Sustainable Rivers Monitoring Plan
Savannah River Basin

US Army Corps of Engineers
Savannah District

September 2012

TABLE OF CONTENTS

Page No.

Page No.

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS

ASU ---------- Augusta State University
BOD ---------- Biological Oxygen Demand
cfs ---------- cubic feet per second
CRD ---------- Coastal Resources Division
DHEC ---------- Department of Health and Environmental Control
DNR ---------- Department of Natural Resources
DO ---------- Dissolved Oxygen
EPA---------- Environmental Protection Agency
EPD---------- Environmental Protection Division
HEC ---------- US Army Corps of Engineers Hydrologic Engineering Center
HTRW ---------- Hazardous, Toxic and Radioactive Waste
JST---------- J. Strom Thurmond
msl ---------- mean sea level
NMFS ---------- National Marine Fisheries Service
NOAA---------- National Oceanic and Atmospheric Administration
NSBLD ---------- New Savannah Bluff Lock and Dam
NWR ---------- National Wildlife Refuge
RBR ---------- Richard B. Russell
RM---------- River Mile
SHEP ---------- Savannah Harbor Expansion Project
SRB---------- Savannah River Basin
SREL ---------- Savannah River Ecology Laboratory
SSU---------- Savannah State University
SNSA---------- Southeastern Natural Science Academy
TMDL---------- Total Maximum Daily Load
TNC ---------- The Nature Conservancy
UGA---------- University of Georgia
USACE ---------- United States Army Corps of Engineers
USFWS ---------- United States Fish and Wildlife Service
USGS---------- United States Geologic Survey
WY ---------- Water Year

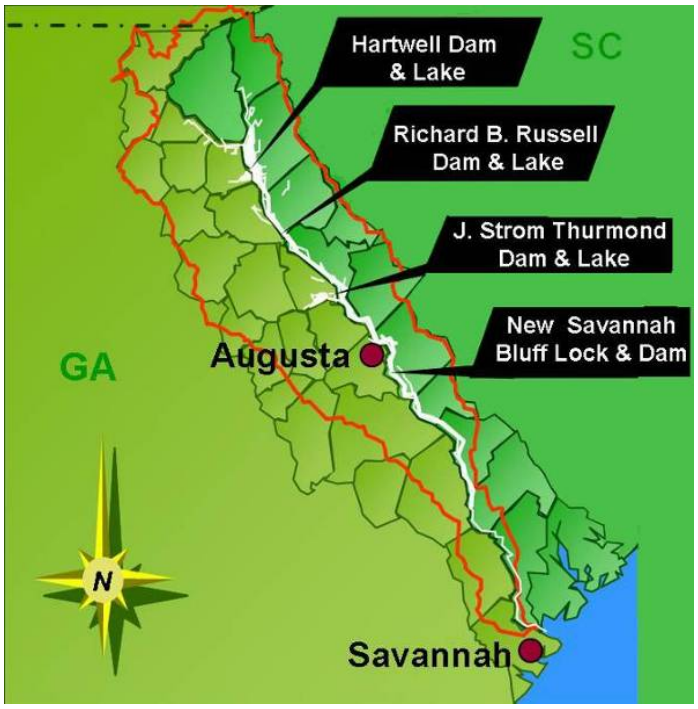
SUSTAINABLE RIVERS MONITORING PLAN- SAVANNAH RIVER BASIN

1.0 **BACKGROUND**

In 2011 a Savannah River Basin (primarily the portion below Thurmond Dam) Monitoring Plan was selected as one of the American rivers actions to be included in the Sustainable Rivers Project, a national collaboration between TNC and USACE.

There has been various biological and physical monitoring performed in the SRB below JST (see map below) in the past. Recent monitoring has targeted the Piedmont mainstem river, the Coastal Plain mainstem river, the estuary and diadromous fish. Many of these efforts are included in Section 6.1. The future monitoring as described herein in Sections 6.2 and 6.3 will also occur in the portions of the basin below Thurmond Dam. It should be noted that the future monitoring does not include requested input from Savannah River Basin Comprehensive Study stakeholders, as a stakeholders meeting has not been held to date. Currently, the stakeholders meeting is scheduled for April 2013.

2.0 **DESCRIPTION OF THE SAVANNAH RIVER BASIN**



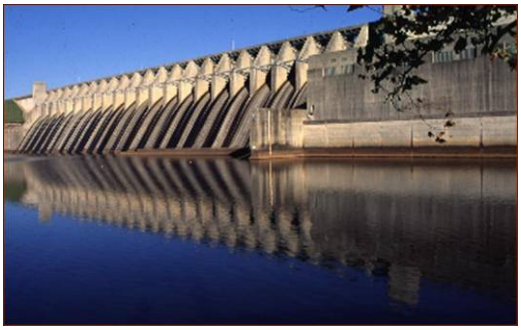
The SRB has a surface area of approximately 10,577 square miles, of which 5,821 square miles are in Georgia, 4,581 square miles are in South Carolina and 175 square miles are in North Carolina. The basin includes portions of 27 counties in Georgia, 13 counties in South Carolina and four counties in North Carolina. The basin area drains portions of three physiographic provinces: the Blue Ridge Mountains, the Piedmont and the Coastal Plain. In its middle and upper reaches the river flow is regulated by several reservoirs, including three large multipurpose Corps projects (Hartwell Lake, RBR Lake and JST Lake) and two large private power reservoirs (Lakes Keowee and Jocassee). Other structures include the NSBLD, the Stevens Creek Dam and the Old Lock and Dam at the Augusta Canal.

The Tugaloo River and the Seneca River meet at what is known as “The Forks” and form the Savannah River at River Mile 312.

Water discharge in the Savannah River varies considerably both seasonally and annually, even though it is largely controlled by releases from the USACE JST Dam located about 20 miles northwest of Augusta, Georgia. Discharge is typically high in winter and early spring and low in summer and fall, but regulation by upstream reservoirs has reduced natural flow variations. At NSBLD, located 12 miles downstream of Augusta, average annual discharge is about 10,000 cfs. Average discharge at Clyo (Effingham County, Georgia) is 12,040 cfs. Tidal effects extend upstream to approximately RM 45 (Reconnaissance Planning Aid Report on the Savannah River Basin Study, US Fish and Wildlife Service, July 1999).


Hartwell Lake and Dam


R. B. Russell Lake and Dam


J. S. Thurmond Lake and Dam


New Savannah Bluff Lock and Dam

3.0 **DESCRIPTION OF THE SAVANNAH RIVER BASIN USACE PROJECTS**

USACE maintains and operates three large multipurpose projects in the SRB. Hartwell Dam and Lake (55,950 acres at summer Guide Curve) is located 89 miles upstream of Augusta and was filled in 1962. RBR Dam and Lake (26,650 acres at summer Guide Curve) is located 59 miles upstream of Augusta and was filled in 1984. JST Dam and Lake (70,000-acres at summer Guide Curve) is located 22 miles upstream of Augusta and was filled in 1954. Proposed monitoring identified in this plan will occur below JST.

The authorized project for the Savannah River between Augusta and Savannah, Georgia, provides for a navigation channel 9 feet deep and 90 feet wide from the upper end of Savannah Harbor (mile 21.3) to the head of navigation just below the 13th Street bridge in Augusta (mile 202.2). This is a distance of 180.9 miles. The project also includes the NSBLD, located about 12 miles downstream from Augusta. However, by 1980, shipping on the river had virtually ceased, and channel maintenance was discontinued.

The existing authorized Savannah Harbor Navigation Project provides a channel 44 feet deep and 600 feet wide across the ocean bar; 42 feet deep and 500 to 600 feet wide to the vicinity of Kings Island Turning Basin; and 30 feet deep and 200 feet wide to a point l,500 feet downstream of the Houlihan Bridge (US Highway 17).

The terminus of the deep-draft channel in Savannah Harbor is at approximately river mile 21 (Reconnaissance Planning Aid Report on the Savannah River Basin Study, US Fish and Wildlife Service, July 1999).

4.0 **WATER QUALITY IN THE SAVANNAH RIVER**

The Savannah River below JST Dam is classified as "Freshwater" by the South Carolina Department of Health and Environmental Control (DHEC) (Watershed Water Quality Assessment-Savannah River Basin, August 2010, Technical Report No. 02F-10).

The Georgia DNR-EPD has classified the designated use of the main river as "Fishing" waters. The water quality standards for dissolved oxygen, as stated in Georgia's Rules and Regulations for Water Quality Control (GA EPD, 2004), Chapter 391-3-6-.03(6)(c)(i), states that this classification requires:

"A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times for waters supporting warm water species of fish".

USACE-Savannah District has completed installation of a DO injection system within JST Lake. Discharges from JST Dam contain at least 5 ppm of DO throughout the year. That level meets both the Georgia and South Carolina standard for DO levels for those waters. The DO system is not designed to function in Level 4 drought.

EPA has prepared the following Total Maximum Daily Loads (TMDLs) for portions of the Savannah River:

- Fecal coliform – Savannah River in Richmond County
- Lead – Savannah River between Butler & McBean Creeks
- Dissolved Oxygen – Savannah River from the Seaboard Coastline Railroad Bridge (RM 27.4 to the coast). The existing zero discharge TMDL is currently being revised by EPA's 2010 draft TMDL based on Georgia's recently revised dissolved oxygen standard.

Seasonal DO sags occur in the summer months in the estuarine portion of the river. EPA's TMDL for DO calls for zero discharge of oxygen-depleting substances from Augusta to the coast.

South Carolina DHEC classifies the estuarine portion of the river as SB: "Tidal saltwaters".

The Georgia DNR-EPD has classified the designated use of the estuarine portion of the river as "Coastal Fishing."

The DO requirement for South Carolina is a daily average of 5.0 mg/L and a daily minimum of 4.0 mg/L for all of the year. The DO requirement listed on Page 6 for Georgia recently changed to effectively match that of South Carolina.

The State of South Carolina uses the current drought plan Level 3 flow of 3,600 cfs (Larry Turner, South Carolina DHEC) at the Savannah River Augusta gage for the permitting of point source discharges in the Augusta area. This flow is adjusted upward to account for tributary input as one moves down the river. The State of Georgia uses the 7Q10 values of 3,800 cfs at the Augusta gage, 4,160 cfs further downstream at the Millhaven gage and 4,710 cfs at the Clyo gage for the permitting of point source discharges (Paul Lamarre, Georgia DNR-EPD).

5.0 **BIOTIC COMMUNITIES IN THE LOWER SAVANNAH RIVER**

5.1. Fish

Riverine fish habitats in the Savannah River have been highly modified or converted to lacustrine habitat by construction of the three major dams and reservoirs that inundate the upper half of the River Basin. This large-scale habitat conversion changed the relative abundance and diversity of fish species from a system dominated by migratory diadromous fish to more localized riverine and lacustrine-dominated fish communities. A comprehensive five-year fishery survey of existing coastal plain habitats concluded that the lower Savannah River supports an abundant, diversified fish community, but has a low to moderately used fishery (Schmitt and Hornsby 1985). Based on numbers and weight collected the most abundant game fish were largemouth bass, striped bass, chain pickerel, black crappie, yellow perch, redbreast sunfish, bluegill, redear sunfish, warmouth, flier, and pumpkinseed. Important non-game fish include longnose gar, bowfin, white catfish, channel catfish, common carp, spotted sucker, silver redhorse, robust redhorse, striped mullet, and brown bullhead. In numerical terms the most important forage fish are gizzard shad and a number of minnow species. Diadromous fishes inhabiting the lower Savannah River include striped bass, American shad, hickory shad, blueback herring, shortnose sturgeon, Atlantic sturgeon, and the catadromous American eel.

Prior to construction of mainstem Savannah Dams from 1840 to 1984, diadromous fish migrations extended throughout the Piedmont. Historical records document the upstream migration of shad and striped bass to the headwaters of the Savannah River, through the Tugaloo River and up the Tallulah River to Tallulah Falls, Georgia, approximately 384 river miles from the ocean. Sturgeon is known to have migrated well into the Piedmont. A portion of the river was diverted in 1846 at the site of the Augusta Diversion Dam. In 1875, that structure was extended to the entire channel width to create the present Augusta Diversion Dam. That structure restricted inland migration of diadromous species except during high flow periods when the Dam was overtopped. When those conditions occurred, some fish species could continue their upstream migrations. A fish ladder was installed in 1886, but it is presently not considered to be effective in passing fish upstream. Completion of the NSBLD in 1937 further restricted

spawning migrations in many years to below river mile 265, with the exception of high flow periods that occurred during the spawning season. The Stevens Creek Dam, a South Carolina Electric and Gas hydroelectric facility, was constructed 0.9 miles upstream of the Augusta Diversion Dam in 1914, blocking all diadromous fish migrations past that point.

Although greatly reduced from former abundance, diadromous fish are an important and increasing component of the River's sport and commercial fisheries. American shad, blueback herring, and lesser numbers of striped bass and sturgeon migrate to the NSBLD facility, which is the first major obstruction to passage on the river. Some fish have continued to migrate to historical spawning grounds above the facility. Some species pass upstream by swimming through fully-opened dam gates at flows of 24,000 cfs or higher, and by swimming through the navigation lock when it is operated in a manner suitable for fish passage. The NSBLD restricts passage of sturgeon to periods when high flows overtop the riverbanks during the spawning season.

Presently, the lower Savannah River provides extremely important striped bass habitat. Although the majority of historical upstream spawning habitat for striped bass has been inundated by major reservoirs, some remaining rocky rapids habitat exists in the Augusta Shoals from just below NSBLD up to Stevens Creek Dam. After construction of mainstem dams and prior to initiation of a Tidegate operation in 1977, the primary spawning area for striped bass in the Savannah River system was the tidal fresh water zone approximately 18-25 miles from the river mouth, specifically the Little Back River (McBay 1968; Rees 1974). Salinity changes due to the Tidegate operation (1977-1992) reduced the extent of this tidal freshwater zone. Studies indicated significant declines in the numbers of striped bass eggs and larvae in the lower Savannah River system during this period. These declines were related to increased salinity and modified transport patterns caused by the Tidegate and associated hydrologic modifications (Van Den Avyle et al. 1990, Winger and Lasier 1990).

5.2. Wildlife

Palustrine emergent wetlands provide habitat for many bird species. Resident, transient, and migrating birds of both terrestrial and aquatic origin utilize food and shelter found in this community. Some species use freshwater marshes for nesting and breeding. Waterfowl feed upon fresh marsh vegetation, mollusks, insects, small crustaceans, and fish found in the fresh marsh community. Wading birds such as the wood stork, great blue heron, little blue heron, green heron, snowy egret, and great egret also heavily utilize the tidal freshwater marsh.

The study area provides excellent habitat for a large number of reptiles and amphibians. Wetland habitats support many kinds of frogs including the bullfrog, bronze frog, southern leopard frog, several species of tree frogs, cricket frogs, and chorus frogs. Turtles found in the wetlands include the river cooter, Florida cooter, pond slider, eastern chicken turtle, snapping turtle, mud turtle, and stinkpot. Snakes found in the wetlands include the red-bellied water snake, banded water snake, brown water snake, eastern mud snake, rainbow snake, and eastern cottonmouth. The American alligator can be observed in streams and ponds of the Coastal Plain study area.

5.3. Endangered Species

Federal Endangered, Threatened, and Candidate species that are likely to occur in the SRB study area are listed in Table 1 (Reconnaissance Planning Aid Report on the Savannah River Basin Study, US Fish and Wildlife Service, July 1999). State species are listed in Table 2.


Wetland Habitat

5.4. Special Biological Areas

The tidal fresh marsh at the Savannah NWR supports an extremely diverse plant community providing food, cover and nesting habitat for a wide variety of wildlife species. Tidal freshwater marsh is relatively scarce in comparison to coastal brackish and salt marshes. Past harbor modifications, including harbor deepening, have greatly increased salinity levels throughout much of the Savannah NWR and reduced the quantity of tidal freshwater marsh. According to the USFWS, the Savannah NWR contained about 6,000 acres of tidal freshwater marsh when it was established in 1927. By 1997, due to the cumulative impacts of development, harbor deepening, and sea level rise, tidal freshwater marsh had declined to 2,800 acres, a reduction of 53 percent (Reconnaissance Planning Aid Report on the Savannah River Basin Study, US Fish and Wildlife Service, July 1999). The freshwater marsh areas had historically been comprised of bottomland hardwoods, but were cleared in the 1800's for agricultural purposes, such as the rice culture. The leveled and diked areas were abandoned when the rice culture was no longer profitable after the Civil War. Those sites partially filled and now support a wide variety of plant and animal species.

Prior to 1977, the Savannah River supported the most important naturally-reproducing striped bass population in the State of Georgia, but production of striped bass eggs in the Savannah River estuary declined by about 95 percent. This was at least partially the result of increases in salinity and loss of suitable spawning habitat throughout most of the Little Back River and the lower Savannah River (Reconnaissance Planning Aid Report on the Savannah River Basin Study, US Fish and Wildlife Service, July 1999). It was hoped that the Tidegate restoration project would improve most of these conditions. The Corps' cessation of operation of the Tidegate (leaving the Tidegate open beginning in 1990) restored salinity levels in Back River to those experienced in the 1980's. Annual stocking efforts by the GA DNR have been very successful in increasing the number of striped bass in the lower Savannah River, and current population levels approach historic levels. After a 17-year closure, the striped bass fishery was partially reopened in October 2005.

Table 1: Federal Endangered, Threatened and Candidate Species Likely to Occur in the Savannah River Basin Study Area

SPECIES	SCIENTIFIC NAME	FEDERAL STATUS
MAMMALS		
Indiana Bat	*Myotis sodalis*	E*
West Indian manatee	*Trichechus manatus*	E
BIRDS		
Red cockaded woodpecker	*Picoides borealis*	E
Piping plover	*Charadrius melodus*	T**
Wood stork	*Mycteria americana*	E
Kirtland's warbler	*Dendroica kirtlandii*	E
REPTILES		
Eastern indigo snake	*Drymarchon corais couperi*	T
AMPHIBIANS		
Flatwoods salamander	*Ambystoma cingulatum*	T
Fish		
Shortnose sturgeon	*Acipenser brevirostrum*	E
Atlantic sturgeon	*Acipenser oxyrinchus*	C***
PLANTS		
Canby's dropwort	*Oxypolis canbyi*	E
Chaff seed	*Schwalbea americana*	E
Schweinitz's sunflower	*Helianthus schweinitzii*	E
Small whorled pogonia	*Isotria medeoloides*	T
Pondberry	*Lindera melissifolia*	E
Rough leaved loosestrife	*Lysimachia asperulaefolia*	E
False Poison Sumac	*Rhus michauxii*	E
Bunched arrowhead	*Sagittaria fasciculata*	E
White irisette	*Sisyrinchium dichotomum*	E
Dwarf flowered heartleaf	*Hexastylis naniflora*	T
Mountain sweet pitcher plant	*Sarracenia rubra ssp. jonesii*	E
Harperella	*Ptilimnium nodosum*	E
Swamp pink	*Helonias bullata*	T
Smooth coneflower	*Echinacea laevigata*	E
Seabeach amaranth	*Amaranthus pumilus*	T
Persistent trillium	*Trillium persistens*	E
Relict trillium	*Trillium reliquum*	E
Little amphianthus	*Amphianthus pusillus*	T
Miccosukee gooseberry	*Ribes echinellum*	T
Bog asphodel	*Narthecium americanum*	C***

* Endangered

** Threatened
*** Candidate

This page intentionally left blank.

Table 2: Georgia and South Carolina Rare, Threatened and Endangered Species Occurring in Counties Adjacent to the Savannah River

SCIENTIFIC NAME	COMMON NAME	GA STATE STATUS	SC STATE STATUS
Acipenser brevirostrum	Shortnose Sturgeon		FE[1]/SE[2]
Aimophila aestivalis	Bachman's Sparrow	R[3]	
Alasmidonta arcula	Altamaha Arcmussel	T	
Amblyscirtes reversa	Reversed Roadside Skipper		N3N4
Ambystoma cingulatum	Flatwoods Salamander		FT[4]/SE
Aneides aeneus	Green Salamander	R	
Autochton cellus	Golden-Banded Skipper		N4
Caretta caretta	Loggerhead		FT/ST[5]
Carex biltmoreana	Biltmore Sedge	T	
Carex manhartii	Manhart's Sedge	T	
Carex misera	Wretched Sedge	T	
Ceratiola ericoides	Rosemary	T	
Chamaecyparis thyoides	Atlantic White-Cedar	R	
Charadrius wilsonia	Wilson's Plover	R	
Clemmys guttata	Spotted Turtle	U	
Clemmys guttata	Spotted Turtle		ST
Corynorhinus rafinesquii	Rafinesque's Big-Eared Bat	R	SE
Cymophyllus fraserianus	Fraser's Sedge	T	
Cyprinella callitaenia	Bluestripe Shiner	T[6]	
Cypripedium acaule	Pink Ladyslipper	U[7]	
Cypripedium parviflorum var. Parviflorum	Small-Flowered Yellow Ladyslipper	U	
Cypripedium parviflorum var. Pubescens	Large-Flowered Yellow Ladyslipper	U	
Draba aprica	Open-Ground Whitlow-Grass	E[8]	
Echinacea laevigata	Smooth Coneflower		FE/SE
Elanoides forficatus	Swallow-Tailed Kite	R	
Elliottia racemosa	Georgia Plume	T	
Elliptio fraterna	Brother Spike		SE
Epidendrum conopseum	Green-Fly Orchid	U	
Fusconaia masoni	Atlantic Pigtoe Mussel	E	
Gopherus polyphemus	Gopher Tortoise		SE
Haematopus palliatus	American Oystercatcher	R	
Hydrastis canadensis	Goldenseal	E	
Hymenocallis coronaria	Shoals Spiderlily	E	
Isoetes tegetiformans	Mat-Forming Quillwort	E	
Isotria medeoloides	Small Whorled Pogonia		FT/ST
Lasmigona decorata	Carolina Heelsplitter		FE/SE
Lindera melissifolia	Pondberry		FE/SE
Lindernia saxicola	Rock False Pimpernel	E	
Litsea aestivalis	Pondspice	T	
Lysimachia fraseri	Fraser's Loosestrife	R	
Marshallia ramosa	Pineland Barbara Buttons	R	
Moxostoma robustum	Robust Redhorse	E	
Mycteria americana	Wood Stork		FE/SE
Myotis leibii	Eastern Small-Footed Myotis		ST
Myotis sodalis	Indiana Myotis		FE/SE

SCIENTIFIC NAME	COMMON NAME	GA STATE STATUS	SC STATE STATUS
Nestronia umbellula	Indian Olive	T	
Notropis hypsilepis	Highscale Shiner	T	
Notropis photogenis	Silver Shiner	E	
Notropis scepticus	Sandbar Shiner	R	
Oxypolis canbyi	Canby's Dropwort	E	
Oxypolis canbyi	Canby's Dropwort		FE/SE
Phenacobius crassilabrum	Fatlips Minnow	E	
Physostegia leptophylla	Tidal Marsh Obedient Plant	T	
Picoides borealis	Red-Cockaded Woodpecker		FE/SE
Plethodon websteri	Webster's Salamander		SE
Pseudobranchus striatus	Dwarf Siren		ST
Ptilimnium nodosum	Harperella		FE/SE
Quercus oglethorpensis	Oglethorpe Oak	T	
Rana capito	Gopher Frog		SE
Ribes echinellum	Miccosukee Gooseberry		FT/ST
Sanguisorba canadensis	Canada Burnet	T	
Sarracenia flava	Yellow Flytrap	U	
Sarracenia minor	Hooded Pitcherplant	U	
Sarracenia purpurea	Purple Pitcherplant	E	
Sarracenia rubra	Sweet Pitcherplant	E	
Schisandra glabra	Bay Starvine	T	
Schwalbea americana	Chaffseed		FE/SE
Scutellaria ocmulgee	Ocmulgee Skullcap	T	
Sedum pusillum	Granite Stonecrop	T	
Senecio millefolium	Blue Ridge Golden Ragwort	T	
Shortia galacifolia	Oconee Bells	E	
Speyeria diana	Diana		N3
Sterna antillarum	Least Tern		ST
Stewartia malacodendron	Silky Camellia	R	
Stylisma pickeringii var. Pickeringii	Pickering's Morning-Glory	T	
Toxolasma pullus	Savannah Lilliput	T	
Trichechus manatus	Manatee		FE/SE
Trillium persistens	Persistent Trillium		FE/SE
Trillium reliquum	Relict Trillium		FE/SE
Waldsteinia lobata	Piedmont Barren Strawberry	T	
Xerophyllum asphodeloides	Eastern Turkeybeard	R	

Sources: Georgia EPD and South Carolina DNR

1 FE - Federal Endangered

2 SE - State Endangered (official state list-animals only)

3 R - Rare

4 FT - Federal Threatened

5 ST – State Threatened (official state list-animals only)

6 T - Threatened

7 U - Unusual (thus deserving of special consideration)

8 E – Endangered

6.0 **MONITORING EFFORTS**

Monitoring is critical for evaluating the effects of past and ongoing management actions for the SRB. Monitoring should seek to answer resource-related questions that are tied to the compliance requirements for USACE and their corresponding operations at Hartwell, Russell and primarily JST Dam, due to its releases to the lower Savannah River. Monitoring along the basin often focuses on relationships between streamflow and key ecosystem attributes. A number of physical and biological aspects of the basin are candidates for monitoring. There are different monitoring scales that exist (e. g. whole river, reach, site), different monitoring measurement frequencies (i. e., daily, weekly, monthly, annual, decadal) and objectives for monitoring (e.g., long-term trend analysis or short-term episodic monitoring that can be in conjunction with particular flow events or experiments).

6.1. Past Monitoring

Monitoring along the lower SRB occurs regularly by various agencies. Many of these past efforts are included below.

The area and number of subpopulations of the Shoals spider lily and also its deer predation has been monitored by ASU and TNC.

The SNSA has monitored various water quality parameters in the upper floodplain and Augusta Shoals area. These include dissolved oxygen, water temperature, discharge, Seston, chlorophyll, phaeopigment, macroinvertebrates, fecal coliform, pH, conductivity, turbidity, depth of water in the Augusta Canal and depth of water at the shoals. River Channel Profiles and Light Profiles have also been produced by SNSA for the upper floodplain and shoals.

Upper floodplain mussel recruitment and mussel community integrity has been monitored by USFWS, TNC, GADNR and SCDNR.

In 2006, the USFWS conducted a freshwater mussel survey in the Savannah River to determine species composition and distribution of mussels. The objective of the 2006 mussel survey was to estimate species composition and distribution in the Savannah River; however, the surveyors only visited a small portion of the available habitat in the river. Specifically, the study encompassed the portion of the river from the Augusta Shoals region (river mile 203) near the Fall Line downstream to the tidewater region (river mile 22.8) near Savannah. The survey evaluated 39 sites using both shallow water (snorkeling and grubbing) and deep water (SCUBA) survey techniques. A total of 26 freshwater mussel species were identified during the survey efforts. The 2006 discovery of four species not previously known to occur in South Carolina demonstrates the gross lack of knowledge regarding the mussel fauna of the Savannah River. With the exception of sites within the Augusta Shoals area, mussels were generally unevenly distributed in the surveyed areas, which is reflective of the distribution and quality of

microhabitats within a particular river segment. In general mussels were most abundant in the thalwag habitats at the base of the river bank, and rare to absent in the shifting sand dominated runs in the center of the channel.

Atlantic pigtoe (*Fusconaia masoni*) and Savannah liliput (*Toxolasma pullus*) were both observed in the 2006 mussel survey. Both of these species are experiencing range-wide declines. Atlantic pigtoe was found only in the Augusta shoals. This species has not been observed in any other Georgia or South Carolina Rivers in the many years. The population of Savannah liliput upstream of Little Hell boat landing (Allendale County) may be the largest remaining population of this species. Savannah liliput in the Savannah River is found primarily in cutoff bends and sloughs. Preliminary observations indicate that much of this habitat is lost or degraded due to loss of connectivity with the main river at flows below 4,000 cfs at Augusta.

The SNSA has monitored various water quality parameters in the lower floodplain. These include dissolved oxygen, flux in temperature, total suspended sediments, water temperature, discharge, Seston, chlorophyll, phaeopigment, macroinvertebrates, fecal coliform, pH, conductivity and turbidity. River Channel Profiles, Light Profiles and meteorological data have also been produced by SNSA for the lower floodplain.

Floodplain monitoring for the altered floodplain tree community, the percent of upland species that are in the bottomland, fish access to floodplain habitats, the intact macroinvertebrate community (guild and integrity indices), mussels and inundation of the floodplain forest habitat was performed by TNC, UGA and SREL.

The characteristic plant community/diversity of the estuary has been monitored by SSU and the chloride concentrations at a municipal water intake have been monitored by the City of Savannah. Dissolved oxygen in the estuary/Savannah Harbor area has been monitored by Savannah District and GADNR CRD.

Diadromous intact fish populations (sturgeon, shad, American eel and striped bass) and shortnose sturgeon seasonal movement (including habitat selection) have been monitored by TNC, SCDNR and GADNR. The condition of striped bass spawning females has been monitored by GADNR. In 2006, TNC monitored the movement of tagged shortnose sturgeon fish when flows exceeded the height of the dam but stayed within the river banks. TNC could not identify any passage of shortnose sturgeon upstream of the NSBLD under those flow conditions. Without access to the upstream shoal spawning habitat, gravel bars downstream of the NSBLD likely represent the only remaining spawning habitat for shortnose sturgeon in the Savannah River.

6.2. Near Future Monitoring

Various agencies have been considering a sequence of monitoring for the SRB in association with experimental reductions in flow from JST. The following pertinent questions and statements were considered in the development of a monitoring plan by the various agencies:

What is the relative influence of canal operation vs. dam operation on shoal inflow?

How much habitat is available for Shoals spiderlily seed germination at low flow increments? The water surfaces relative to the lily roots could be measured and the aerial extent of lily patches could be measured and plotted as a function of water level changes.

How does suitable spawning habitat for suckers, including robust redhorse, change as flows decline? At four different flows, velocity and depth transects could be measured. The amount of habitat along the transects that is considered suitable spawning habitat could be measured and plotted as a function of estimated shoal inflow.

How does the amount of suitable sturgeon spawning habitat/ gravel bar habitat change below NSBLD as a consequence of flow declines?

Are flow thresholds encountered that affect oxbow-mainstem connectivity, oxbow habitat extent, and oxbow water quality? What are they?

To what degree is salinity at the National Wildlife Refuge intake affected by reductions in freshwater inflow?

Does dissolved oxygen in the Augusta Shoals decline below state standards at night as a consequence of low flows and high BOD?

Are the freshwater marshes that adjoin the National Wildlife Refuge affected by the range of drought flows prescribed by the DCP?

After considering the above questions and statements a proposal to monitor the habitat and biotic effects of drought flow releases during an experimental flow reduction similar to that depicted below was developed. Monitoring would occur at each discharge level identified in the 2012 Drought Plan Revision for the Savannah River Basin, and at additional discharge levels below those already approved but under consideration as a component of a future study. A proposal also exists to perform the monitoring in conjunction with the November to January Level 3 reduction to 3,100 cfs if that reduction occurs. The monitoring that would be conducted is listed below for each of the lower Savannah River segments.

Discharge Level (cfs at Thurmond Dam)	**Date**	**Description**
3800	Sept 15	Initiate sampling/measurements
3600	Oct 7	1 week at each increment
3100	Oct 14	2012 SRB Drought Revision level
2500	Oct 21	Experimental level
3100	Nov 1	Return to approved level

Monitoring under this proposal that has been identified for the Augusta Shoals includes: real time water quality, boat ramp locations, seedling counts, real time flow, fisheries, dissolved oxygen, temperature, pH, Ortho Phosphorus and Nitrate.

Monitoring under this proposal that has been identified for the floodplain (Clyo up to New Savannah Bluff Lock and Dam) includes: real time water quality, mussels including Toxolasma (lilliputs), oxbow connectivity, boat ramp locations, sturgeon concentrations, fisheries, dissolved oxygen, temperature and conductance below outfalls.

Monitoring under this proposal that that has been identified for the estuary (Savannah River up to Clyo) includes: real time water quality, boat ramp locations, fisheries, dissolved oxygen, salinity and temperature. Sonde (probes) may be used in some locations to measure temperature, conductivity, salinity, dissolved oxygen, pH, turbidity and depth.

There is also a proposal to look at the zooplankton of the River.

6.3. Future Monitoring

Any efforts listed in Section 6.2 and not completed in conjunction with the listed flow prescription become future monitoring opportunities. Additional monitoring opportunities that exist and have not been pursued include: 1) the presence/condition of the shallow fast fish guild and shallow slow fish guild, 2) the upriver shift of keystone species, such as crabs, 3) crab, fish and shrimp primary and secondary production, 4) the percent cover of salt marsh, brackish marsh, bare soil, developed land and dredge spoil, 5) the presence and absence of aquatic invasive species and pathogens, 6) the in-channel fish community, 7) the area of foraging, nesting habitat and predation for keystone bird species and 8) the intact mussel community. Flow prescriptions (low or high) are not specifically required for these eight efforts.

The sturgeon spawning habitat at the two gravel bars should be systematically monitored. After the SHEP mitigation NSBL&D fish passage becomes operational, sturgeon spawning usage of the gravel bars before and after can be compared. Also, monitoring eight or ten of the existing Decadal River Cross-Sections can be performed. Gravel bar and Cross-Section monitoring would require varying levels of low flow with the level of flow based on the desired area to access.

Scientists at Clemson University have realized that better sensors are needed to keep track of the environment. They are developing and plan to deploy sensors in datasondes in the Savannah River that will be connected to each other and to Clemson through a data transfer system as part of what they refer to as their Intelligent River Research program. Each datasonde will contain a small battery-operated computer, float about three feet below the surface, be anchored to the river floor and will be able to collect, store and send data on river conditions including water temperature, dissolved oxygen, flow rate, turbidity, oxygen levels, pollutants, conductivity, depth and storm water runoff. A large number of sensors would be configured into a network. The number has not been determined, but could eventually approach 1,000. Information would be displayed within minutes of an incident and a database will be created for anyone to access and reference.

7.0 **CONCLUSIONS**

Identifying a set of future monitoring opportunities for the Lower Savannah River Basin has recently been under consideration by various agencies. Those actions identified in Section 6.2 will probably be initially pursued. Any of these efforts that are not pursued, or not completed, can be considered with those in Section 6.3 if a similar low flow prescription is required. Preferences are not included in Section 6.3 as system inflows and lake levels will likely play a role in identifying the next monitoring opportunity.

8.0 **LITERATURE CONSULTED**

Applied Technology and Management, 1998. Savannah Harbor Expansion Environmental Impact Statement. Georgia Ports Authority. Savannah, Georgia. 244 pp.

Aquatic Plant Management Plan, US Army Corps of Engineers, Savannah District, Calendar Year 2010 Update.

Collins, M.R., W.C. Post, D.C. Russ, and T. I. J. Smith. 2002. Habitat use and movements of juvenile shortnose sturgeon in the Savannah River, Georgia-South Carolina. Transactions of the American Fisheries Society. 131:975-979

Collins, M.R., D. Cooke, B. Post, J. Crane, J. Bulak, T. Grieg, and J. Quattro. 2003. Shortnose sturgeon in the Santee-Cooper Reservoir system, South Carolina. Transactions of the American Fisheries Society. 132:1244-1250.

Conrads, P. A., E. A. Roehl, R. C. Daamen, and W. M. Kitchens, 2006. Simulation of water levels and salinity in the rivers and tidal marshes in the vicinity of the Savannah National Wildlife Refuge, Coastal South Carolina and Georgia. U.S. Geological Survey Scientific Investigations Report 2006–5187, 134 p.; available online at *http://pubs.usgs.gov/sir/2006/5187/*

Cooney, T. W., K. H. Jones, P. A. Drews, S. W. Ellisor and B. W. Church, 1998. Water Resources Data for South Carolina - Water Year 1998. US Geological Survey Report SC-98-1. Columbia, South Carolina. 546 pp.

Draft Fish and Wildlife Coordination Act Report on the Savannah River Basin Comprehensive Study, US Fish and Wildlife Service, October 2003.

Ecosystem Flow Recommendations for the Savannah River below Thurmond Dam, Final Report from April 1-3, 2003, Scientific Stakeholders Workshop, September 2003.

Environmental Assessment for Savannah River Basin Drought Contingency Plan Update, US Army Corps of Engineers, Savannah District, August 2006.

Environmental Assessment for Savannah River Basin Drought Plan Revision, US Army Corps of Engineers, Savannah District, July 2012.

Environmental Assessment for Temporary Deviation, Drought Contingency Plan, Savannah River Basin, US Army Corps of Engineers, Savannah District, November 2008.

Glimpse, Clemson University, Spring 2012. 14-21 pp.

Higgins, J. V., C. P. Konrad, A. Warner, and J. T. Hickey, 2011. A Framework for Monitoring, Reporting and Managing Dam Operations for Environmental Flows at Sustainable Rivers Project Sites.

Jackson, Rhett, University of Georgia, phone conversation of 14 Oct 2012.

Krueger, Eric, The Nature Conservancy, e-mail correspondence of 16 Aug 2011.

Reconnaissance Planning Aid Report on the Savannah River Basin Study, US Fish and Wildlife Service, July 1999.

Savannah River Basin Drought Contingency Plan, US Army Corps of Engineers, Savannah District, March 1989.

Science Strategy for the Bill Williams River Corridor, Bill Williams River Corridor Steering Committee, January 2011 Review Version.

Summary Report Supporting the Development of Ecosystem Flow Recommendations for the Savannah River below Thurmond Dam, June 2003. University of Georgia Team.

Sustainable Rivers Monitoring Plan
Savannah River Basin
Appendices

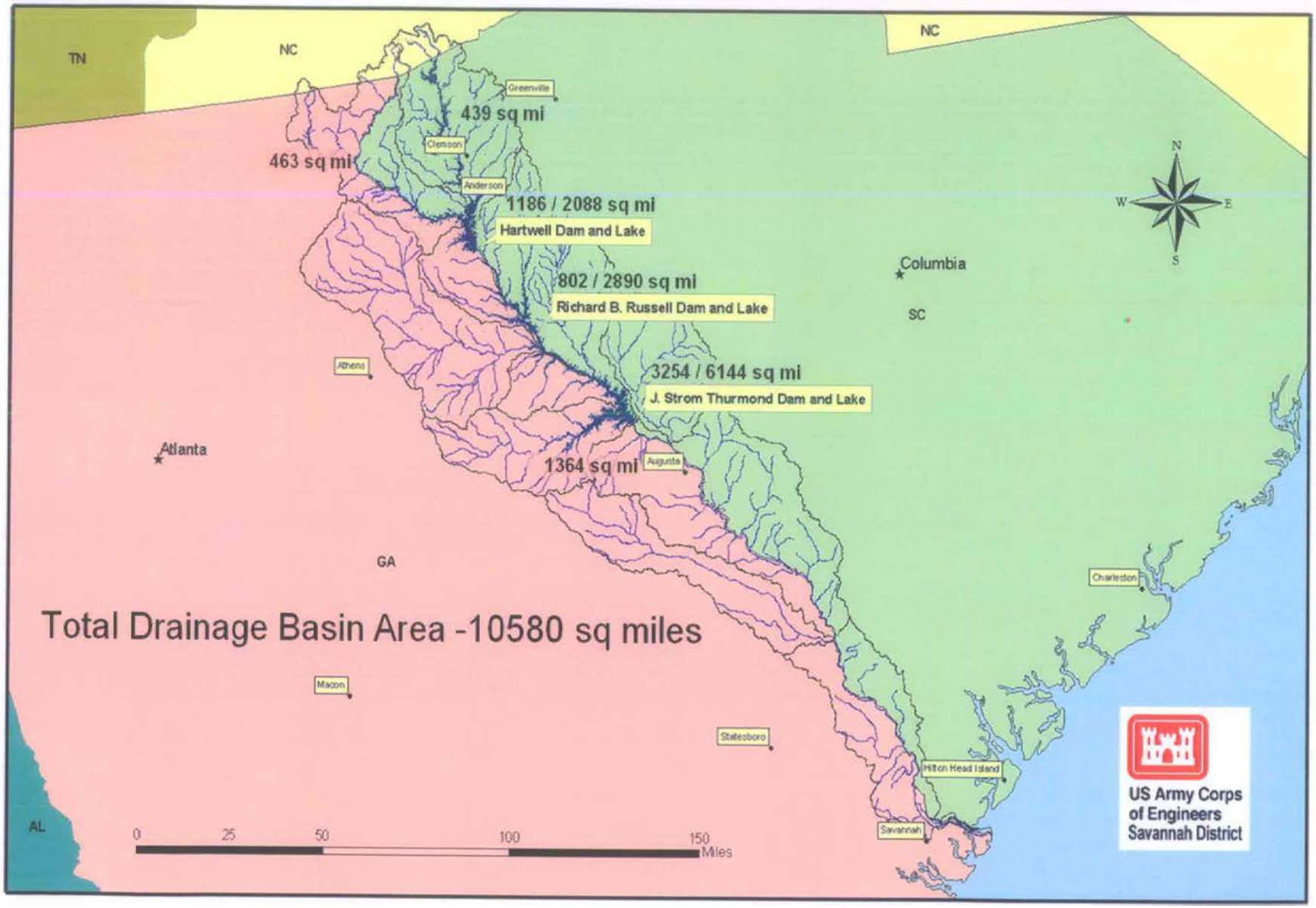
US Army Corps of Engineers
Savannah District

September 2012

LIST OF APPENDICES

APPENDIX A

SAVANNAH RIVER BASIN MAP


TN
NC
NC
Greenville
439 sq mi
463 sq mi
Clemson
Anderson
1186 / 2088 sq mi
Hartwell Dam and Lake
802 / 2890 sq mi
Richard B. Russell Dam and Lake
3254 / 6144 sq mi
J. Strom Thurmond Dam and Lake
1364 sq mi
Augusta
Columbia
SC
N
W
E
S
Athens
Atlanta
GA
Total Drainage Basin Area -10580 sq miles
Charleston
Macon
Statesboro
Hilton Head Island
Savannah
AL
0
25
50
100
150
Miles
US Army Corps
of Engineers
Savannah District

APPENDIX B

RECOMMENDATIONS

FROM

2003 ECOSYSTEM FLOW WORKSHOP

FOR

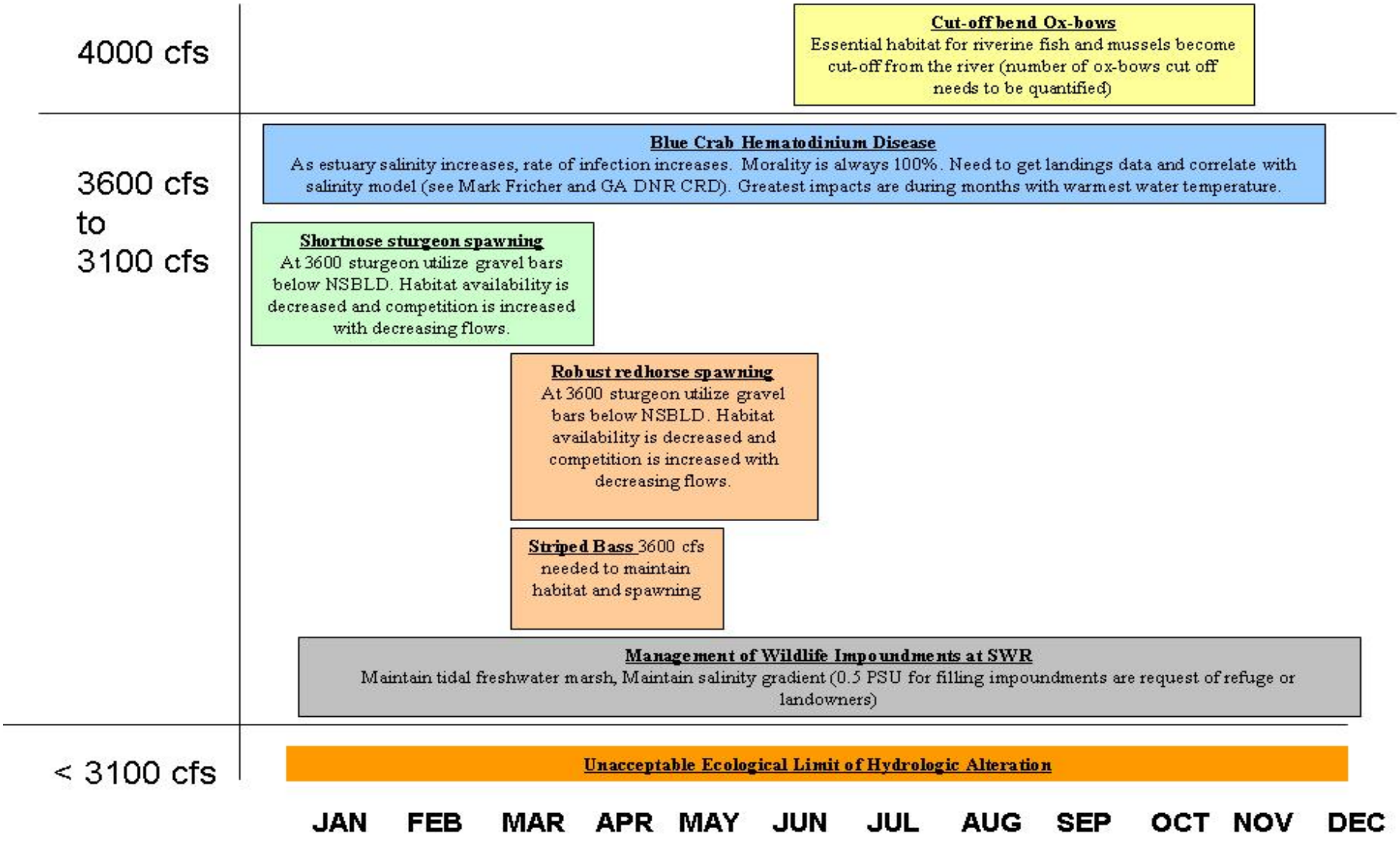
SAVANNAH RIVER

DOWNSTREAM OF

THURMOND DAM

Ecosystem Flow Recommendations

Savannah River, below Thurmond Dam (Extreme Low Flows)



APPENDIX C

LIST OF PREPARERS

LIST OF PREPARERS

Larry Olliff Biologist	USACE Planning - Environmental