HYDROLOGIC MODIFICATIONS TO THE LOWER SAVANNAH RIVER

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Abstract. This project uses existing flow and river morphology data to evaluate how the reservoir system and navigational dredging have altered the hydrology and form of the river over the last 50 years. This analysis is being conducted to support a joint Nature Conservancy – Corps of Engineers program to determine ways in which the management of dams can be changed to lessen the impact on natural systems, while continuing to provide benefits to people such as flood control, electricity generation, and recreation. Two USGS gages on the Savannah River below Augusta provide sufficient data to characterize the hydrology of the lower Savannah prior to and following installation of the Savannah River dams above Augusta. The operation of the dams has greatly reduced peak flows in the lower river. Under current operating rules, the 100-year flow is approximately the same magnitude as the pre-dam 2-year flow. River-floodplain interactions probably have decreased commensurately. Conversely, 7-day low flows in the lower river have increased greatly since dam operations began. In addition to these hydrologic alterations, the lower Savannah has been directly modified through dredging and channelization to allow barge traffic to reach Augusta. Dredging and navigation efforts have been suspended for more than a decade due to a lack of demand for barge navigation. Approximately 26 miles or 13% of the river's original length has been removed due to the creation of forty navigation cuts.

INTRODUCTION

The Savannah River Basin drains approximately 10,600 square miles and includes portions of North Carolina, South Carolina, and Georgia. The headwaters originate in the Blue Ridge Mountains and flow into the Seneca and Tugaloo Rivers. These rivers join and are then impounded by Hartwell Dam to create Lake Hartwell. The Savannah River begins below this reservoir and flows across the Piedmont where it is dammed two more times. It then crosses the Fall Line at Augusta Shoals and flows through the Coastal Plain before discharging into the Atlantic Ocean at Savannah, GA.

The Lower Savannah River is the reach stretching from below Thurmond Dam (just north of Augusta) to the estuary (beginning below Houlihan Bridge on Hwy 17) and collects water from 3,600 square miles below Thurmond Dam. The reach is 181 miles in length (USACE, 1992). Since the early 1900's, the river has been altered in several ways to meet growing demands of human populations in the basin.

MODIFICATIONS

Throughout most of the 20th century, the river was channelized and dredged to facilitate navigational needs from Savannah to Augusta. Since 1954, three dams have been installed on the Savannah River for the purposes of reducing flood damage, creating recreational opportunities, creating habitat for fish and wildlife, generating hydropower, and supplying water for the public. Hartwell Dam, which creates Lake Hartwell, is the northernmost dam and was completed in 1963. The next impoundment is Lake Russell, which was filled in 1983 after the completion of the Richard B. Russell Dam. The flows released from these two dams are of little importance to the flow modifications to the Lower Savannah River because of the presence of Clarks Hill Reservoir, which is impounded by Thurmond Dam. The oldest of the three, Thurmond Dam was completed in 1954. It re-regulates the flows released from the upper two dams making their management regimes' inconsequential to the Lower Savannah River. So, in dealing with flow modifications to the Lower Savannah River we will only consider releases from Thurmond dam.

The Nature Conservancy is currently sponsoring a multidisciplinary project entitled

"Ecosystem Flow Alternatives for the Savannah River Below Thurmond Dam." The team working on this project is in the process of assembling data necessary to make management recommendations to create more ecologically suitable flow releases at Thurmond Dam. A panel of experts will meet at a workshop in Augusta, GA on April 1-3 to develop these management alternatives. Floodplain ecology, aquatic ecology, estuarine ecology, and river hydrology are disciplines this project covers. We are interested in evaluating the flow modifications resulting from Thurmond Dam. This will enable us to provide a before and after glimpse of flow conditions for those working in the other disciplines.

CONSEQUENCES

Dredging and Channelization

Dredging and channelization have caused severe modification to the Lower Savannah River's original form. Dredging operations, conducted to maintain a navigation channel nine feet deep and ninety feet wide from river mile 21.3 to 202.2, ceased in 1979 due to a lack of demand for barge traffic between Savannah and Augusta (USACE, 1992). The Corps of Engineers has identified forty cut-off bends that were created to shorten and straighten the navigation route (Table 1). The creation of these cuts has removed approximately 13% of the Lower Savannah River's original 204.4 miles. Reconnecting the cut-off bends to the main channel is a possibility for mitigating the problems associated with their removal. The Corps of Engineers began restoring bend 3 in 2002 and are considering restoring 11 other cut-off bends.

Thurmond Dam

Upon completion, Thurmond dam immediately modified the natural flow regime of the Lower Savannah River in several ways. The hydrograph became very dampened, meaning that the previous variation in flows were removed. Peak flows, which are essential for floodplain inundation and channel flushing, were reduced significantly. Additionally, low flows increased, reducing the frequency and severity of low flow periods in the river. The dams also appear to cause a 10% reduction in mean annual flow due to increased evaporation (Figure 6).

Figures 1 and 2 illustrate the dampening affect the dam has on the hydrograph. The difference in the peaks and troughs can be seen to be in excess of

Table 1. Cut-off bends of the Lower Savannah River

Cut #	Cut-Off Bend Name	River Mile	Yr. Created	Length (ft)
-	Fritz Cut	183.5	Prvt - 1889	8000
-	Bailey's Cut	181.9	Prvt - 1921	7100
24	Beckum's Cut	181.5	1959	3,137*
23	Lower Silver Bluff Landing	173.3	1959	3150
22	Gray's Landing	169.5	1959	3600
21A	Eagle Point	169	1976	8400
21	Cox Point	153.2	1959	4350
20	Cunningham Point	137.5	1959	3100
19C	Sweetwater Cut	136.5	1976	2484
19B	Catfish Hole Point	136	1959	3900
19A	Devil's Elbow	135.5	1959	3500
19	Swift Cut	135.3	1959	2200
-	Little Hell Landing	134.5	Nat Cut-off	4,000*
18B	Little Randall Point	128.5	1960-61	6,275*
18A	Fat Meat Point	120.8	1960-61	4400
18	Green Log (Egg) Point	112.4	1960-61	3000
17	Dick's Lookout Point	107	1960-61	3500
16	Cook's Field Point	102.8	1960-61	3900
15A	Wildcat Point	102.2	1960-61	5359
15	Seven-day Baptist Point	101.1	1960-61	1,438*
14A	Miller's Old Lake	100.2	Nat Cut-off	3,529*
14	Whirligig Point	99.9	1960-61	3000
13	Pfeiffers Landing	93.8	1960-61	3,450*
12	Thompsons Cow Fold Point	92.8	1960-61	6000
11	Mosquito Camp Point	88.8	1960-61	5100
10	Poor Robin Upper Point	87.1	1960-61	2100
9A	Poor Robin Lower Point	85.2	1960-61	2000
9	Ware Creek Cut	85.4	1960-61	2500
8C	Blanket Point	81	1960-61	7600
8B	Wildcat Cut	78.6	1960-61	8100
8A	Duck Cut	65	Natural??	6,536*
8	Hog Nose Point	62.3	1960-61	6100
7A	McKenzie's Camp	59.7	1960-61	2,353*
7	Bowl Maker Point	51.4	1962	3900
6	Big Keiffer Point	43.2	1962	2800
5	Bay Bush Point	41.6	1962	1300
4	Flat Ditch Point	41.3	1962	7,059*
3	Hickory Bend	40.9	1962	2,092*
2	Pine Tree Camp Point	37.2	1962	2800
1	Moody Cut	31.4	1962	6000
			Total (ft)	**139943**
			Total (Miles)	**26.5**

* Lengths found in: US Army Corps of Engineers, Savannah District, South Atlantic Division. April 1992. Lower Savannah River Environmental Restoration: Reconnaissance Report. Appendix A.

All other bend lengths measured from aerial photography.

90,000 cfs in Figure 1 (pre-dam), while the maximum observed difference in Figure 2 (post-dam) is approximately 45,000 cfs. The peaks and troughs are not only reduced, but the natural flashiness of the hydrograph has been almost entirely removed. These graphs show that the sporadic nature of the pre-dam hydrograph has been replaced by a much more predictable behavior. Annual peak flows have been curbed sharply since the installation of Thurmond Dam. Similar to the pre- and post-dam hydrograph, Figure 3 shows a reduction in both peak flows and their variation. The maximum peak flows observed before the dam was installed have been reduced by a factor greater than three. Without significant flood pulses, the river loses its ability to move sediment, flush woody debris, naturally shape its channel, and deliver water to the floodplain.

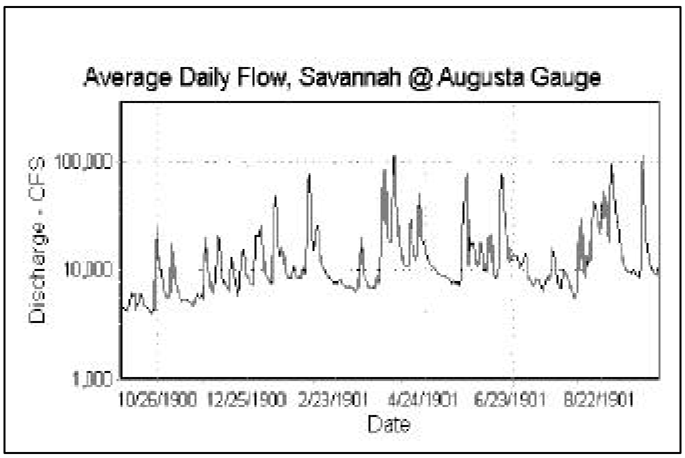

Figure 1. Average daily flow for Water Year 1901, USGS gage #02197000.

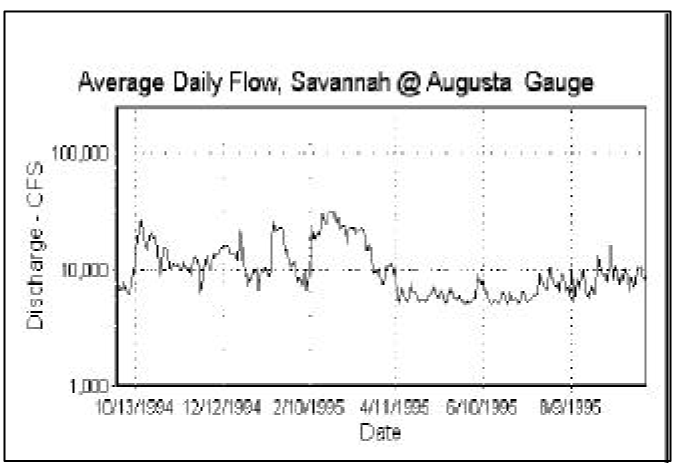

Figure 2. Average daily flow for Water Year 1995, USGS gage #02197000.

The flow return period of the Lower Savannah River has been increased as a result of regulation at Thurmond Dam. Figure 4 illustrates the pre-dam 2-year flow being approximately equal to the post-dam 100-year flow. In other words, flows that should occur every other year are now occurring only once in a hundred years.

The dam has also modified characteristics of the river during drought conditions. Figure 5 illustrates that the 7-day low flows (derived by Dr. John Dowd's RiverStat software) have increased since dam installation. The annual pre-dam low flow now occurs only once in approximately every 5 to 7 years according to Figure 5. Even more remarkable is the fact that the current 100-year, 7-day low flow is approximately equal to the pre-dam's 1.5-year low flow. This could have significant impacts on the biological communities in and around the river system.

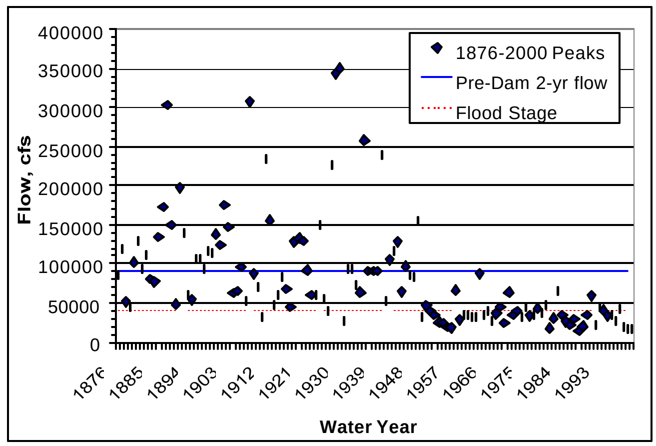

Figure 3. Peak flows for the period of record at USGS gage #02197000.

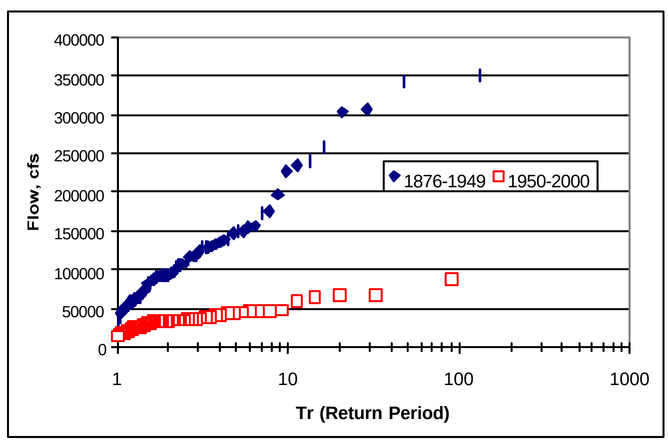

Figure 4. Flow recurrence graph, comparing pre- and post-dam recurrence intervals, for USGS gage #02197000.

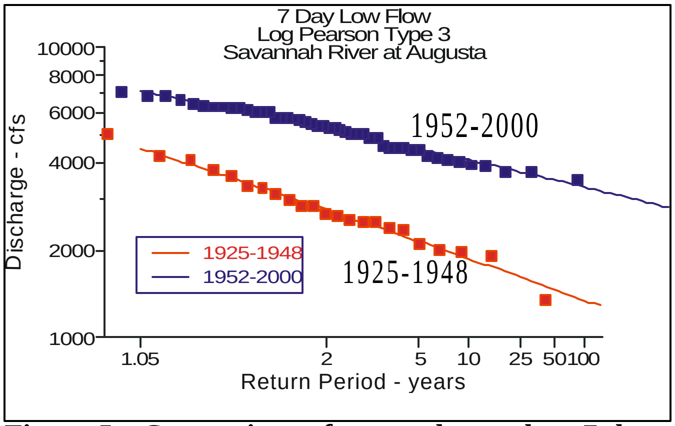

Figure 5. Comparison of pre and post-dam 7-day low flows at USGS gage #02197000.

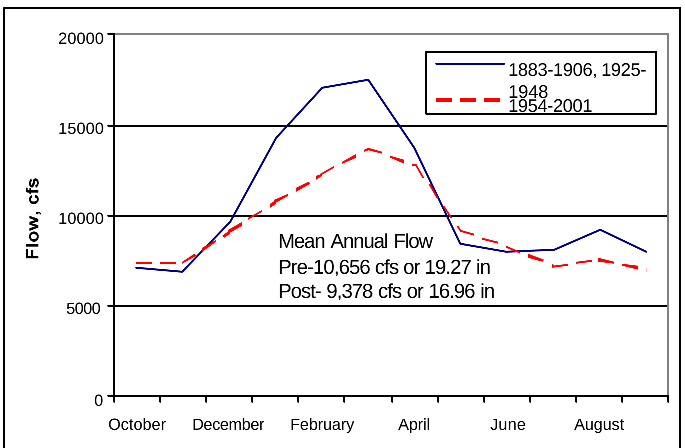

Figure 6. Pre- and post-dam mean monthly flows for the Savannah River at USGS gage #02197000.

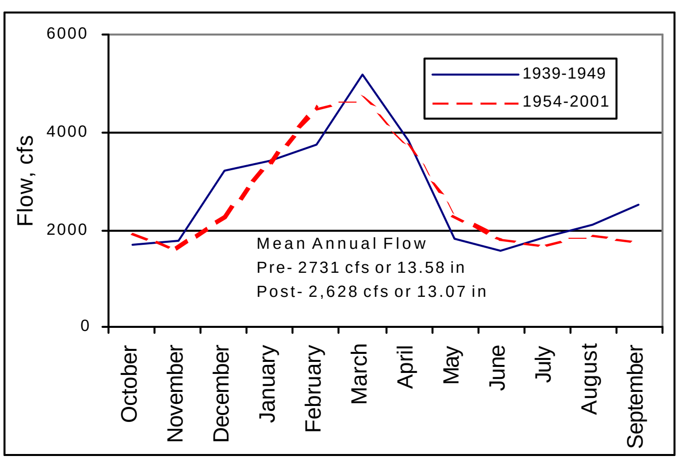

Figure 7. Mean monthly flows for Edisto River at USGS gage #02175000.

Mean monthly flows are a good tool for quantifying how flows have changed over the long term. Figure 6 indicates that there has been a reduction in mean monthly flows in the wetter portion of the year since the dam installation. Such changes are not apparent in the adjacent, unregulated Edisto River (Figure 7) so climate changes do not appear to be responsible. The loss of water could be attributed to several factors. Increased water usage from Clarks Hill Reservoir, the filling of the two upper reservoirs, or reservoir evaporation could be suspect for the reduced mean monthly flows. After considering the behavior of the hydrographs in Figure 1 and the peak flows in Figure 3, we can conclude that the loss of two and a third inches of water from the mean annual flow is a result of Thurmond dam. Using a lake evaporation coefficient (3.42 ft/ year), we estimated that water loss due to evaporation from the three reservoirs would be 3.2 inches (Table 2). This estimate of evaporative loss is close to the apparent loss from the gage record.

Table 2. Evaporative water loss calculations

Reservoir	Area (Ac)	Est. Mean Annual Evaporation (Ac-ft)	Drainage Area Above Dam (sq. mi.)	Est. Water Loss (In.)
Thurmond	78500	268208.33	6144	0.82
Russell	29340	100245	2890	0.65
Hartwell	55950	191162.5	2088	1.72
TOTALS:	**163790**	**559615.83**	**11122**	**3.19**

CONCLUSIONS

The manipulation of the Lower Savannah River through dredging, channelization, and flow regulation has caused significant changes in hydrology and channel form. The Nature Conservancy project will not be able to restore the hydrology or morphology of the river to its original condition, however it may be able to produce management alternatives that will benefit the ecosystems of the Lower Savannah River.

LITERATURE CITED

US Army Corps of Engineers, Savannah District, South Atlantic Division. April 1992. Lower Savannah River Environmental Restoration: Reconnaissance Report.

RiverStat. Software developed by Dr. John Dowd. Assistant Professor, University of Georgia.