence rows
Turdidae	Eastern Bluebird	*Sialia sialis*	X	Common in all seasons	Open rural areas, farmlands, fence rows, open suburban areas, and parks with scattered trees
Turdidae	Swainson's Thrush	*Catharus ustulatus*		Fairly common in spring and fall	Woodlands with dense undergrowth
Turdidae	Hermit Thrush	*Catharus guttatus*		Common in winter, spring, and fall	Woodlands with dense undergrowth
Turdidae	Wood Thrush	*Hylocichla mustelina*	X	Common in spring, summer, and fall	Woodlands and wooded suburbs with understory
Turdidae	American Robin	*Turdus migratorius*	X	Common in all seasons	Short grass areas with scattered trees
Mimidae	Gray Catbird	*Dumetella carolinensis*	X	Common in spring and fall	Hedgerows, thickets, fence rows, and dense brushy vegetation bordering ponds and lakes
Mimidae	Northern Mockingbird	*Mimus polyglottos*	X	Common in all seasons	Openings with short grass, scattered shrubs, and trees
Mimidae	Brown Thrasher	*Toxostoma rufum*	X	Common in all seasons	Short ground cover vegetation near dense thickets, hedgerows, and shrubs
Motacillidae	American Pipit	*Anthus rubescens*		Fairly common in winter, spring, and fall	Open country, especially on plowed fields and mudflats

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Bombycillidae	Cedar Waxwing	*Bombycilla cedrorum*	X	Common in winter, spring, and fall, and occasional in summer	Areas with trees and shrubs that produce fruits, such as hackberry, mulberry, cedar, cherry, and holly
Parulidae	Tennessee Warbler	*Vermivora peregrine*		Common in spring and fall	Woodlands
Parulidae	Northern Parula	*Parula Americana*	X	Fairly common in spring, summer, and fall	Tall trees along streams, swamps, and lakes; woodlands during migration
Parulidae	Yellow Warbler	*Dendroica petechia*	X	Common in spring and fall, and rare in summer	Small trees and shrubs near water
Parulidae	Magnolia Warbler	*Dendroica magnolia*		Common in fall, fairly common in spring, and occasional in summer	Woodlands
Parulidae	Yellow-rumped Warbler	*Dendroica coronata*		Common in winter, spring, and fall	Woodlands
Parulidae	Black-throated Green Warbler	*Dendroica virens*	X	Common in fall, fairly common in spring and summer	Coniferous and deciduous forests; in migration, found in woodlands
Parulidae	Yellow-throated Warbler	*Dendroica dominica*	X	Fairly common in spring, summer, and fall, and occasional in winter	Older pine forests, and woodlands with sycamores, especially near water; in migration, found in woodlands
Parulidae	Pine Warbler	*Dendroica pinus*	X	Common in all seasons	Mature pine woodlands
Parulidae	Prairie Warbler	*Setophaga discolor*	X	Common in spring, summer and fall, and occasional in winter	Brushy early successional growth, particularly regenerating clearcuts
Parulidae	Palm Warbler	*Dendroica palmarum*		Common in spring, fairly common in fall, and rare in winter	Open areas with scattered shrubs and trees
Parulidae	Bay-breasted Warbler	*Dendroica castanea*		Fairly common in spring and fall	Woodlands
Parulidae	Black-and-white Warbler	*Mniotilta varia*	X	Common in spring and fall	Hardwood and mixed hardwood-coniferous forests; in migration, found in woodlands
Parulidae	American Redstart	*Setophaga ruticilla*	X	Common in spring and fall, and fairly common in summer	In breeding season, found in deciduous woods, especially riverine systems; in migration, found in woodlands
Parulidae	Prothonotary Warbler	*Protonotaria citrea*	X	Common in spring, summer, and early fall	Swamp and bottomland forests
Parulidae	Swainson's Warbler	*Limnothlypis swainsonii*	X	Fairly common in spring and summer, and uncommon to rare in fall	Dense thickets in swamps, along streams, and in woodland areas

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Parulidae	Ovenbird	*Seiurus aurocapillus*	X	Fairly common in spring and fall	In breeding season, found in deciduous forests; in migration, found in woodlands, especially with dense understory
Parulidae	Northern Waterthrush	*Seiurus noveboracensis*		Fairly common in spring and fall	Along shorelines of swamps, lakes, ponds, and streams
Parulidae	Louisiana Waterthrush	*Parkesia motacilla*	X	Common in spring, summer, and early fall	Older bottomland forests along streams
Parulidae	Kentucky Warbler	*Oporornis formosus*	X	Fairly common in spring, summer, and fall	Moist woodlands with dense herbaceous ground cover
Parulidae	Common Yellowthroat	*Geothlypis trichas*	X	Common in spring, summer, and fall, and rare in winter	Along woodland edges, and in hedgerows, thickets, marshes, and wet meadows
Parulidae	Hooded Warbler	*Wilsonia citrine*	X	Common in spring, summer, and fall	In breeding season, found in shrubby forests; in migration, found in woodlands, especially in understory
Parulidae	Yellow-breasted Chat	*Icteria virens*	X	Common in spring, summer, and fall, and occasional in winter	Early successional growth areas
Thraupidae	Summer Tanager	*Piranga rubra*	X	Common in spring, summer, and fall, and occasional in winter	In breeding season, found in open, mixed hardwood-coniferous forests and along forest edges
Thraupidae	Scarlet Tanager	*Piranga olivacea*	X	Fairly common in spring, summer, and fall	In breeding season, found in hardwood forests; in migration, found in woodlands
Emberizidae	Eastern Towhee	*Pipilo erythrophthalmus*	X	Common in all seasons	Brushy woodlands and early successional growth
Emberizidae	Chipping Sparrow	*Spizella passerine*	X	Common in all seasons	Open areas with short grass and scattered trees, especially conifers
Emberizidae	Field Sparrow	*Spizella pusilla*	X	Common to fairly common in all seasons	Early successional growth areas, especially with dense ground cover
Emberizidae	Savannah Sparrow	*Passerculus sandwichensis*		Common in winter, spring, and fall	Open grassy fields
Emberizidae	Song Sparrow	*Melospiza melodia*	X	Common in winter, spring, and fall, and uncommon to rare in summer	Open brushy and weedy areas
Emberizidae	Swamp Sparrow	*Melospiza Georgiana*		Common to fairly common in winter, spring, and fall	Freshwater marshes, and shrubby and weedy areas, especially near water
Emberizidae	White-throated Sparrow	*Zonotrichia albicollis*		Common in winter, spring, and fall, and rare in summer	Thickets and shrubby areas

FAMILY	COMMON NAME	SCIENTIFIC NAME	BREEDS IN PROJECT AREA	ABUNDANCE/ SEASONALITY	HABITAT
Emberizidae	Dark-eyed Junco	*Junco hyemalis*		Common in winter, spring, and fall, and occasional in summer	Open woodlands, and brushy and grassy areas
Cardinalidae	Northern Cardinal	*Cardinalis*	X	Common in all seasons	Shrubby areas, hedgerows, thickets, and suburban gardens
Cardinalidae	Rose-breasted Grosbeak	*Pheucticus ludovicianus*		Fairly common in spring and uncommon in fall	Woodlands, especially in the canopy
Cardinalidae	Blue Grosbeak	*Passerina caerulea*	X	Common in spring, summer, and fall	Open thickets and hedgerows, especially along field borders
Cardinalidae	Indigo Bunting	*Passerina cyanea*	X	Common in spring, summer, and fall, and occasional in winter	Brushy and weedy area, in early successional stages and woodland openings, and along woodland and field borders
Icteridae	Red-winged Blackbird	*Agelaius phoeniceus*	X	Common in all seasons	Marshes, and brushy, weedy and grassy areas, especially when wet
Icteridae	Eastern Meadowlark	*Sturnella magna*	X	Common in all seasons	Grassy, weedy fields, especially high grass
Icteridae	Common Grackle	*Quiscalus quiscula*	X	Common in all seasons	Open woodlands, especially those with pines and grassy areas; also fields with short grasses or in cultivated fields
Icteridae	Brown-headed Cowbird	*Molothrus ater*	X	Common in all seasons	Open areas, especially with livestock
Icteridae	Orchard Oriole	*Icterus spurious*	X	Common in spring, summer, and fall	In breeding season, found in open areas, with scattered trees, especially near water. In migration, found in woodlands
Icteridae	Baltimore Oriole	*Icterus galbula*	X	Fairly common in spring and fall, but rare in summer and winter	In breeding season, found in open areas, with scattered trees, especially near water. In migration, found in woodlands
Fringillidae	House Finch	*Carpodacus mexicanus*	X	Common in all seasons	Open woodlands
Fringillidae	American Goldfinch	*Carduelis tristis*	X	Common in winter, spring, and fall	Open woodlands, brushy areas, and willow thickets
Passeridae	House Sparrow	*Passer domesticus* *Exotic*	X	Common in all seasons	Urban and suburban areas, and open farmland

Source: Mirarchi 2004, Causey 2006

Table 2: Mammal Species Potentially Occurring in the Harris Project Vicinity

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	DISTRIBUTION IN ALABAMA	HABITAT
Didelphidae	Virginia Opossum	*Didelphis virginiana*	Common	Found statewide	All habitats, including urban areas
Soricidae	Least Shrew	*Cryptotis parva*	Poorly known	Found statewide	Grasslands and other upland areas, weedy fencerows, fields, roadsides, and meadows
Soricidae	Southeastern Shrew	*Sorex longirostris*	Poorly known	Found statewide, except southern tier of counties	Occupies a variety of habitats from bogs and marshes to upland grassy areas and forests, and even bare hillsides and dry upland hardwoods. May favor moist areas bordering swamps, marshes, lakes, and streams
Talpidae	Eastern Mole	*Scalopus aquaticus*	Poorly known	Found statewide and common in a variety of habitats	In both forested and unforested areas. Occupies moist, loose, sandy or loamy soils, and spends most of life underground
Vespertilionidae	Gray Myotis (bat)	*Myotis grisescens*		Found statewide, except for southwestern region	Occupies deep caves near permanent water in winter and summer. Forages primarily over water, along streams, and over lakes and ponds
Vespertilionidae	Northern Long-eared (bat)	Myotis *septentrionalis*	Poorly known	Found statewide, except southwestern region	Forested ridges appear favored over riparian woodlands. Hibernacula include caves and mines, but may use crevices in walls or ceilings. Summer roosts include tree holes, birdhouses, or behind loose bark or shutters of buildings
Vespertilionidae	Eastern Pipistrelle (bat)	*Pipistrellus subflavus*	Common	Found statewide	Occupies hollow trees, tree foliage, caves, mines, rock crevices, and buildings
Vespertilionidae	Big Brown Bat	*Eptesicus fuscus*	Common	Found statewide and common	Roosts typically in human-made structures, but also in caves, mines, hollow trees, and crevices, or behind loose bark. Commonly inhabits bat houses, attics, and louvered attic vents
Vespertilionidae	Eastern Red Bat	*Lasiurus borealis*	Common	Found statewide and common	Roosts in a variety of trees, but frequently uses clumps of Spanish moss
Vespertilionidae	Seminole Bat	*Lasiurus seminolus*	Common	Found statewide	Common in mixed coniferous and deciduous woodlands, often associated with Spanish moss. Mostly forages at tree-top level in forests, although also flies over open water, forest clearings, and along forest edges

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	DISTRIBUTION IN ALABAMA	HABITAT
Vespertilionidae	Evening Bat	*Nycticeius humeralis*	Common	Found statewide, but may be most common in southern half	Primary habitat is deciduous forest where it roosts in hollow trees, under loose bark, and in human-made structures, such as outbuildings, churches, belfries, and attics
Dasypodidae	Nine-banded Armadillo	*Dasypus novemcinctus*	Common	Found statewide	Woodlands, forest edges, savannas, and brushy areas
Leporidae	Swamp Rabbit	*Sylvilagus aquaticus*	Poorly known	Distributed statewide, except for southern tier of counties along Florida Panhandle	Floodplain forests, wooded bottomlands, briar and honeysuckle patches, and canebrakes
Leporidae	Eastern Cottontail	*Sylvilagus floridanus*	Common	Found statewide	Primarily occurs in deciduous forests and forest edges, but also in grasslands, along fencerows, and in urban areas
Sciuridae	Eastern Chipmunk	*Tamias striatus*	Common	Found statewide, except for extreme southwestern and southeastern regions	Occupies wooded areas with dense canopy and sparsely covered forest floor, open brushy habitats, ravines, deciduous growth along streams, and urban areas
Sciuridae	Woodchuck	*Marmota monax*	Poorly known	Distribution includes northern 2/3 of state	Occupies forest edges and open fields and pastures near brushy fencerows or other cover
Sciuridae	Gray Squirrel	*Sciurus carolinensis*	Common	Found statewide	Hardwood forests, mixed forests, and urban areas
Sciuridae	Fox Squirrel	*Sciurus niger*	Fairly Common	Found statewide	Favors mature deciduous and pine-oak woodlands, but also occurs at forest edges and in riparian woodlands
Sciuridae	Southern Flying Squirrel	*Glaucomys volans*	Common	Found statewide	Most common in mature, broad-leaved forests, but also found in coniferous-deciduous woodlands, and urban areas. Nocturnal existence belies its common occurrence
Castoridae	Beaver	*Castor Canadensis*	Common	Found statewide	All habitats with open water. Considered a pest in some areas
Muridae	Marsh Rice Rat	*Oryzomys palustris*	Common	Found statewide	Wet meadows and dense vegetation near marshes, swamps, streams, ponds, and ditches
Muridae	Eastern Harvest Mouse	*Reithrodontomys humulis*	Poorly known	Once common	Old fields containing dense stands of weeds and grasses, but may be declining in Alabama

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	DISTRIBUTION IN ALABAMA	HABITAT
Muridae	Cotton Mouse	*Peromyscus gossypinus*	Common	Found statewide	Dense underbrush, bottomland hardwood forests, and a variety of other habitats, including old fields, upland forests, hammocks, and swamps
Muridae	White-footed Mouse	*Peromyscus leucopus*	Poorly known	Occurs in northern 2/3 of state	Common in woodlands with fallen logs, brush piles, and rocks, and in shrubs along fencerows and streams
Muridae	Golden Mouse	*Ochrotomys nuttalli*	Common		Woodlands, floodplains, borders of fields, and thickets bordering swamps and dense woods
Muridae	Hispid Cotton Rat	*Sigmodon hispidus*	Found statewide	Populations fluctuate greatly among years.	Grassy areas of fields and along roadways,
Muridae	Eastern Woodrat	*Neotoma floridana*	Poorly known	No recent surveys; populations may be declining	Occupies woodland and brushy habitats south of Tennessee River. Usually found associated with rocky outcrops, but also in areas with dense vegetation
Muridae	Pine Vole	*Microtus pinetorum*		Found statewide, except for southwestern section	Occupies a wide range of habitats, including leaf litter, grassy fields with brush and brambles, and beneath mats of dense vegetation
Muridae	Muskrat	*Ondatra zibethicus*	Common	Found nearly statewide, except counties bordering Florida Panhandle	Habitats include saline, brackish, and freshwater streams; marshes; ponds; lakes; ditches; and rivers
Muridae	House Mouse	*Mus musculus Exotic*	Common	Found statewide	Often found in habitats associated with native rodents fairly distant from human habitation
Carnivora	Coyote	*Canis latrans*	Common in all habitats	Found statewide, including urban areas	Wide rage, upland forests and swamps to pastures and fields
Carnivora	Red Fox	*Vulpes*	Common	Found statewide	Forested uplands interspersed with pastures and farmland
Carnivora	Gray Fox	*Urocyon cinereoargenteus*	Common	Found statewide	Forested habitats statewide
Procyonidae	Raccoon	*Procyon lotor*	Common	Found statewide	All habitats statewide, including urban areas; often associated with water, especially bottomland swamps, marshes, and flooded woodlands

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	DISTRIBUTION IN ALABAMA	HABITAT
Mustelidae	Long-tailed Weasel	*Mustela frenata*	Poorly known	Probably found statewide, but little known about current status	Woodlands, forest edges, fencerows, agricultural, and urban areas
Mustelidae	Mink	*Mustela vison*	Poorly known	This semiaquatic species occurs statewide	Usually near permanent water
Mustelidae	River Otter	*Lontra Canadensis*	Poorly known	Probably present statewide	In association with rivers, creeks, and lakes, especially open water bordered with wooded habitat
Mephitidae	Striped Skunk	*Mephitis mephitis*	Common	Found statewide	Open areas, forest edges, and urban habitats
Mephitidae	Eastern Spotted Skunk	*Spilogale putorius*	Poorly known	Found statewide	Variety of habitats such as pastures, woodlands, forest edges, and farmlands
Felidae	Bobcat	*Lynx rufus*	Common	Found statewide	Wide array of habitats including dense understory, bottomland hardwood forests, swamps, and farmlands
Cervidae	White-tailed Deer	*Odocoileus virginianus*	Common and important game species	found statewide	Urban habitats
Suidae	Feral Swine	*Sus scrofa* *Exotic*	Fairly Common	Found statewide	Woodlands, swamps, and fields, primarily near water

Source: Mirarchi 2004, Causey 2006

Table 3: Reptile and Amphibian Species Potentially Occurring in the Harris Project Vicinity

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	HABITAT
Amphibians				
Bufonidae	American toad	*Bufo americanus*	Common	Upland forests, suburban areas
Bufonidae	Fowler's toad	*Bufo woodhousii*	Common	Sandy areas around shores of lakes, or in river valleys
Hylidae	northern cricket frog	*Acris crepitans*	Common	Creekbanks, lakeshores, and mudflats
Hylidae	Cope's gray treefrog	*Hyla chrysoscelis*	Common	Small trees or shrubs, typically over standing water; on ground or at water's edge during breeding season
Hylidae	green treefrog	*Hyla cinerea*	Moderately common	Permanent aquatic habitats
Hylidae	mountain chorus frog	*Pseudacris brachyphona*	Moderately Common	Forested areas in most of northern Alabama
Hylidae	northern spring peeper	*Pseudacris crucifer*	Common	Ponds, pools and swamps
Hylidae	upland chorus frog	*Pseudacris triseriata feriarum*	Moderately Common	Grassy swales, moist woodlands, river-bottom swamps, and environs of ponds, bogs and marshes
Microhylidae	eastern narrow-mouthed toad	*Gastrophyrne carolinensis*	Common	Variety of habitats providing suitable cover and moisture, including under logs and or leaf litter
Pelobatidae	eastern spadefoot toad	*Scaphiopus holbrooki*	Moderately	Forested areas of sandy or loose soil
Ranidae	bullfrog	*Rana catesbeiana*	Common	Permanent aquatic habitats
Ranidae	bronze frog	*Rana clamitans spp.*	Moderately Common	Rocks, stumps, limestone crevices of stream environs, bayheads and swamps
Ranidae	wood frog	*Rana sylvatica*	Uncommon	Moist wooded areas
Ranidae	southern leopard frog	*Rana pipiens sphenocephala*	Moderately Common, believed to be declining	All types of aquatic to slightly-brackish habitats
Ambystomatidae	spotted salamander	*Ambystoma maculatum*	Moderately Common, believed to be declining	Bottomland hardwoods, woodland pools
Ambystomatidae	marbled salamander	*Ambystoma opacum*	Common	Bottomland hardwoods, woodland pools
Plethodontidae	spotted dusky salamander	*Desmongnathus conanti*	Common	Damp habitats, seepage areas
Plethodontidae	Southern two-lined salamander	*Eurycea cirrigera*	Common	Shaded aquatic habitats
Plethodontidae	three-lined salamander	*Eurycea guttolineata*	Common	Shaded aquatic habitats, forested floodplains

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	HABITAT
Plethodontidae	Webster's salamander	*Plethodon websteri*	Moderately Common	Damp deciduous forest
Plethodontidae	Northern slimy salamander	*Plethodon glutinosus*	Common	Wide variety of habitats
Plethodontidae	Northern red salamander	*Pseudotriton ruber*	Common	Aquatic margins in forested areas
Salamandridae	Eastern newt	*Notophthalmus viridescens louisianensis*	Moderately Common	Terrestrial or aquatic habitats, depending on life stage
Salamandridae	central newt	*Notophthalmus viridescens*	Moderately Common	Terrestrial or aquatic habitats, depending on life stage
		Reptiles		
Chelydridae	common snapping turtle	*Chelydra serpentina*	Common	Aquatic habitats
Emydidae	painted turtle	*Chrysemys picta ssp.*	Moderately Common	Lakes, rivers, and ponds
Emydidae	Alabama map turtle	*Graptemys pulchra*	Moderately Common	Rivers and large streams in AL
Emydidae	river cooter	*Pseudemys concinna*	Common	Rivers, streams, and some lakes
Emydidae	eastern box turtle	*Terrapene carolina*	Common	Wooded uplands
Emydidae	yellow-bellied pond slider	*Pseudemys scripta*	Common	Ponds, rivers, creeks, and open swamps
Emydidae	red-eared pond slider	*Pseudemys scripta elegans*	Common	Ponds, rivers, creeks, and open swamps
Kinosternidae	eastern mud turtle	*Kinosternon subrubrum*	Common	Sluggish aquatic habitats
Kinosternidae	Loggerhead musk turtle	*Sternotherus minor ssp.*	Moderately Common	Creeks and rivers
Kinosternidae	Stinkpot	*Sternotherus odoratus*	Common	Sluggish aquatic habitats
Iguanidae	green anole	*Anolis carolinensis*	Common	Wide range of upland and riparian areas
Scincidae	common five-lined skink	*Eumeces fasciatus*	Common	Forests and a variety of other habitats
Scincidae	southern five-lined skink	*Eumeces inexpectatus*	Uncommon	Dry and relatively open forestlands
Scincidae	broad-headed skink	*Eumeces laticeps*	Moderately Common	Rotting logs, stumps, and tree cavities
Scincidae	ground skink	*Scincella lateralis*	Common, believed to be declining	Forested areas
Iguanidae	Eastern fence lizard	*Sceloporus undulatus*	Common	Wide range of upland and riparian areas

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	HABITAT
Colubridae	worm snake	*Carphophis amoenus ssp.*	Moderately Common	Fossorial, under rocks and in rotting logs
Colubridae	scarlet snake	*Cemphora coccinea*	Common, but believed to be declining	Areas with loose, well drained soils
Colubridae	black racer	*Coluber constrictor ssp.*	Common, believed to be declining	In or near water, streams passing through cypress swamps
Colubridae	ringneck snake	*Diadophis punctatus ssp.*	Common	Under shelter in upland areas near water
Colubridae	corn snake	*Elaphe guttata*	Moderately Common	Wide range of upland and riparian areas
Colubridae	rat snake	*Elaphe obsoleta ssp.*	Common	Wide range of upland and riparian areas
Colubridae	gray rat snake	*Elaphe obsoleta*	Common	Wide range of upland and riparian areas
Colubridae	eastern hognose snake	*Heterodon platyrhinos*	Uncommon, believed to be declining	Fields, open woods, disturbed areas
Colubridae	black kingsnake	*Lampropeltis getula niger*	Moderately Common	Dry rocky hills, open woods, dry prairies, and stream valleys
Colubridae	scarlet kingsnake	*Lampropeltis triangulum elapsoides*	Uncommon, believed to be declining	In or near woodlands, especially pinelands
Colubridae	Plain-bellied water snake	*Natrix erythrogaster ssp.*	Common	Riverbottoms, swamps, marshes, and river/lake edges
Colubridae	queen snake	*Regina septemvittata*	Common, believed to be declining	Streams and impoundments
Colubridae	Dekay's brown snake	*Storeria dekayi ssp.*	Common	Environs of Bogs, swaps, freshwater marshes, moist woods and hillsides
Colubridae	northern red-bellied snake	*Storeria occipitomaculata*	Common, believed to be declining	Mesic habitats in or near open woods; in or near sphagnum bogs
Colubridae	eastern ribbon snake	*Thamnophis sauritus*	Moderately Common	Semi-Aquatic
Colubridae	eastern garter snake	*Thamnophis sirtalis*	Moderately Common	Wide range of upland and riparian areas
Colubridae	rough earth snake	*Virginia striatula*	Moderately Common	Abandoned fields, deciduous forests
Colubridae	eastern smooth earth snake	*Virginia valeriae*	Moderately Common	Abandoned fields near deciduous forests
Viperidae	southern copperhead	*Agkistrodon contortrix*	Common	Upland forests and riparian zones
Viperidae	northern copperhead	*Agkistrodon contortrix mokeson*	Common	Upland forests and riparian zones
Viperidae	eastern cottonmouth	*Agkistrodon piscivorus*	Common	Aquatic
Viperidae	Florida cottonmouth	*Agkistrodon piscivorus conanti*	Common	Aquatic

FAMILY	COMMON NAME	SCIENTIFIC NAME	ABUNDANCE IN PROJECT AREA	HABITAT
Viperidae	western cottonmouth	*Agkistrodon piscivorus leucostoma*	Common	Aquatic
Viperidae	timber rattlesnake	*Crotalus horridus*	Common	Upland and bottomland forests, riparian zones

Source: Mirarchi 2004, Causey 2006