Mississippi Valley Division,
Regional Planning and Environment Division South

Pearl River Basin, Mississippi Federal Flood Risk Management Project

Draft Appendix E – Hydrologic and Hydraulic Model

June 2024

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SECTION 1
Introduction

This Appendix includes the limited hydrologic, hydraulic, and statistical analysis conducted by the U.S. Army Corps of Engineers (USACE) Hydraulic Project Delivery Team (PDT) members to support an update to modeling and risk following review of the final array of alternatives in the July 5, 2022, Nonfederal interest (NFI) 211 report.

PROJECT AREA

The Pearl River Watershed is in the south-central portion of Mississippi and in southeastern Louisiana. The river drains an area of 8,760 square miles (sq. mi.) consisting of all, or parts, of 23 counties in Mississippi and parts of three Louisiana parishes. The primary study area comprises the Pearl River watershed between river mile (RM) 270.0, located south of Richland, MS, and RM 301.77, just downstream of the Ross Barnett Reservoir dam. Municipalities within the study area include Flowood, Jackson, Pearl, and Richland. The study area includes parts of Hinds and Rankin counties. Major tributaries of the Pearl River within the study area include Caney, Eubanks, Hanging Moss, Hog, Lynch, Prairie Branch, Purple, Richland, and Town Creeks. Per the NFI report, the study area denotes the area that will be potentially impacted by implementation of the project, which is different from the project area, the actual site the project will occupy.

PREVIOUS EVENTS

Numerous flood events that have affected the study area, most notably the Easter flood of 1979, the May flood of 1983, and the February 2020 flood event. The 1979 event flooded transportation routes, homes, and businesses, causing damages that, at that time, totaled approximately $223 million. If the same event occurred in the present day, damages would surpass $1.2 billion. More recently, the Pearl River crested at 36.67 feet in Jackson on February 17, 2020, the third highest crest ever recorded. The communities sustaining the most devastation from this flood event were in minority and low-income areas of Jackson.

PROJECT ALTERNATIVES

The final array of alternatives as provided by the NFI included a nonstructural plan (Alternative A), a levee plan (Alternative B) and a locally preferred plan that includes a weir (Alternative C). Per direction to the PDT, final alternatives discussed in this report will be a nonstructural plan ((A1), a National Economic Development (NED) plan, the Locally Preferred Plan (LPP), and the Combination Thereof Plan (CTO).

The Combination Thereof Plan contains a variety of features available for the ASA to select. For the purposes of H&H modeling, it can be assumed that the results are adequately similar to use the CTO plan for an analysis for both with and without the proposed weir construction.

NFI 211 REPORT REVIEW

USACE reviewed the final array of alternatives and associated reporting as provided by the NFI for technical accuracy and consistently to support the ASA-CW comment list for items **specific to the hydraulic, hydrologic, and statistical analyses.** USACE worked though these items in support and in addition to the overall PDT direction of developing the updated nonstructural Alternative, NED, and LPP. **Items with economics, cost, or plan form objectives are not included in this list.**

MODEL UPDATES

To resolve the ASA review comments, USACE recommended the following model updates. Further details and results of this model update are provided in the following sections of this report.

- Hydrology Model Creation and Calibration
- Updates to Hydraulic Model and Calibration
- Update to Statistical Modeling
- Routing of Existing Conditions and Proposed Alternatives
- Simplified Climate Change Analysis
- Simplified Risk Assessments
- Model and Report Review

Historical Project and Flood Analysis

HISTORY OF REGION/RIVER

The Pearl River drains nearly 78,000 square miles in Mississippi and 900 in Louisiana, running from Edinburg, Mississippi to near the Rigolets at the Gulf of Mexico. Spanish Explorers discovered the river in 1519. In 1699 Jean-Baptiste Le Moyne, Sieur de Bienville named the stream La Riviere des Perles- a translation of the Acolapissa Indian name. In July and August 1732 Lt. Sieur Louis Joseph Guillaume de Regis du Roullet explored the Pearl River from Source to Mouth. He reported a land empty of humans (Hernando De Soto's expedition spread European diseases and recent Choctaw-Chickasaw wars) and noted a draft of driftwood choking the lower river, which was repeated by Andrew Ellicott in 1798. After the war of 1812, the United States began to settle the areas near the mouth of the Pearl River. (Mississippi Encyclopedia 2018) The river was cleared of driftwood to the 31st parallel, but Natchez Residents blocked further development of the river. (National Geographic 2023)

Mississippi became a state in 1817; and in that year Andrew Jackson and General Thomas Hinds negotiated the Treaty of Doak's Stand with the Choctaw Indian Nation in 1820, where 5 million acres in central and western Mississippi was opened to settlement. (Britannica 2023) Three commissioners were ordered to place and survey a new capital city in the center of the state. The exact center of the state was a swamp, so the commissioners located the city just down the Pearl River to the southeast, at the site of LaFleur's Bluff, a small village founded by French-Canadian trader Louis LeFleur. (The City of Jackson Mississippi 2023)

The Choctaw was the first steamboat to make to Jackson in 1835, and by 1840 there was regular traffic along the river, only traveling as far north as Jackson during higher river stages. (Sea Coast Echo 2022) By 1856 the Pearl, which had been clear, became threatened environmentally. Planters and rivermen cut off river bends to increase the water's flow rate and to shorten distances along the river, but this loss of pool increased flooding. In addition, timber clearance on the banks increased silting and erosion. Nevertheless, the Pearl remained a key transportation highway until the Civil War. (Mississippi Encyclopedia 2018)

The city of Jackson was occupied multiple times and destroyed by Union Troops during the Civil War, and to recover in the following decades. The arrival of new railroads in the 1880s and discovery of natural gas fields in the 1930s helped to improve recovery and economic growth. (Britannica 2023)

EARLIEST RECORDED EVENTS- 1874 TO 1902

The earliest recorded events are a series of floods occurring between 1874 and 1902. Peak stage/flow measurements are available from 1874, and stage data is available at the Jackson gage from 1901 to the present. USACE added the floods of April 25, 1874, December 5, 1880, and April 21, 1900, to the gage record from data provided by residents and newspaper records. Periodic weather observations are also available from 1849-1871 and 1873-1876 prior to the gage development to help inform the historical flood record. The 1902 event was the historical flood of record with a recorded discharge of 85,000 cubic feet per second (cfs). (Grice 2006, USGS 2023)

J.H. FEWELL WATER TREATMENT PLANT (WTP) AND WEIR-1915

In 1915, to ensure a reliable source of water supply, the city of Jackson constructed a weir at the J. H. Fewell WTP located at river mile (RM) 290.7. Jackson's current water supply still draws on this weir, along with the O.B. Curtis WTP, which withdraws water from the Ross Barnett Reservoir.

ROSS BARNETT-1965

The Ross Barnett Reservoir is a 33,000-acre impoundment just upstream of Jackson, Mississippi. The lake provides water supply for the city of Jackson and various recreational opportunities. Construction began in 1960 and the lake reached full pool by 1965. The Pearl River Valley Water Supply District maintains the reservoir between 296 to 297.5 feet. Although the reservoir does not have a flood reduction mission, in recent years the reservoir has been operating under large inflow events in conjunction with the Lower Mississippi River Forecast Center and USACE's Vicksburg District, to implement future informed releases within the lake limits to delay or decrease peak releases for events with a forecasted peak discharge above 35,000 cfs. The principal spillway consists of ten (10) 40-foot (width) by 21-foot (height) gates with a discharge capacity of 180,000 cfs. The emergency spillway is a fuse plug type with a discharge capacity of 70,000 cfs. (State of Mississippi 2023; FTN Associates 2011)

BRIDGES IN THE AREA-1960S

There are many road crossings though the project reach many of which were constructed in the 1960s. Table E2-1 lists each crossing from upstream to downstream and Figure E2-1 provides a profile plot of the peak of the 2020 flood event showing approximated water surface increases occurring due to the constrictions at each crossing.

Table E2-1. Listing of Local Bridges with Date of Construction (Road Crossings: Clarion Leger 2023)

Bridge Location	Date of Construction
Highway 25 (West)	1965/2001
Highway 25 (East)	1965/2001
Highway 25 Relief (West)	1965/2001
Highway 25 Relief (East)	1965/2001
Abandoned Railroad (GM&O)	1927 (Historical Marker Database)
I-55 over Pearl (North)	1967/1998
I-55 over Pearl (South)	1967/1997
Silas Brown/Woodrow Wilson (Old Brandon Road)	1925
KCS Railroad	1838/1868 (Newspapers.com 2023)
Highway 80	1938
I20 (West)	1965
I20 (East)	1965/1998
CN Railroad	Unknown

***Many of the older bridges have been modified/rebuilt since dates listed.*

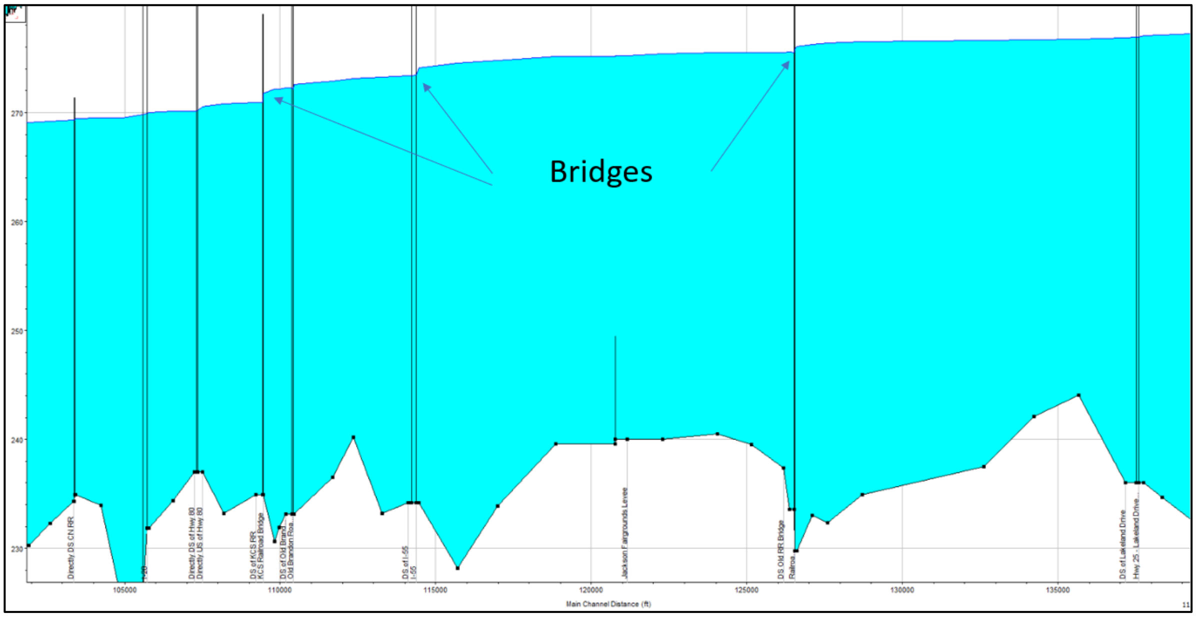


Figure E2-1. Water Profile Showing Backwater at Bridge

FEDERAL LEVEES AND CHANNEL STRAIGHTENING-1960S

The Jackson Fairgrounds and East Jackson Levees were authorized in the 1960 Flood Control Act, with construction completed in 1968. This work included two earthen embankments, 5.34 miles of river channel work, four gated outlets, and two pumping plants. (Rankin Hinds 2021; figure E2-2).

Figure A. 1963 Aerial Photograph

Figure B. 1968 Aerial Photograph

Figure E2-2. Levees and Channel Straightening

Source: (Rankin Hinds 2021)

APRIL 1979

The winter of 1978-1979 was exceptionally wet, December and January received at least 150% above normal rainfall, and February – April 9th also received well above average precipitation. On April 11, a squall line associated with a slow-moving cold front began to move over the area. Four to five inches of rainfall fell over the Jackson Metropolitan Area and induced flash flooding. The National Weather Service office in the Jackson area measured 4.5 inches of rainfall accumulation in just over an hour. (NWS 2023a, b)

The cold front continued to western Mississippi on April 12th and became stationary. Eight to ten inches of rain fell over the headwaters of the Pearl, Noxubee, and Tombigbee Rivers in one day. Total rainfall for the basin for the event is shown in the graphic below. (NWS 2023a, b), see Figure E 2-3.

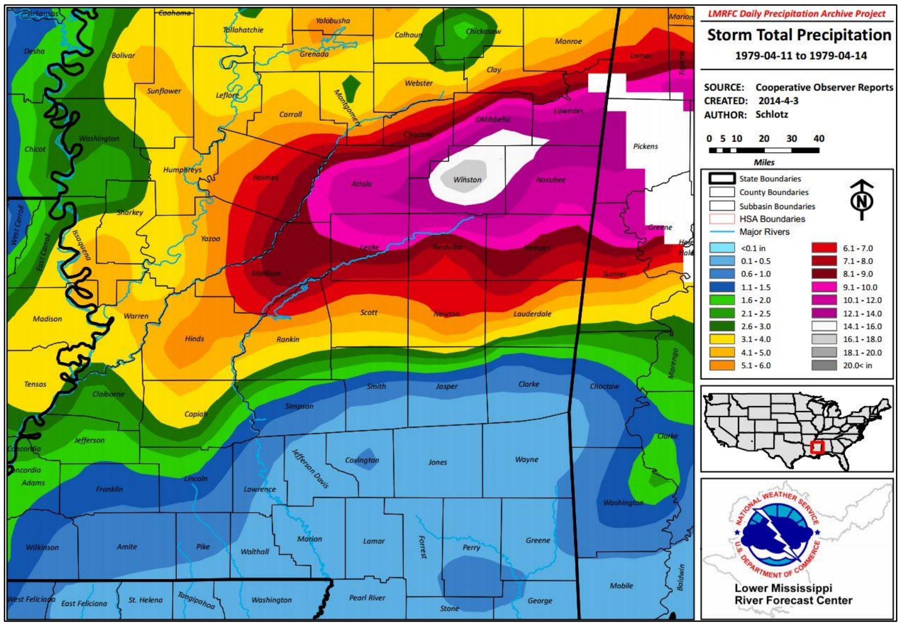


Figure E 2-3. Total Rainfall 1979 Event

Source: (NWS 2023a)

At 6 a.m. Friday morning, April 13, the river was at 33.5 feet and rising rapidly. The water due to the river flooding began impacting some homes and businesses at about 34 feet. Later in the day the reservoir officials (after coordination with USACE and the National Weather Service (NWS)) decided to try and lower the reservoir pool to provide storage for large inflows forecasted in the next few days. By April 14th the historic flood of record (1902-37.5 feet) was exceeded, and the stage continued to rise rapidly. I-55 South was closed at approximately 5 p.m. on April 14th when water began to encroach in multiple places. (NWS 2023a, b) (Hederman, 1979) (Figure E 2-4)

On Easter Sunday, April 15th, wide streams of water began to overtop the fairground levee. Workers attempted to plug the gaps but were unable to stop the floodwater from flanking the levee at Fortification Street. By late Monday the Ross Barnett Dam, which now held a record pool, began showing signs of stress, and emergency workers reinforced weak spots. Peak flows into the reservoir were estimated at 160,000 cfs. (NWS 2023a, b) (Hederman, 1979)

On the Rankin County side of the river, hundreds, perhaps thousands, of volunteers worked feverishly night and day to keep the levees intact. By the time they were through, they had added about 3 feet to their levee. (NWS 2023a, b) (Hederman, 1979).

The river crested at 43.28 feet around 3 p.m. on Tuesday, April 17th. Many homes in the northeast section of the city were under water for a week. Many businesses in the downtown area were flooded by backwater from a creek that runs through town. Other businesses were impacted when the river flanked around the levee. (NWS 2023a, b) (Hederman, 1979) (Figure E 2-5).

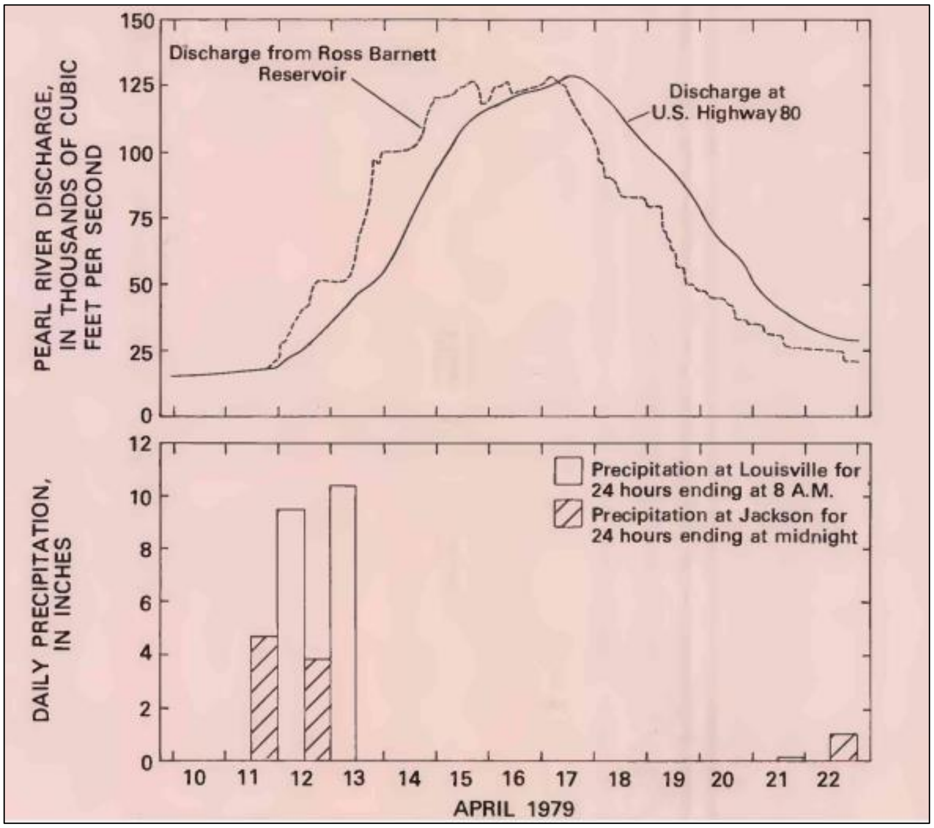


Figure E2-4. 1979 Routing-United States Geological Survey (USGS) Publication
(Source: USGS 2023d)

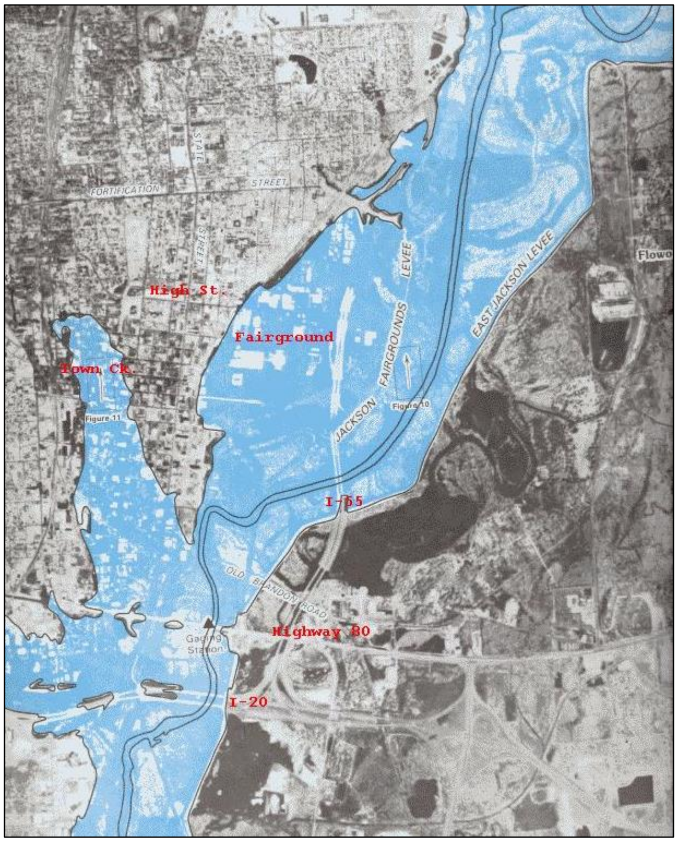


Figure E2-5. Inundation Extent 1979 Flood

(Source: USGS 2023a)

APRIL 1983

In May 1983 another severe rainfall in the upper Pearl River Basin generated a peak inflow into the Ross Barnett Reservoir of 117,000 cfs. Downstream of the dam, the peak at the Jackson gage was 78,000 cfs. The resulting peak stage at the Jackson Gage was 39.6 feet, the second highest recorded peak stage. (Rankin Hinds 2021)

LEVEE EXTENSION – 1984

The Fortification Street Levee Extension to the Jackson Fairgrounds levee was authorized and funded in the 1984 Jobs Bill and completed in 1984. This extension involved building up Fortification at the I-55 Northbound Access Ramp, adding a side fill levee on the river side of the ramp, and providing dikes across the Interstate 55 median and the ditch on the west side of the southbound lane of the interstate. (USACE 1985) (Figure E 2-6).

Figure E 2-6. 1984 Levee Extension to Prevent Flanking

(Source: Left: Final Rankin Hinds EIS, 2022; right: National Levee Database)

CLEARING-1983 TO 1985

In 1983, channel modification was conducted at the Highway 25 bridge, which consisted of removing material from the west bank of the Pearl River approximately 600 feet upstream and downstream of the bridge to increase the conveyance of the stream at that location. The Pearl River Basin Development District (PRBDD) completed this work in 1983.

A 3.3-Mile-Long overbank clearing, and channel enlargement work was also authorized in the supplemental Appropriations Bill of Fiscal Year 1983 and completed in 1985. This project consisted of 237 acres of complete clearing, 20 acres of selective clearing, 89 acres of partial clearing, and the placement of riprap around some bridges. The Pearl River Basin Development District was also the sponsor of this activity.

ADDITIONAL PUMP CAPACITY (1993)

The Jackson East Levee Pumping Station consists of four 67,000 gallon per minute or 150 cfs pumps. Three of these pumps are contained in the same building and were constructed in 1968. In 1993, the local sponsor constructed an additional pump adjacent to the existing pumping station. The pump platform was placed in the approach channel to the existing gravity structure (USACE 2012a)

Three identical pumps are installed in the Fairgrounds Pumping Station. The station was constructed in 1966 as part of the Jackson Flood Control Project. The station capacity was increased in 1996 by the addition of a new 42 inches vertical shaft pump rated at 20,000 gallons per minute (GPM) at 15 feet. The station has a total pumping capacity of 40,100 GPM when pumping against a static head of 19.0 feet. (USACE 2012b)

MOWING/SPRAYING- 2013/2014

PRPRBDD removed excess vegetation from the locations and resumed regular O&M (herbicide treatment on a 3-to-5-year interval) in the 2013/2014 time period.

The Pearl River Basin Development District (PRBDD) areas of O&M responsibility were transferred to the Rankin-Hinds Pearl River Flood and Drainage Control District when the PRBDD closed in 2018. The district no longer had adequate funding due to decreased participation and lack of grants and federal funding. (Thompson 2017)

February 2020

A very wet January and February, led to a saturated river system. Then between February 10 and 13, a swath of 5 to 10 inches of rain fell over the Pearl, Big Black, and Tombigbee Rivers. (NWS 2023c). Reference figure E 2-7 for rainfall totals.

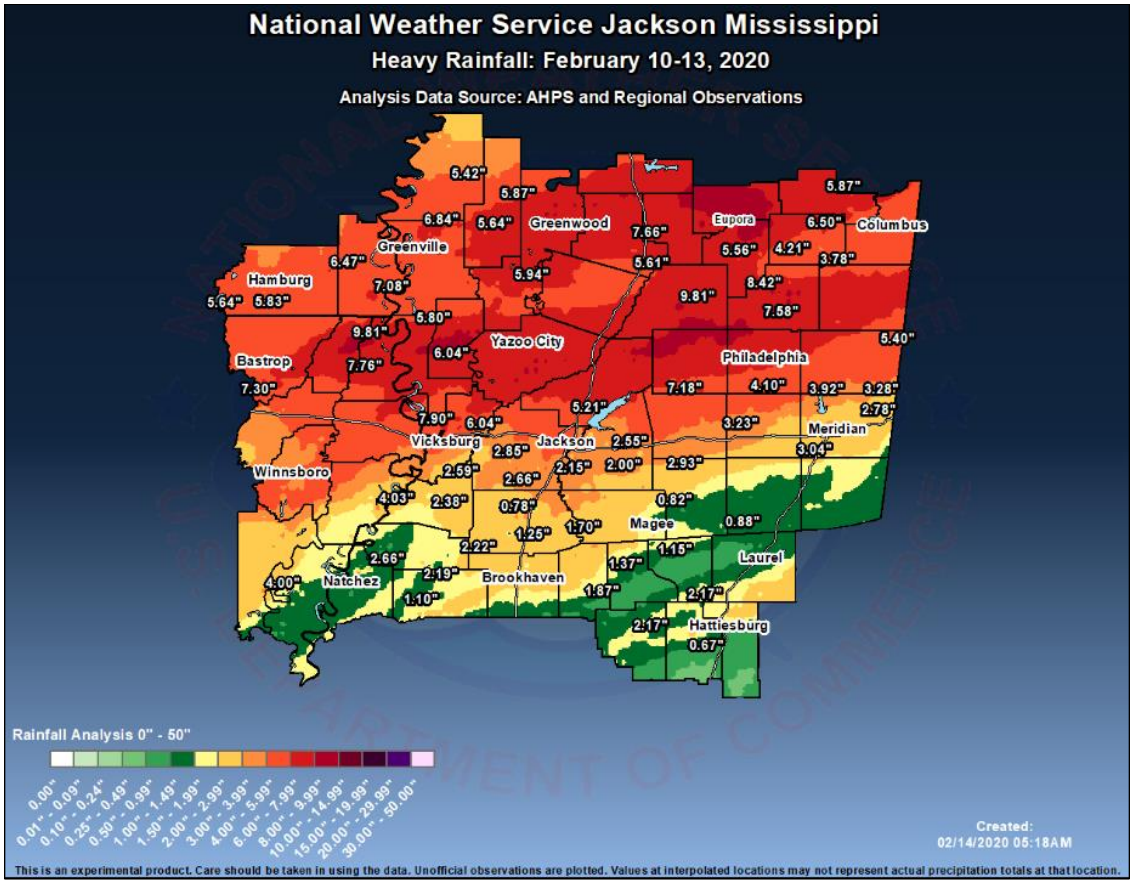


Figure E2-7. 2020 Rainfall Totals

(Source: USGS 2023c)

The river crested at 36.7 feet at the Jackson Gage on February 17th and was the 3rd highest crest of the gage's period of record. Roughly 120 homes and businesses were damaged from the flood, and many more businesses and homes were temporarily inaccessible due to roadway overtopping. No levees were overtopped during this event. (NWS 2023c). Figure E 2-8 depicts the extent of inundation in 2020.

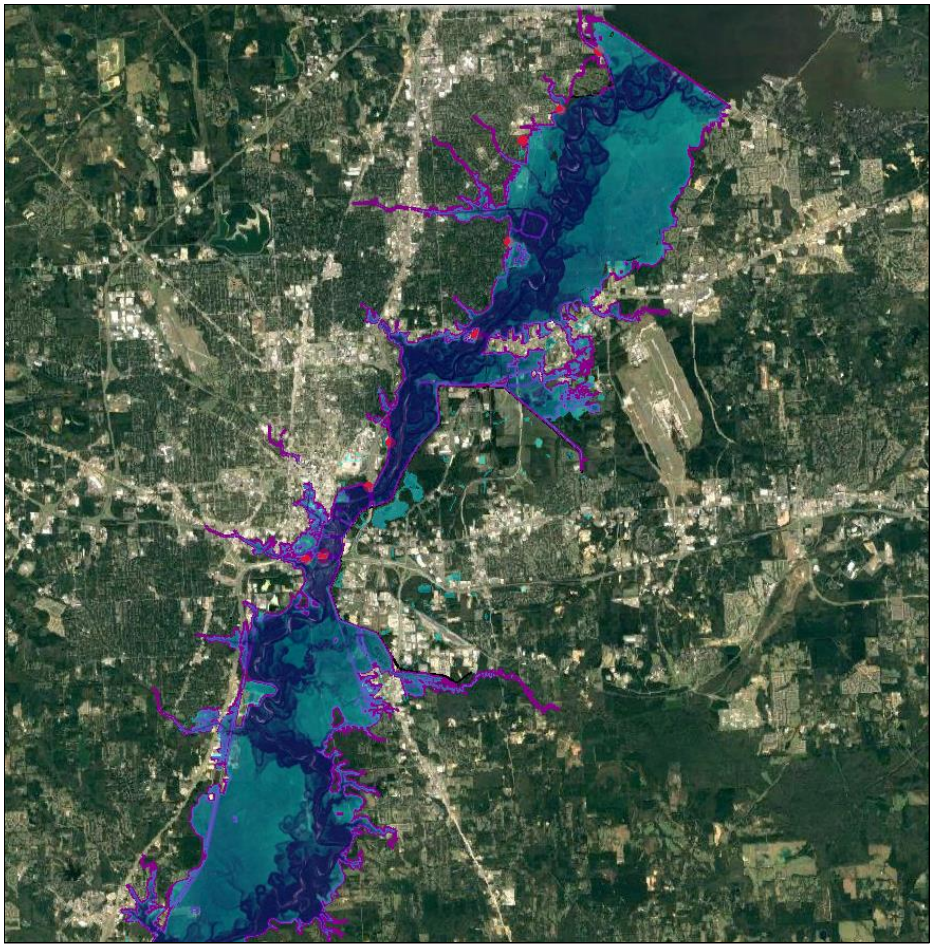


Figure E2-8. 2020 Inundation Extent

LOADING DIFFERENCES

"The river was now pushing MORE water though the gauge at LOWER stages" -- NWS Storymap. The 2020 Flood Event was devastating but could have been much worse.

"Now, why was this? [The system response] It is hard to precisely know the reason, but there are several theories. One insists that the riverbed has changed drastically due to some of the higher discharges from the Reservoir causing sand and silt to be picked up and carried downstream. Another theory: after the 1983 flood, the land between the levee in Jackson was clear cut of all the trees and in the recent years the levee board has been keeping the grass mowed. This would cut down on the friction between the river and the ground and allow the water to move though unimpeded.” (NWS 2023c)

“Another interesting factor in this flood had to do with the Ross Barnett Reservoir and the spillway operations. Originally the Reservoir was built as a recreational and water supply lake and NOT for the purpose of flood control. In 2019 though, the Reservoir officials made the decision to keep the winter lake levels lower than normal because an aquatic plant pest called Giant Salvinia … Well, due to these lower lake levels, the Reservoir was able to act (in part) like a flood control reservoir and hold back some of the flood waters which would normally have to pass through the spillway."" It is difficult to measure how much storing 3.5 feet of water across the lake was able to shave the peak flow, but it is estimated that the stage at Jackson could have been at least 1-1.5 ft higher.” (NWS 2023c)

Other significant differences include the levee extension in 1984, and the increased pump capacity that was installed in the 1990s, which reduces flash flooding due interior drainage.

During the 2020 event, further discrepancies were noted between what was happening and previous events. The neighborhoods north of Lakeland Drive were experiencing flooding more than expected with a 38 feet river stage at the Jackson gauge while the areas south of Lakeland Drive, particularly in downtown Jackson, were experiencing flood patterns more typical of previous events. (NWS 2023c) (figure E2-9, E2-10). Table E2-2 presents the 1983 and 2020 stage and flow data.

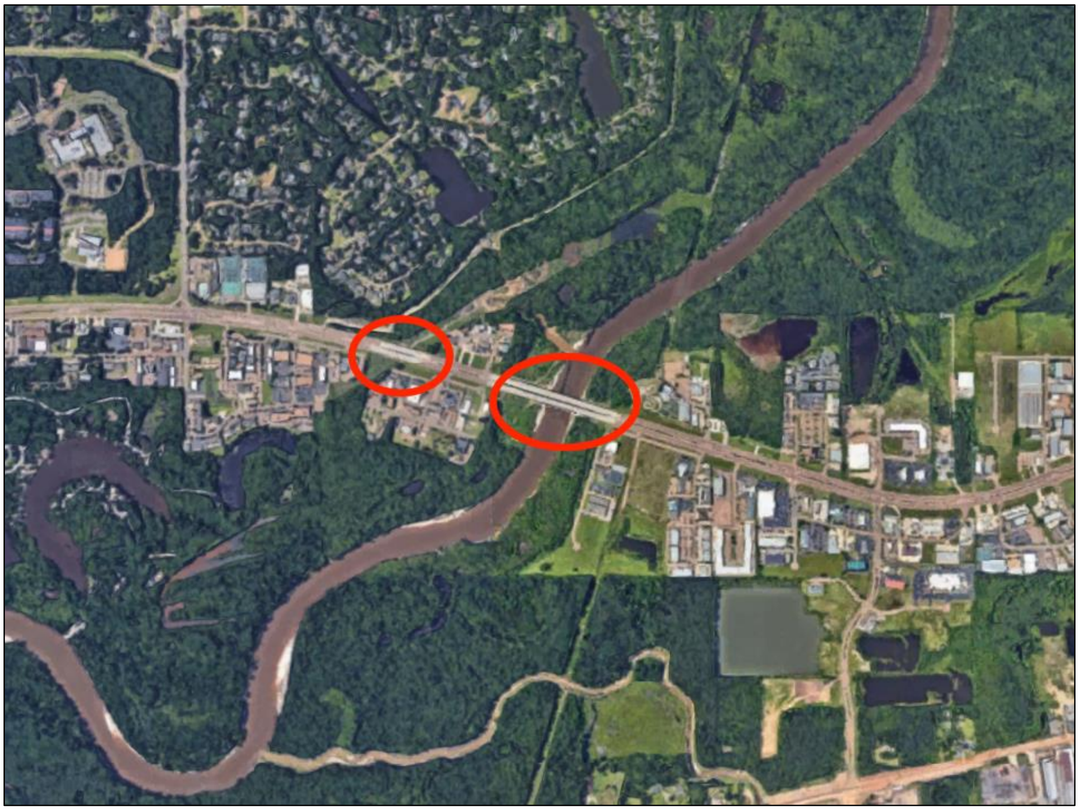


Figure E 2-9. Lakeland Drive/HWY 25 Bridge and Overflow Bridge

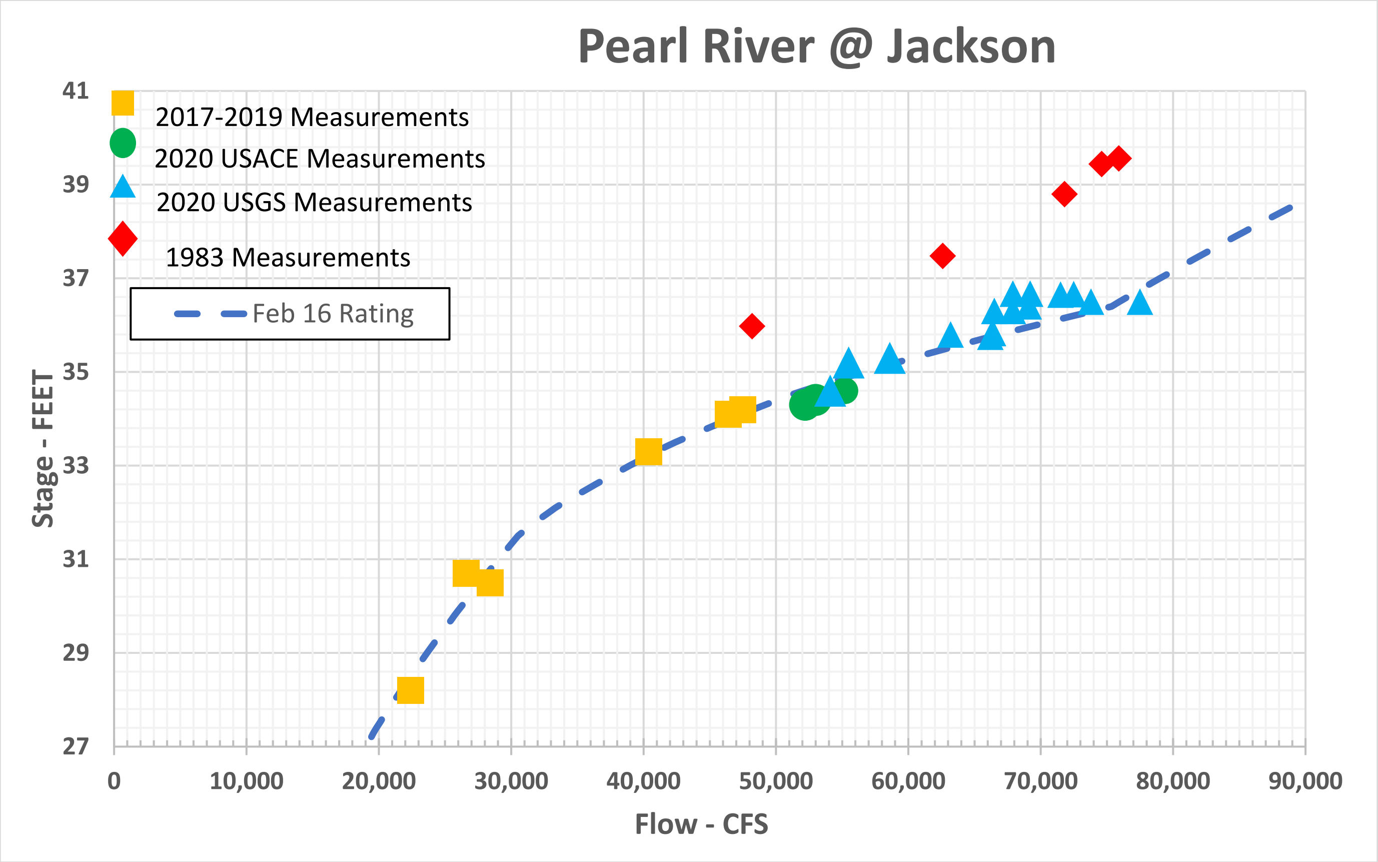


Figure E2-10. Updated Rating Curve with Discharge Measurements

Table E2-2. 1983 and 2020 Stage and Flow Data

Flood Event Year	Ross Barnett Release (CFS)	Flow at Hwy 80 Gage (CFS)	Elevation at Hwy 80 Gage (Feet, NAVD 88)
1983	85,000 (prev. 78,000)	79,500	272.9
2020	78,361	77,300	270.0

ROSS BARNETT RELEASE DISCREPANCY

Along with the channel efficiency adjustments, the Ross Barnett Reservoir releases were underestimated prior to 1999. It is noted in the 1999 Downstream Impact and Reservoir Regulation Flood Control and Development Plan for the Jackson Metropolitan Area (source, date) that “part of the problem may be in the way the reservoir calculated discharge at its gate…Also our study of the gate construction plans indicates that the cables which elevate the gates, produce lift in excess of the amount calculated. If we are correct, the reservoir is understating discharges during major floods (such as the 1979 flood) by about 10%. Tables included in this document indicate that at the maximum pool of 300 feet mean sea level (MSL) (1979 was at elevation 299.9) flows could have been miscalculated by as much as 15,000 cfs.)

This revises the original 1979 Ross Barnett Discharge from 124,500 CFS to 137,000 CFS, and the 1983 peak discharge from 78,000 to 85,000. The Ross Barnett Reservoir operators updated their reporting method in at some point between the 1983 flood event and the 1999 report described in the section and therefore all recent peaks are considered valid (Table E2-3 and Figures E2-11 thru 14).

Table E2-3. Rating Adjustments at the Ross Barnett Reservoir

Water @ 300' MSL			
Gate Elevation	**Calculated Flow Rate**	**Reported Flow Rate**	**Discrepancy**
288	125500	112000	13,500
289	135000	121000	14,000
290	144000	131400	12,600
291	154000	139000	15,000
292	163500	149000	14,500

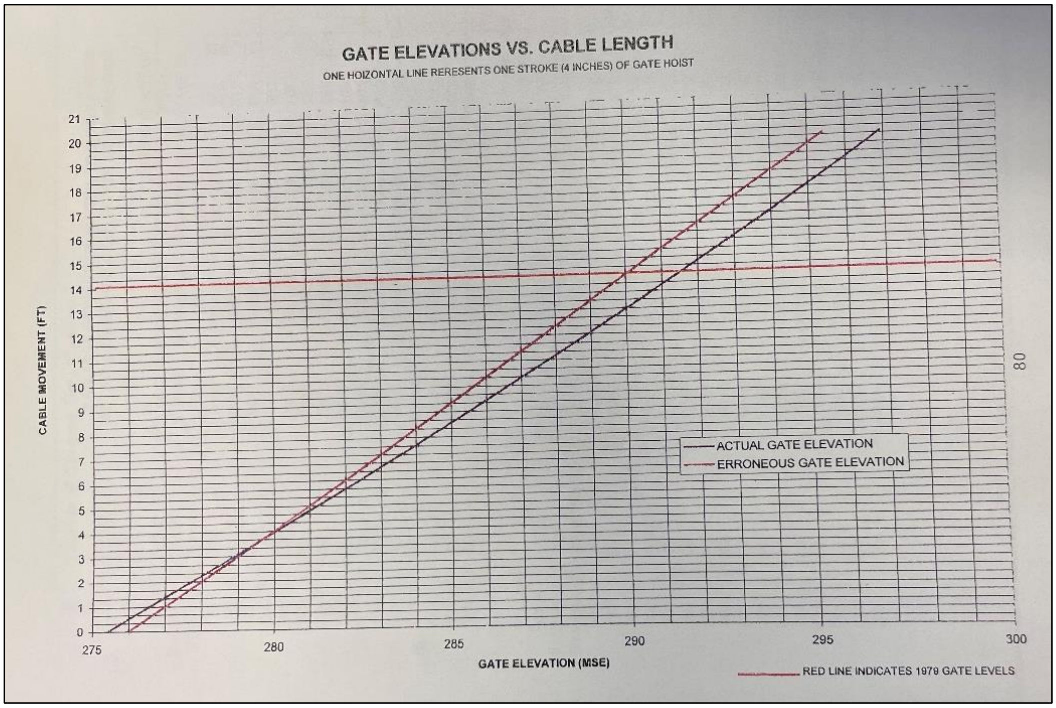


Figure E2-11. Gate Elevation vs Cable Length Discrepancy

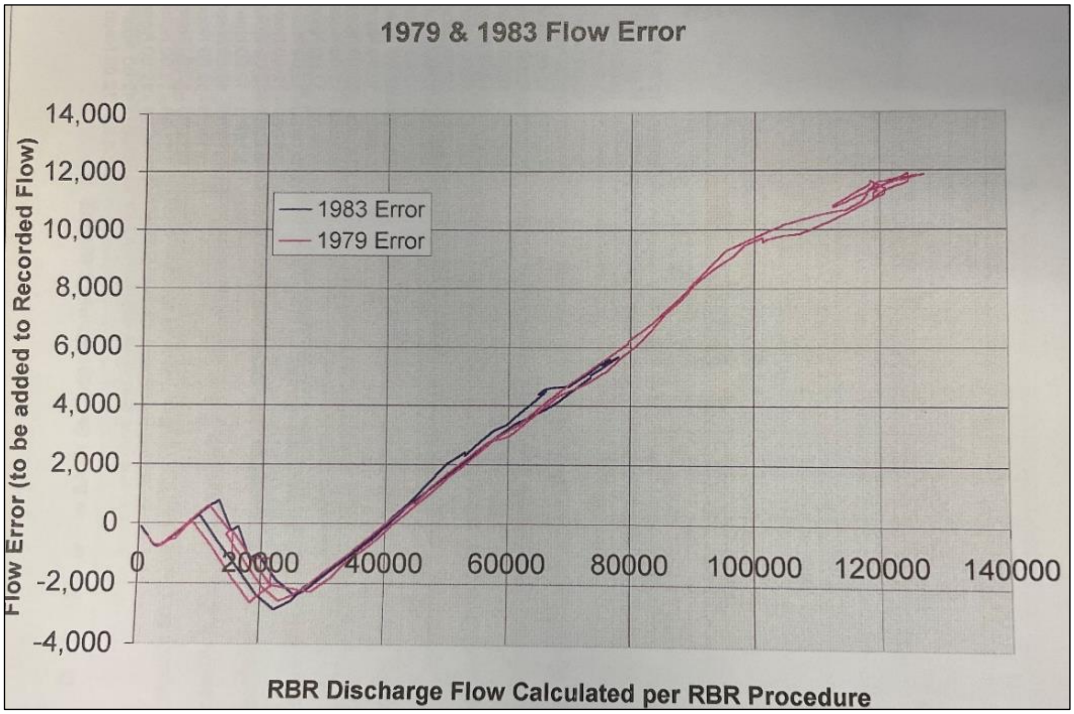


Figure E2-12. 1979 and 1983 Flow Error

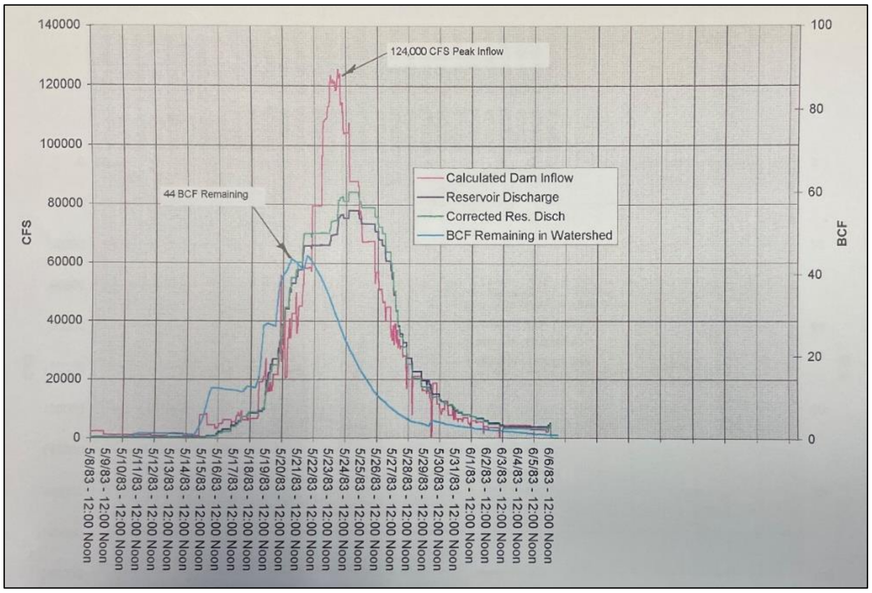


Figure E2-13. 1983 Corrected Routing

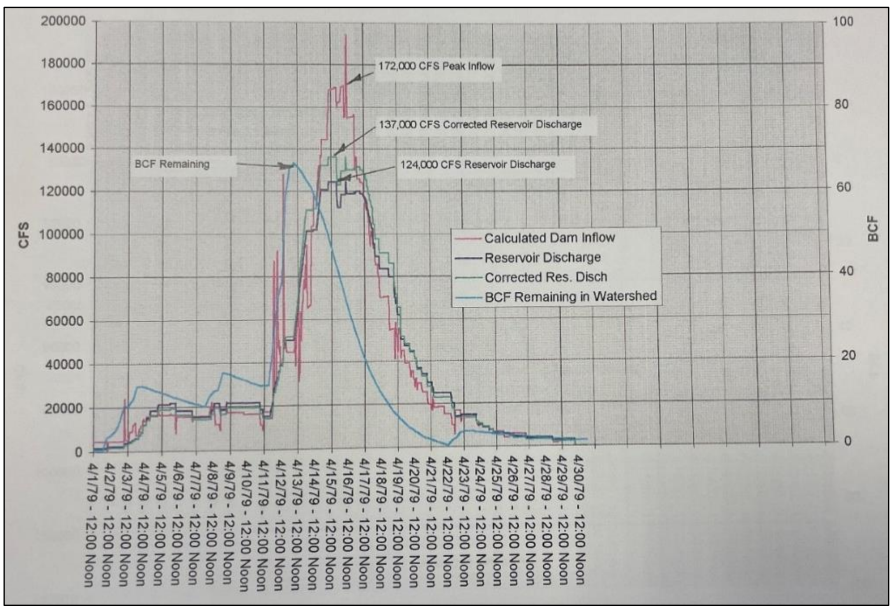


Figure E2-14. 1979 Corrected Routing

VARIOUS PEARL RIVER STUDIES-1970-PRESENT

Various studies have been completed in the Jackson MSA in recent history. Table E2-4 summarizes these studies.

Table E2-4. Various Pearl River Studies Occurring Since 1970

Project/Report	Relevant Dates	Status
Comprehensive Survey of the Pearl River Basin, MS, and LA Report	1970: Report Released Included Structural and NS measures.	Projects were never implemented.
Edinburg Dam Phase I Design Memorandum	January 1972: Memo Released identifying only Edinburg Dam economically justified. 1974: WRDA authorized Edinburg Dam Project. 1980: No longer economically justified.	USACE re-evaluated in 2007.
Reconnaissance Pearl River Basin Interim Report on Flood Control	November 1981: Report Released with Four Point Plan developed. 1983: The Four Point Plan was authorized for construction in the FY 83 Supplemental Appropriations Bill.	May 1984: DM No. 1, “Flood Control for Jackson, Mississippi,” contained documentation for the Four Point Plan with only the clearing plan moving forward at HWY 25.
The Pearl River Basin Interim Report on Flood Control	July 1985: Report Released with recommendation of Shoccoe Dam. 1986 WRDA: Authorized construction of Shoccoe Dam.	Schoccoe Dam later identified as not implementable.
Carthage/Leake County, MS Interim Flood Control Report	February 1987: Report Released with recommendation of Shoccoe Dam, levees, and channel improvements.	Not implemented as later found to be not economically feasible.
Draft Feasibility Flood Risk Reduction Report for Jackson Metropolitan Area, MS	1996: DRAFT Report released with recommendation of the comprehensive levee plan.	July 1998: was found to be not implementable due to lack of local support.
DRAFT Flood Control, Pearl River Basin, Mississippi, Jackson Metropolitan Area, Mississippi, Feasibility and Environmental Impact Statement (EIS)	2007: DRAFT Report released. No plan recommended but Comprehensive Levee Plan was economically justified and the Lefleur Lakes (LL) Plan was found not justified due to not meeting environmental policy objectives.	
ATR Summary Report for the Pearl River Watershed Integrated Feasibility Report and Environmental Impact Statement	June 2020: ATR of the draft and final report products from June 2017 to April 2020. ATR was closed with significant concerns that were identified during review of the final report documents.	
Letter Report for Water and Wastewater Infrastructure, Jackson, MS Savanna Street Wastewater Treatment Plant (WWTP) Improvements	December 2022: Mississippi Division approved the Letter Report for increment of work for the Savanna Street WWTP Improvements	
Tributary work	Various tributary projects are ongoing. See main report for a listing.	

NFI STUDY

The Nonfederal Interest, the Rankin Hinds Flood Control District produced a Draft EIS in June 2018 and a final EIS in June 2022 for the Pearl River at Jackson MSA. The locally preferred plan."

NFI Locally Preferred Alternative Description- "C"

Additional coordination occurred between USACE and the NFI to provide the clarified project description for this alternative. Alternative C realized flood risk management through removing areas that constrict the floodplain along with widening and deepening of the channel and floodplain within the project footprint, thereby improving downstream conveyance of water through the project area and lowering the water surface elevation of the river in some places within the project area by as much as 8 feet (2.4 m). Water surface elevation reductions due to this excavation would provide reduction of flood elevations not only within the reach of excavation, but additional elevation reductions upstream of the excavation. Alternative C consists of the construction of channel improvements, demolition of the existing weir near the J. H. Fewell WTP site and construction of a new weir with a low-flow gate structure further downstream for water supply to be continued while simultaneously creating an area of surface water for recreational opportunities, Federal levee improvements (excavated material plan), and upgrading an existing non-Federal ring levee with slurry wall around the Savannah Street WWTP.

Construction of the project will require relocations and/or improvements to various public and private utilities and infrastructure, mitigating potential Hazardous, Toxic, and Radioactive Waste (HTRW) and other hazardous waste sites within the floodplain, avoidance and minimization features required under the Environmental Site Assessment, and the creation of new habitat mitigation areas to offset losses within the project's construction footprint areas. A more detailed description of alternative C (Figure E2-15) is located within the main report.

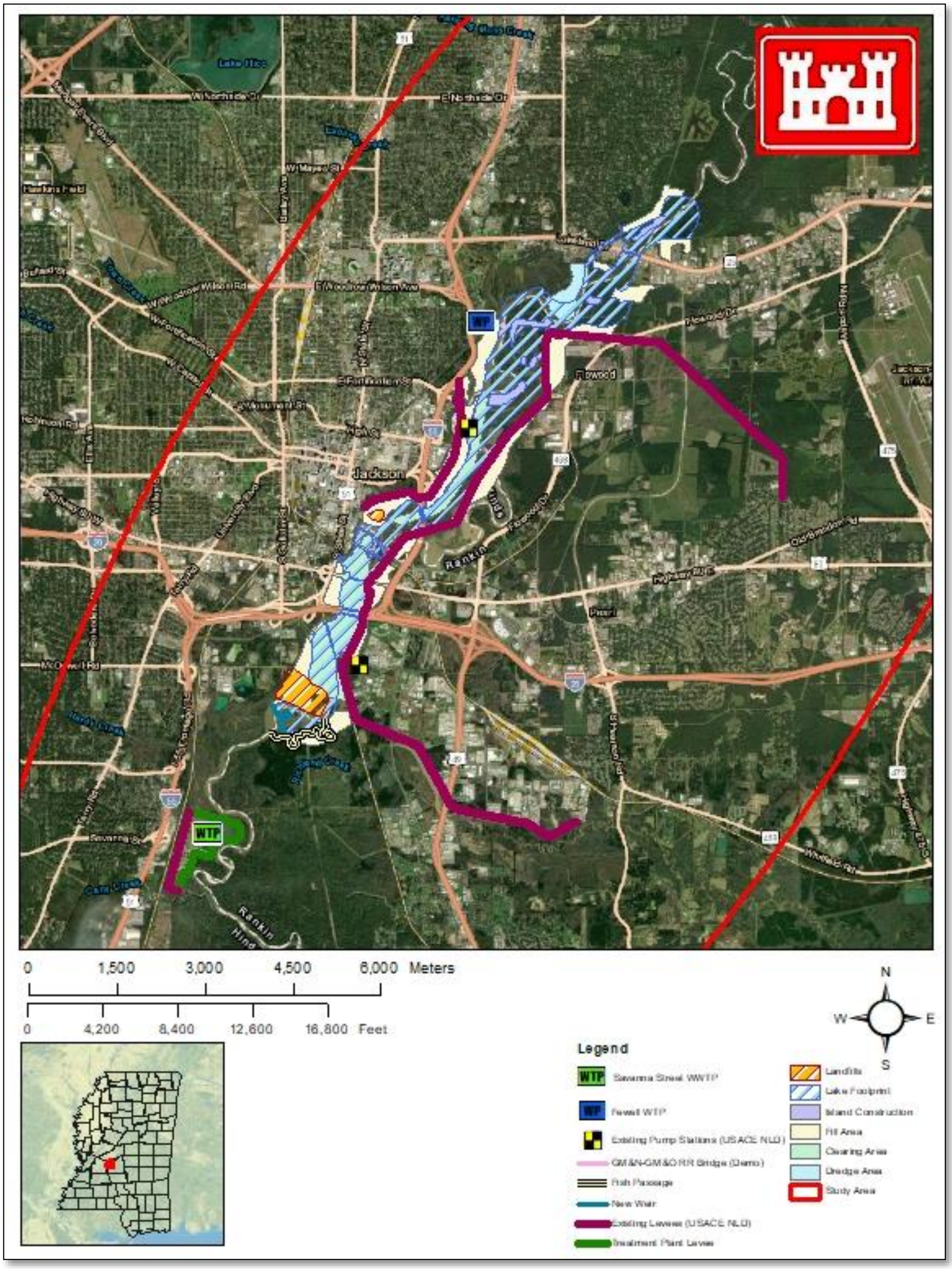


Figure E2-15. Alternative C Features

Channel Improvements

Channel improvements consist of excavating areas along the Pearl River, to improve conveyance from RM 284 to 294. The excavation will be of various widths ranging in width from 400 to 2,000 feet (121.9-609.6 m) to be determined during later phases of study. Excavation depths will vary between 5-20 feet to meet the proposed bottom elevation of 248.0 National Geodetic Vertical Datum of 1929 (NGVD 29). The preliminary project layout also includes islands within the channel improvement excavation area that will be maintained and/or expanded upon from RM 289.5 to RM 292.0 (Figure E2-16 thru 17) The existing river channel would not be widened, instead excavation of the overbank areas would occur.

Overbank Modifications

1. <u>Station 10+00 through 140+00</u>. Specific items included in this reach are the I-20 Interstate bridges (Sta. 95+00±) as well as the U.S. Highway 80 (Sta. 110+00), Old Brandon Road (Sta. 135+00±), and railroad bridges (Sta. 70+00±, Sta. 130+00±). Two high-pressure gas lines run through this reach and will have to be carefully monitored as excavation and grading activities progress. Multiple access points on both sides of the river will have to be maintained and monitored from a perspective of public safety and construction use. Projected quantities for earthwork are approximately 6 million cubic yards (yd^3).
2. <u>Station 140+00 through 290+00.</u> This reach contains the eastward expansion of the east side levees and the construction of islands in the lowered overbank. Islands will be formed as part of the excavation activities. As with the previous reach segment, numerous access points will require management and maintenance for use and safety. A creosote slough area (Sta. 240+00±) will be avoided, when possible, to not disturb or cause any objectionable material to be exposed or mixed with other excavated material. In the event avoidance is not possible, the slough area may be excavated and hauled to a separate disposal site, and the remaining exposed surface capped prior to final grading. Projected excavation quantities are 6 million yd^3.
3. <u>Station 290+00 through 400+00</u>. As with the previous downstream reaches, there are bridges to work around (Highway 25 near Sta. 360+00), and gas lines and transmission lines that must be monitored during earthmoving operations. Depending on the final design, Mayes Lake (Sta. 310+00±) may need tie-in work to maintain its current level. A determination about the tie-in work will be made during later phases of study. An existing abandoned railroad embankment of the Gulf, Mobile & Northern/Gulf Mobile and Ohio (GM&N/GM&O) Railroad Bridge could also be affected and was removed in H&H modeling. Some island forming work will be required in this reach. The existing weir at the water works bend near Station 290+00 will remain undisturbed until completion of the new weir at the downstream terminus as to maintain water supply for the treatment plant. Projected excavation quantities in this reach are approximately 8 million yd^3.

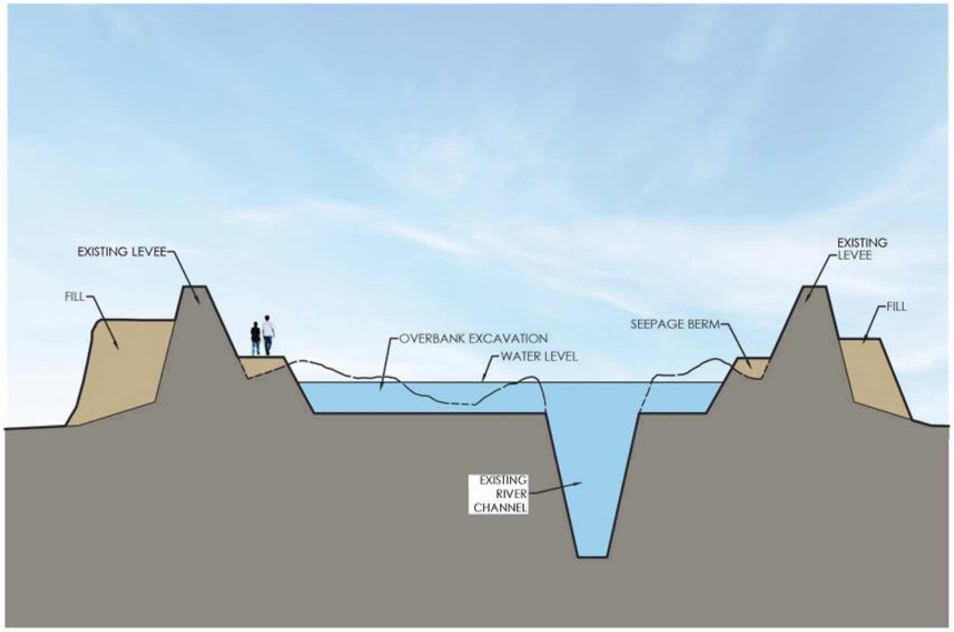


Figure E2-16. Channel Improvements with a Relocated Weir.

Hardpoints at Base of Tributary

Multiple tributary inflow points exist within this reach and Alternative C will add a hardpoint, via a riprap chute to prevent backward erosion at each tributary inflow where the excavation of overbanks decreased the tributary channel bottom elevation at or near the confluence of those tributaries with the Pearl River.

Maintenance and Reinforcement of Bridge Abutments of Bridges

Stabilization or armoring, such as riprap, slope paving, slide repairs, etc., would be required due to changed river conditions and will be carried out prior to clearing and any major channel work. Following its own analysis, the Mississippi Department of Transportation (MDOT) has informed the Rankin-Hinds Flood Control District (the Flood Control District), MDOT agrees to collaborate with the Flood Control District in “the advancement of this project and to ensure countermeasures are included, if determined necessary during the future design process.” (letter to G. Rhoads, dated February 26, 2024) To this end, the Flood Control District developed a range of cost estimates for potential structural and hydraulic countermeasures that could be recommended if countermeasures are determined necessary. The array of countermeasure features analyzed will mitigate potential impacts to MDOT bridges that will be identified during the later phases of study. The estimated cost for these features is based upon known costs for the construction of hydraulic and structural countermeasures on another MDOT project at downstream hydraulic crossings of the Pearl

River. When additional information becomes available during later phases of study adjustments to the design can and will be made to reduce potential impacts. Any proposed countermeasure design and implementation will be conducted with MDOT's concurrence, review, and approval.

Rough estimations of the level of effort required to mitigate for bridge impacts include improvements for approximately 36 bents, 12 piers, abutment scour, as well as funding to conduct monitoring surveys. A pile is a concrete post that is driven into the ground to act as a leg or support for a bridge. A bent is a combination of the cap and the pile. Together, with other bents, act as supports for the entire bridge.

There are a total of 2 active railroad bridges within the project area. All efforts would be made to avoid, monitor, and protect these structures. Additional modeling is required to validate these assumptions during later phases of study. If avoidance is not possible, then coordination with the operating entity to determine specific requirements of each railway bridge will be conducted during later phases of study. All alterations of railroad bridges would be in accordance with Section 3 of the 1946 Flood Control Act (22 USC 701p).

Excavated Material Plan

Federal levees exist within much of this reach and Alternative C would use the existing levees, upgraded with excess excavation placed behind them. Excavated fill would be placed in designated disposal areas on the protected side of existing levees. These areas would be graded to be at the same elevation or lower than existing levees, compacted for suitably for future land development, and grassed to establish long-term erosion control. Additional riprap or other armoring would be placed as required during the final grading operations.

The excavated material disposal fill areas placed on the protected side of levees would impact approximately 465.6 acres (188.4 ha) (Figure 2-15). Clearing of wooded areas to the east of the proposed new banks (small areas on the west side) would be cleared and grubbed ahead of receiving excavated material from the channel overbank excavation. The excavated material would be used to create a substantial new land mass within the Jackson MSA. The new land mass created behind the levees would range from 200 to over 1,000 feet (121.9-304.8 m) in width. The newly created riverfront area would allow for expanded riverfront access, natural areas, and commercial development, along with recreational opportunities.

If any structures are to be built on top of any portion of the maintenance berm designed or used a seepage control, the berms would be overbuilt and utilities or any other structure or penetrations would be limited to within the overbuilt section. Penetrations trough the berm could become seepage exit points, and this is specified to limit fracture through the main berm

Where water would be permanently ponded against the riverside slope, these areas would require a 40-foot-wide semi-compacted impervious riverside maintenance berm to limit seepage through the levee. The typical details include a detail of the berm assumed to extend the entire length of any levee section where water is pooled. The berm would have a crown elevation 3 feet above normal pool, a 1V on 40H top slope and a 1V on 3H toe slope. No removal of the riverside blanket near the existing levees is anticipated.

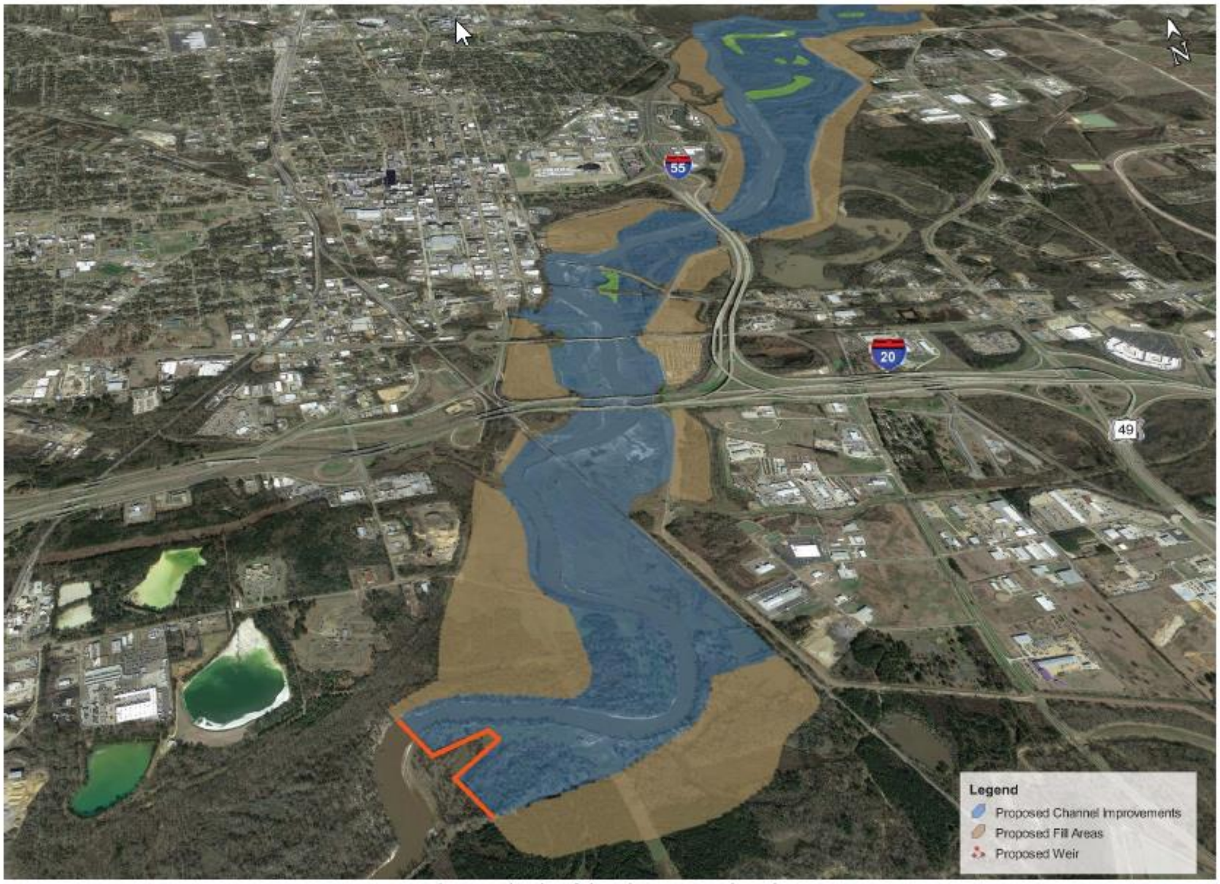


Figure 5-2, Plan View of Channel Improvement Alternative

Figure E2-17. Plan View of Proposed Channel Improvements, Excavated Material Plan, & Weir

Structure Demolition

The existing weir located at RM 291 near the J. H. Fewell WTP site would be demolished and replaced with a new weir further downstream near RM 284.3 at the south end of the channel improvements area. In the area surrounding the J. H. Fewell WTP, Plan C calls for the demolition of the J.H. Fewell Weir located at RM 291, which is currently set to approximate elevation 250 feet. Dredging would be conducted to elevation 248 feet. It is undetermined if the water intake structures and access way of the J. H. Fewell WTP would need further modification. Demolition may also be required at all or part of the abandoned GM&N/GM&O Railroad Bridge since it was removed in H&H modeling. The length of area (including the island) directly along the railroad bridge is approximately 3,600 feet.

Construction of New Weir with Fish Passage

The demolished weir would be replaced with a new weir constructed downstream near RM 284.3 at the south end of the channel improvements area. The purpose of the new weir would be to maintain the baseline low-water level for water supply at the J. H. Fewell WTP within the channel improvements area. The new weir would provide for a significantly larger body of water within the Pearl River channel to the north of the weir. Downstream low-water hydrologic flows (extreme drought condition minimum flows) within the Pearl River channel would be maintained by means of a 12 x 12-foot low-flow gate. The gate is also required for any future maintenance which requires drawdown of the lake. Portions of weir would be submerged during flood events thereby allowing excess water to pass downstream. As opposed to the existing weir, the replacement weir would be constructed to a higher elevation of 258 NGVD vs. the current of 250 NGVD, and a larger width of 1,500 feet along an approximately 1 mile (1.6 km) stretch on the southern end of the proposed channel improvements area. This weir would impound an area of approximately 2600 acres. Baffle blocks to help prevent floating solids from flowing over the weir are part of the conceptual designs. Further, additional excavation for the fish ladder would occur along the left descending bank of the relocated weir in the project area. The fish ladder has been conceptually designed to be approximately 7,300 feet (2,225.0 m) in length. The fish passage design will be coordinated with The Service and state agencies during later phases of study.

The proposed weir meets USACE and State criteria to be defined as a dam based on the height of the structure and water storage. Additional costs were added to the NFI project cost to account for a redesign and constructing the weir to higher USACE and State criteria for a dam. Rough cost estimates were derived using some unit costs from the NFI. A more refined cost estimate would be done once the dam is redesigned to meet USACE and State criteria.

Public recreation facilities within the floodplain (i.e., boat ramps and landings, pedestrian access points, public and RV parks, natural areas, and trails) are not part of Alternative C; however, at a later time, those features may be added by other entities as a result of the weir's new expanded year-round recreational water body.

New Federalized Levee

An existing non-Federal levee protects the Savanna Street WWTP near RM 282. As part of Alternative C, the levee would undergo maintenance and additional upgrades, so the levee meets the freeboard needed for certification for a 1 percent AEP flood event in advance of the main construction phases (Figure E2-18). The levee section proposed for the new Federalized levee around the WWTP consists of a 10-foot crown width with 1V on 3H landside and riverside slopes. If needed, a slurry wall for seepage mitigation would be added. At this location, additional pumps would not be needed to provide protection behind levees since the existing pumps are already in progress of being replaced as part of the Section 219 Environmental Infrastructure Program as discussed in Section 1.5.2 of this report.

Principal features of the work include mobilizing and demobilizing, clearing and grubbing, removing and stockpiling any existing crushed stone surface, semi compacted levee embankment, traverses, adding new crushed stone surfacing, mowing, turfing, erosion control matting, preventing storm water pollution, and providing environmental protection. Additional work could include trenching and the creation and backfill of a concrete slurry wall within the levee footprint. (Figure E2-18).

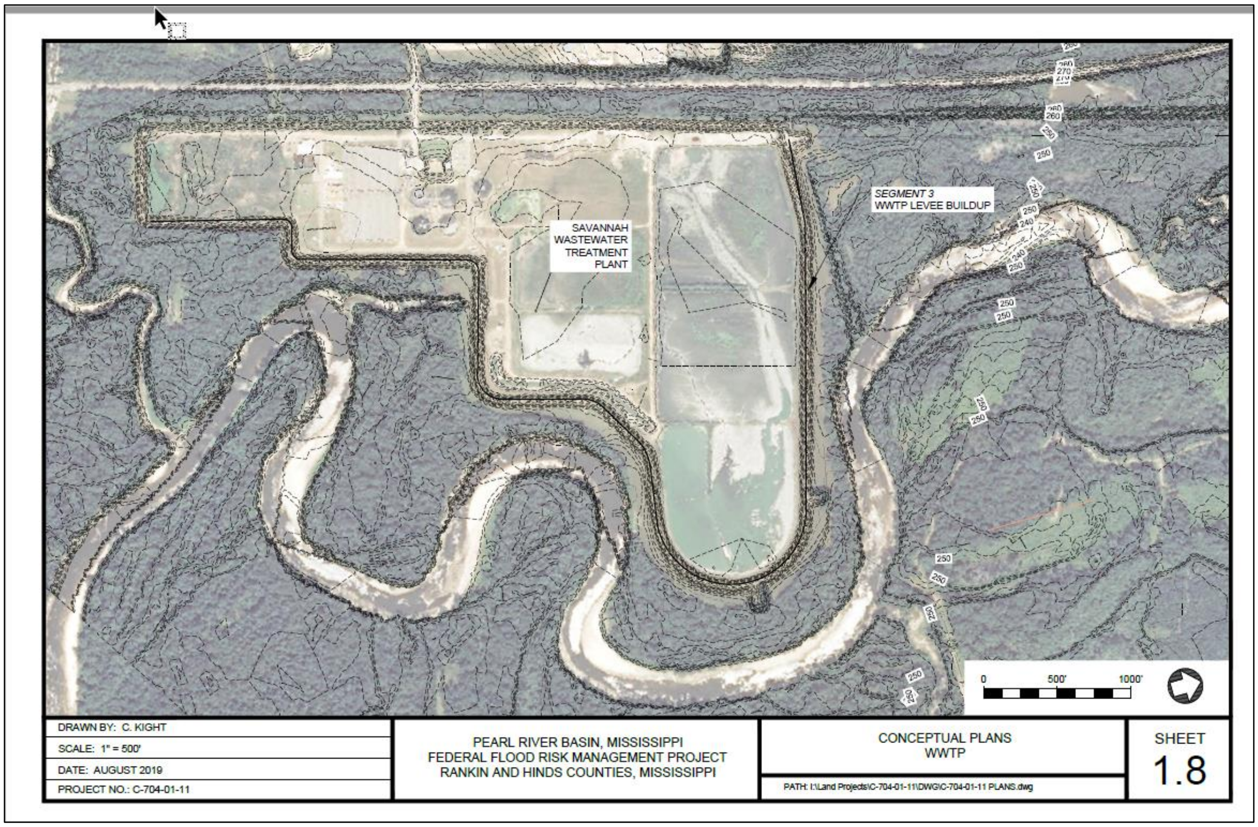


Figure E2-18. Proposed Federalized Levee at WWTP

Interior Drainage Evacuation for Existing Levees

The existing levees contain drainage structures that allow water to drain from the interior of the leveed area when the Pearl River is low. When the Pearl River water level is high, the drainage structure is closed, and pump stations are used to pump water out of the leveed area. The original design of these features called for the drainage structure to handle a 0.01% AEP interior drainage flow and the pumps were originally designed for a smaller event.

The existing levees contain drainage structures that allow water to drain from the interior of the leveed area when the Pearl River is low. When the Pearl River water level is high, the drainage structure is closed, and pump stations are used to pump water out of the leveed area. The original design of these features called for the drainage structure to handle a 1 percent AEP interior drainage flow and the pumps were originally designed for a smaller event.

The proposed new weir would maintain a minimum pool at elevation 258.0 ft. As a result, the drainage structures would have always at least 9 ft of water on the structures and would no longer be able to operate in order to prevent the new reservoir from flooding the interior leveed areas. Additional pumping capacity would be needed to mitigate for the loss of capacity of the drainage structures. In addition, some of the proposed fill areas in the NFI plan would fill in part of the sump that is used to store water for pumping. The NFI did not perform an interior flooding analysis to determine mitigation features for the loss of the use of the drainage structures. This analysis would need to be completed if Alternative C is selected for construction. Additionally, the Operation and Maintenance of the additional pumping would need to be substantially updated from the existing O&M plan for the pumping ability and constant operations prior to construction. Costs for this effort is estimated to range from $100 to $200 million depending on the size of the pump stations needed. Cost estimates (adjusted for inflation) were based off recent experience with pump cost estimation from studies or actual construction, such as the proposed pump station for the Raritan Bay and Sandy Hook Bay Hurricane Sandy Limited Reevaluation Report dated September 2016 and pump station construction in the Trinity River Corridor were also used to verify cost ranges.

The NFI did not perform an interior flooding analysis to determine mitigation measures for the loss of the use of the drainage structures. This analysis will need to be completed if Alternative C is selected for construction.

CURRENT EFFORT-OTHER ALTERNATIVES CONSIDERED

Congress has directed the Assistant Secretary of the Army for Civil Works to select from a variety of alternatives. This is described as the LPP, NED or a combination thereof. One alternative option is the locally preferred alternative “C”. Another alternative considered is the NFI non-structural plan, known locally as the “A” alternative, an updated USACE non-structural plan, known as “A1.” A conceptual plan with options to address the combination thereof requirement is also considered. This plan is commonly known as “Combination Thereof” (CTO). An additional alternative developed by the NFI and USACE over a series of studies, “B” was a levee-based plan. This plan was not considered due to limited NFI interest, due to limited economic benefits and limitations of implementation.

Alternatives “A” and A1

For the purposes of the H&H portions of this study, Alternatives A and A1, which are based on buyouts and floodproofing are hydraulically the same as the existing condition. Model results may be used interchangeably.

C Sensitivity

Alternative C created flood reduction benefits by removing areas that constrict the floodplain along with widening and deepening of the channel and floodplain within the project footprint; This sensitivity seeks to determine if it is possible to reduce costs while maintaining a similar level of FRM benefits.

Alternative C consists of the construction of channel improvements. Federal levee improvements (excavated material plan) and upgrading an existing non-Federal ring levee. Construction of the project will require relocations and/or improvements to various public and private utilities and infrastructure, mitigating potential HTRW and other hazardous waste sites within the floodplain, avoidance and minimization measures required, and the creation of new habitat mitigation areas to offset losses within the project’s construction footprint areas.

Channel Improvements

For this sensitivity, the differences to channel improvements are primarily reduced excavation depths. Excavation depths will vary between 2-17 feet to meet the proposed bottom elevation of 251.0 NGVD. Excavation is preliminary set to the same extent as Alternative C, less the excavation at the Gallatin Street Landfill HTRW Site.

Overbank Modifications

Overbank modifications are the same as alternative C for this sensitivity.

Maintenance Berm

No Maintenance Berms are required for this sensitivity. However, the areas previously recommended as Maintenance Berms for Alternative C may be used to place fill excavated from the channel overbanks.

Hardpoints at Base of Tributary

Hardpoints are the same for this sensitivity and alternative C.

Maintenance and Reinforcement of Bridge Abutments or Repair Bridges

If any stabilization or armoring, such as riprap, slope paving, slide repairs, etc. are the same for this sensitivity and alternative C.

Excavated Material Plan

The excavated material plan is the same as alternative C for this sensitivity.

Weir Demolition and Construction of New Weir with Fish Passage

The existing weir, which is currently set to approximately 250 feet, and is located at RM 291 near the J. H. Fewell WTP site would remain in place.

This sensitivity does not include a weir to be constructed near RM 284.3 as there are no FRM befits associated and the channel improvements to an elevation 251.0 ft does not result in the loss of pool at the current weir location. However, the NFI or other entity could add another dam or weir and any necessary improvements to existing levees and other infrastructure at their own cost to supplement this effort.

New Federalized Levee

Any modifications to existing non-Federal levee protects the Savanna Street WWTP near RM 282 are the same for alternative C and this sensitivity.

Alternative CTO

Section 3104 of the WRDA provided that the Secretary of the Army may select any or all of the features identified below to form a CTO Alternative, so long as the combined features provide the same level of flood risk reduction as the NED Plan, or better. The USACE evaluated various combinations of the project features to determine a combination that would maximize the flood risk reduction benefits while reducing adverse impacts and costs. Based on H&H modeling and agency coordination, the CTO Alternative would be comprised of the following features:

- Alternative A1 Non-Structural Plan
- Excavation of Main Channel
- Federal levee improvements
- Construction of new weir, Fish passage
- Non-Federal levee improvements (Savannah Street WWTP)
- Levees
- Bridge modifications
- Mitigation features

CTO FEATURE SUMMARY

Nonstructural Component

The nonstructural analysis was conducted based on a residential and non-residential structure inventory developed by USACE in 2023 using the National Structural Inventory database of structures, version 2.0. An assessment of structures located in the 10 percent, 4 percent, 2 percent, and 1 percent AEP floodplains in the Post Project Construction was performed (reference Appendix N for more details). Elevation and floodproofing was used to determine the effectiveness of a nonstructural alternative. For the analysis, residential structures were to be elevated to the 1 percent Annual exceedance probability (AEP) base flood elevation (BFE) based on year 2082 hydrology up to 13 feet above the ground and nonresidential structures to be floodproofed up to 3 feet above the ground. Participation in the nonstructural plan would on a voluntary basis by the property owner.

As a result of feedback from the public meetings held in May and June 2023, the option to include property acquisition (buyout) on a voluntary basis is included in the nonstructural implementation plan (Appendix N). Full details regarding the Non-structural implementation plan are included in Appendix N

Channel Improvements

The Alternative CTO provides similar flood risk reduction at the NFI Alternative C with a smaller footprint. Alternative CTO consists of the construction of channel improvements, a new weir with a low-flow gate structure downstream for future potential water supply while simultaneously creating a lake area for recreational opportunities. Federal levee improvements (excavated material plan) and raising an existing non-Federal ring levee (the Savannah Street WWTP Levee).

Modifications include constructing a weir upstream of the location identified for Alternative C, reducing excavation limits which reduces fill areas and thus reducing environmental impacts throughout the project footprint. The new weir would have a lower elevation than proposed for alternative C as well as a reduction in the overbank excavation limits. These changes could reduce environmental impacts especially to HTRW sites within the project footprint.

The Alternative CTO seeks to realize flood risk management through a reduced scope of measures that provide similar levels of flood risk reduction as Alternative C. Flood risk management is realized through lowering of the channel overbanks within the project footprint, thereby improving conveyance of water through the project area and lowering the water surface elevation of the river in some places within the project area over 4 feet (1.2 m). Water surface elevation reductions due to this excavation would provide reduction of flood elevations not only within the reach of excavation, but additional elevation reductions upstream for over 8 miles upstream of the excavation limits.

Alternative CTO consists of the construction of channel improvements, a new weir with a low-flow gate structure downstream for future potential water supply while simultaneously creating a lake area for recreational opportunities. Federal levee improvements (excavated material plan) and raising an existing nonfederal ring levee. (Savannah Street WWTP levee) Construction of the project would require relocations and/or improvements to various public and private utilities and infrastructure avoidance and minimization.

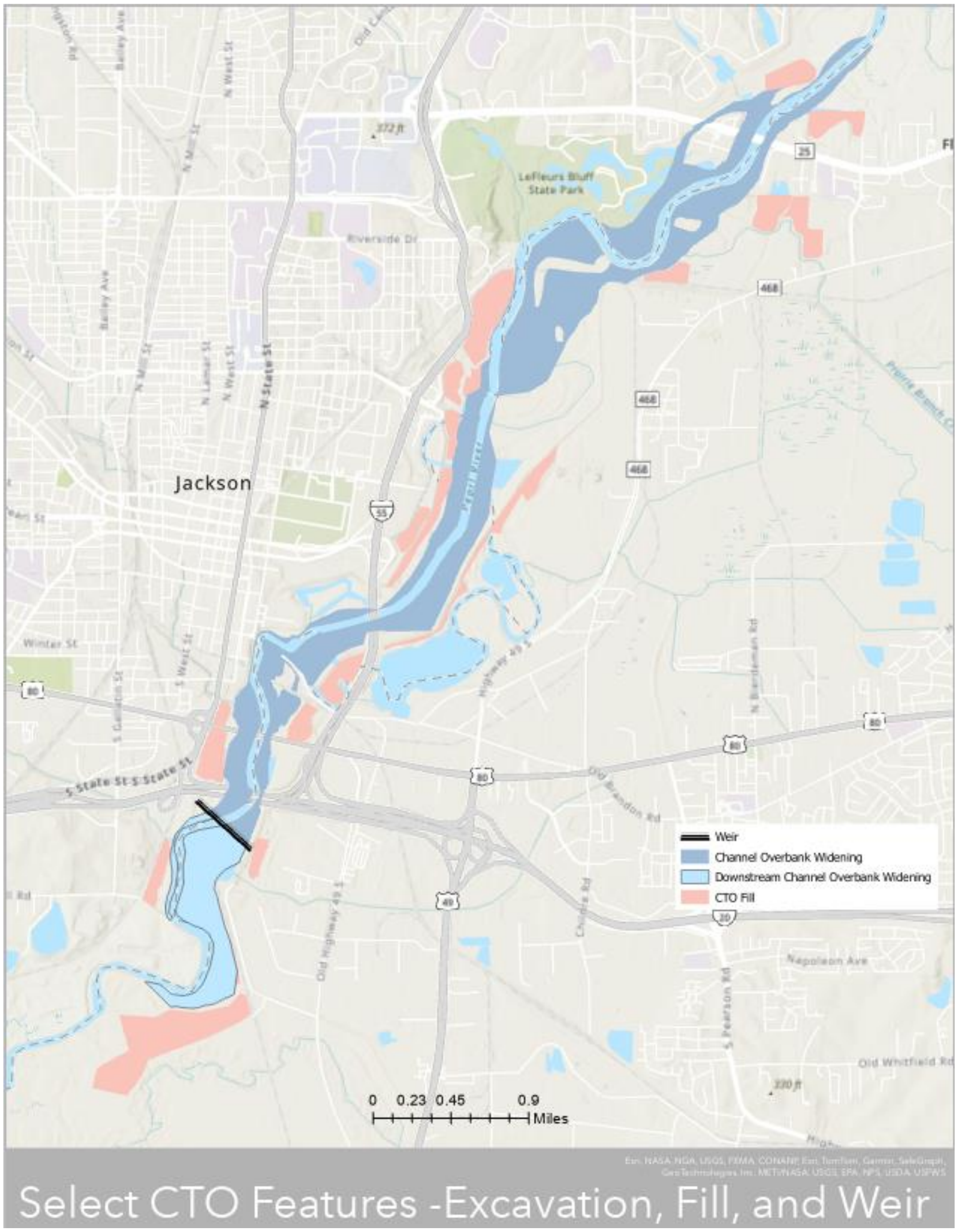


Figure E2-19. Select CTO Features – Excavation, Fill, and Weir

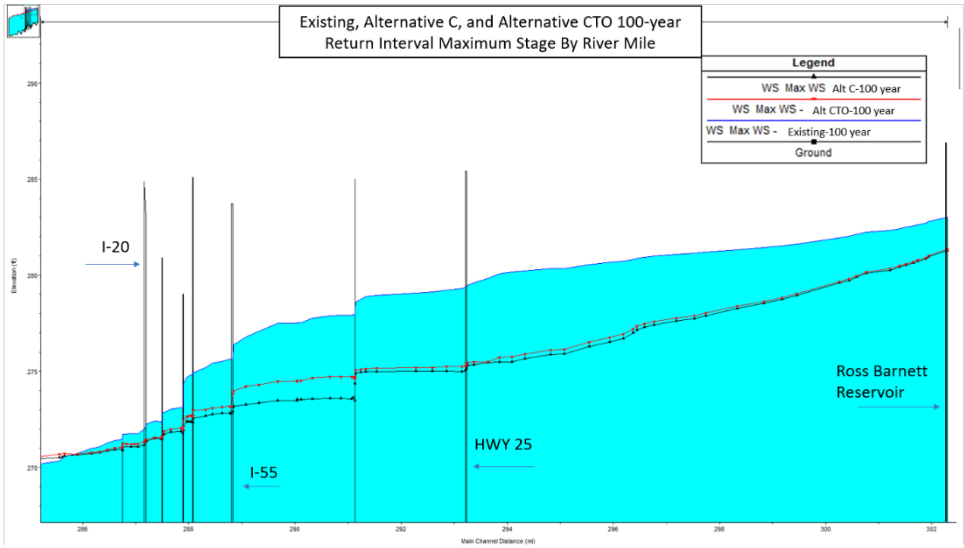


Figure E2-20. USACE modeling Results for the 1% AEP (100-year) With and Without Project Routing Scenario

Channel improvements (Figure 2-19) consist of excavating areas along the Pearl River to improve conveyance from RM 285 to 294., which included river reaches previously channelized during the existing levee construction. The channel improvement footprint includes excavation of up to 1,016 acres. Of the total 1,016 acres, approximately 853 acres are located above the proposed weir, and approximately 163 acres are located below the proposed weir. The width of excavation would vary ranging from 500 to 2,600 feet (152-793 m) including the river width. The actual widths would be determined during later phases of study. The depth of excavation would vary between 0 -15 feet to meet the proposed bottom elevation of 250.0 feet NGVD. The quantity of material excavated from the floodplain and channel overbanks would range from 11.3 to 14.1 million cubic yards (8.6-10.7 million m³) of material. The existing river channel would not be widened, instead excavation of the overbank areas would occur.

The preliminary project layout includes islands within the channel improvement excavation area that would be maintained and/or expanded upon from RM 288.0 to RM 292.0. Further, sand bars could be constructed inside the floodplain and along the existing islands to compensate for the loss of sand bar habitat.

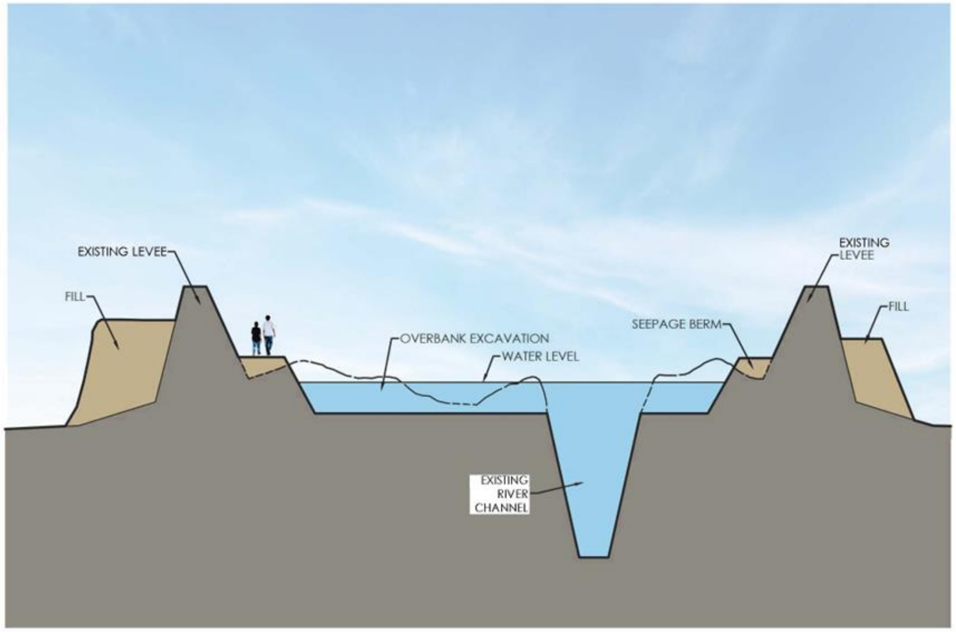


Figure E2-21. Channel Improvements with a Relocated Weir

Overbank Modifications
The existing overbank areas of the Pearl River channel would be lowered to increase conveyance of flood flows. Existing levees would remain in place and would be maintained to increase this control and to aid in haul access. Excavation limits near the existing levees would be determined during final design.

1. Station 10+00 through 140+00. Specific items included in this reach are the I-20 Interstate bridges (Sta. 95+00±) as well as the U.S. Highway 80 (Sta. 110+00), Old Brandon Road (Sta. 135+00±), and railroad bridges (Sta. 70+00±, Sta. 130+00±). Two high-pressure gas lines run through this reach and will would have to be carefully monitored as excavation and grading activities progress. Multiple access points on both sides of the river would have to be maintained and monitored from a perspective of public safety and construction use.

2. Station 140+00 through 290+00. This reach contains excavating the overbank areas around high points such that high points would appear as islands. As with the previous reach segment, numerous access points would require management and maintenance for use and safety. A creosote slough area (Sta. 240+00±) will be avoided during construction, to not disturb or cause any objectionable material to be exposed or mixed with other excavated material.

1. Station 290+00 through 400+00. As with the previous downstream reaches, there are bridges to work around (Highway 25 near Sta. 360+00), and gas lines and transmission lines that must be monitored during earthmoving operations. Depending on the final design, Mayes Lake (Sta. 310+00±) may need tie-in work to maintain its current level. A determination about the tie-in work would be made during later phases of study. An existing abandoned railroad embankment of the Gulf, Mobile & Northern/Gulf Mobile and Ohio (GM&N/GM&O) Railroad Bridge could also be affected and was removed in H&H modeling. Some excavation would be required in this reach such that high points would appear as islands. The existing weir at the water works bend near Station 290+00 would remain undisturbed.

Excavated Material Plan (Fill material)

Alternative CTO would upgrade the existing federal levees by placing excavated material on the protected side of the levees. Excavated fill material would also be placed in designated disposal areas in other locations within the flood plain. The disposal fill areas would impact approximately 485 acres (151 ha).

Clearing and grubbing of approximately 1501 acres would occur prior to placement of the excavated fill material from the channel lowering. The excavated fill material would be used to create land areas ranging from 6.5 to 88 acres (2.6 – 21 hectares) within the Jackson MSA. The newly created areas could allow for expanded riverfront access, natural areas, and commercial development, along with recreational opportunities.

Fill material placed behind levees would be graded to the same elevation or lower than existing levees, compacted for suitably for future land development. However, if any structures are built on top of any portion of the maintenance berm designed or used as a seepage control, the berms would need to be overbuilt and utilities or any other structure or penetrations would be limited to within the overbuilt section.

Where water would be permanently ponded against the riverside slope, these areas will require a 40-foot-wide semi-compacted impervious riverside maintenance berm to limit seepage through the levee. The berm assumed to extend the entire length of any levee section where water is pooled. No removal of the riverside blanket near the existing levees is anticipated. A riverside blanket refers to a top layer of clay and/or silt soil with low permeability constructed on the riverside of a levee to reduce the movement of water underneath the levee.

If any structures are to be built on top of any portion of the maintenance berm designed or used a seepage control, the berms would be overbuilt and utilities or any other structure or penetrations would be limited to within the overbuilt section. Penetrations trough the berm could become seepage exit points, and this is specified to limit fracture through the main berm.

Material Provided to NFI

Up to 1,660,000 cy (1,269,000 3) of fill material (estimated as 100 acres (40.5 hectares) of fill 10 feet high) would be provided to the NFI for additional usage within the project footprint. This material would either hauled directly from the excavation site or moved to a staging area for removal by the NFI. Existing fill areas would be used as staging areas after clearing and grubbing but prior to fill activities.

Hardpoints at Base of Tributaries

Multiple tributary inflow points exist within this reach and Alternative CTO will add a hardpoint, via a rock chute to prevent backward erosion at each tributary inflow where the excavation of overbanks decreased the tributary channel bottom elevation at or near the confluence of those tributaries with the Pearl River.

Reinforcement and Repair of Bridge Abutments of Bridges (as required)

Stabilization or armoring, such as riprap, slope paving, slide repairs, etc., would be required and will be carried out prior to clearing and any major channel work. Following its own analysis, the Mississippi Department of Transportation (MDOT) has informed the Rankin-Hinds Flood Control District (the Flood Control District), MDOT agrees to collaborate with the Flood Control District in “the advancement of this project and to ensure countermeasures are included, if determined necessary during the future design process.” (letter to G. Rhoads, dated February 26, 2024) To this end, the Flood Control District developed a range of cost estimates for potential structural and hydraulic countermeasures that could be recommended if countermeasures are determined necessary. The array of countermeasure features analyzed will mitigate potential impacts to MDOT bridges that will be identified during later phases of study. The estimated cost for these features is based upon known costs for the construction of hydraulic and structural countermeasures on another MDOT project at downstream hydraulic crossings of the Pearl River. When additional information becomes available during later phases of study, adjustments to the design can and will be made to reduce potential impacts. Any proposed countermeasure design and implementation will be conducted with MDOT’s concurrence, review, and approval.

Rough estimations of the level of effort required to mitigate for bridge impacts include improvements for approximately 36 bents, 12 piers, abutment scour, as well as funding to conduct monitoring surveys. A pile is a concrete post that is driven into the ground to act as a leg or support for a bridge. A bent is a combination of the cap and the pile. Together, with other bents, act as supports for the entire bridge.

There are a total of 2 active railroad bridges in the project area. All efforts would be made to avoid, monitor, and protect these structures. Additional modeling is required to validate these assumptions during later phases of study. If avoidance is not possible, then coordination with the operating entity to determine specific requirements of each railway bridge will be conducted. All alterations of railroad bridges would be in accordance with Section 3 of the 1946 Flood Control Act (22 USC 701p).

Construction of New Weir and Gate with Fish Ladder

Alternative CTO may include a new weir to be constructed further downstream near RM 286.5 at the southern end of the channel improvements area. It should be noted that the

CTO alternative does not include any modifications to the existing J. H. Fewell weir. This new weir would provide for a larger lake within the Pearl River channel to the north of the weir and fish ladder. Downstream low-water hydrologic flows (extreme drought condition minimum flows) within the Pearl River channel would be maintained by means of a 12 x 12 foot low-flow gate. any future maintenance which requires drawdown of the lake. Portions of the weir would be submerged during normal flow allowing excess water to pass downstream. Water would pass over the weir with inflow into the lake approximately equaling outflow at any given time (with the exception of the extreme drought, which has a minimum release and outflow could be greater than inflow. However, this is expected to very rarely occur, as the Ross Barnett Reservoir also has a minimum release requirement that would pass through the system). As opposed to the existing weir, the new weir would be constructed to a higher elevation of approximately 256 feet. (Approximately 6 feet higher than the existing weir, and 2 feet lower than the Proposed Alt C weir.) NAVD 88 with a length of up to 1,700 feet with a fish ladder located on the southern end of the proposed channel improvements area. The weir would impound approximately 6 feet of water along the excavated overbanks (about 1350 ft) and up to 22 feet in the approximately 350 feet across the main channel. This would impound an area of approximately 1706 acres, of this area approximately 637 acres are upstream of the Fewell Water Treatment Plant Weir. Downstream erosion protection from flow over the weir are part of the conceptual designs.

A fish ladder (Figure E2-23) would be excavated around the relocated weir within the project area. The fish ladder is conceptually designed to be approximately between 5,000 - 6,000 feet (1524-1829 m) in length. The fish ladder would be constructed at an approximate 0.004 ft/ft slope and tie into the Conway Slough which connects to the Pearl River 0.8 miles downstream of the CN Railroad Bridge. The fish ladder design would be coordinated with US Fish and Wildlife and state agencies during later phases of study.

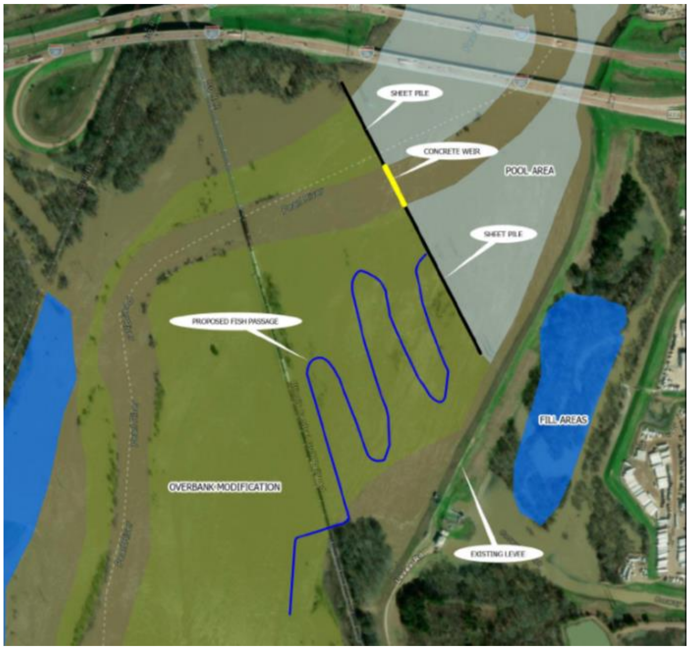


Figure E2-23. Proposed Weir (Black) and Fish Ladder (Blue) Exact Dam Design to be determined in later phases of design.

The proposed weir meets USACE and State criteria to be defined as a dam based on the height of the structure and water storage. As a result, the dam would be designed and constructed to meet USACE and State criteria for a dam.

The construction of a weir without excavation of the overbanks has not been sufficiently investigated to ensure that inducements do not occur. Construction of the weir without channel conveyance improvement was not analyzed and would require additional study if selected.

The proposed weir would result in an expanded, year-round recreational water body capable of supporting recreational facilities. Potential recreation sites would be limited to areas disturbed by construction and design of the facilities would be coordinated during later phases of study. The potential recreational opportunities could include boat ramps, camping areas, fishing piers, trails, or wildlife viewing areas.

Pumping Needs at Existing Levees

The existing levees contain drainage structures that allow water to drain from the interior of the leveed area when the Pearl River is low. When the Pearl River water level is high, the drainage structures are closed, and pump stations are used to pump water out of the leveed area. The original design of these features called for the drainage structure to handle a 1 percent AEP interior drainage flow and the pumps were originally designed for a smaller event.

Alternative CTO calls for the construction of a new weir with a minimum pool at elevation 256.0 ft. As a result, the drainage for the Jackson Fairgrounds Levee would always impound at least multiple feet of water on the structure and would no longer be able to operate via gravity flow in order to prevent the new lake from flooding the interior leveed areas.

The proposed new weir was placed upstream of the East Jackson Levee drainage structure, so the pool should not impact the operation of the drainage structure. Additional pumping capacity would be needed to mitigate for the loss of capacity of the gravity flow drainage at the Jackson Fairgrounds Levee. Additionally, the Operation and Maintenance of the additional pumps would need to be substantially updated from the existing O&M plan for the pumping capacity and constant operations.

Savannah Street WWTP Levee
This is an existing non-Federal levee that provides flood risk reduction to the Savanna Street WWTP near RM 282 (Jackson-East Jackson Flood Control Project NLDID: 14050000124). The levee would undergo maintenance and additional upgrades to meet the freeboard necessary to meet a 1 percent AEP flood event in advance of the main construction phases (Figure 2-24). The new Federalized levee around the WWTP consists of a 10-foot crown width with 1V on 3H landside and riverside slopes. If needed, a slurry wall for seepage mitigation would be added.

Principal features of the work include mobilizing and demobilizing, clearing and grubbing, removing and stockpiling any existing crushed stone surface, semi compacted levee embankment, traverses, adding new crushed stone surfacing, mowing, turfing, erosion control matting, preventing storm water pollution, and providing environmental protection. Additional work could include trenching and the creation and backfill of a concrete slurry wall within the levee footprint.

Figure E2-24. Proposed Federalized Levee at Savannah WWTP

Levees Plan

Canton Club Levee

A levee segment of approximately 1.5 miles is proposed on the west bank of the Pearl River in northeast Jackson. This levee would provide additional flood risk reduction for approximately 100 acres of high density developed neighborhoods. This area is bounded on the north by the North Canton Club Circle and Beechcrest Drive on the South. It is estimated this would reduce flood risk for over 250 homes.

Figure E2-25. Proposed Canton Club Levee (orange line)

Principal features of the work include mobilizing and demobilizing equipment, clearing and grubbing, removing and stockpiling any existing crushed stone surface, semi compacted levee embankment, traverses, adding new crushed stone surfacing, mowing, turfing, erosion control matting, preventing storm water pollution, and providing environmental protection.

If additional borrow is necessary, the borrow areas would be acquired by the NFI and furnished by the Government to the contractor (government furnished borrow). Some small areas could be more appropriate for the construction of a short floodwall, typically an I or T wall, could be more appropriate for some small areas due to space constraints, though further analysis would be required. Constructing a less designed berm could be more appropriate where smaller loadings would occur.

Construction of the project will require relocations and/or improvements to various public and private utilities and infrastructure, avoidance and minimization features required under the ESA, and the creation of new habitat mitigation areas to offset losses within the project's construction footprint areas.

Items not included within Alternative CTO

Given the magnitude of the Pearl River Basin, Mississippi flood risk, water supply and water quality concerns, it has become apparent that a systematic approach involving multiple projects from several different programs and under several different authorities will be required to effectively deal with a problem of such large proportions. Below is a listing of items that could be considered for separate efforts that were considered beyond the scope of the existing study.

Storage in Tributaries

Future projects could consider additional storage in tributary, either by upstream detention, or by side channel storage. These options could have limited benefit due to the downstream channel constraints, which are already restricting flow and lack of available land for side channel storage, as the tributaries are urban drainages. It may also afford recreational access to the waterway.

Storage in Pearl River Channel

Future projects could consider additional storage by upstream detention. This option was previously considered and known as “Lake Shoccoe” but removed due to a lack of public support. Comments at the public meetings supporting this plan suggest reincluding this as an option. Thes options could have some limits due to the downstream channel constraints, which are already restricting flow, but a reasonable reduction of damages could be realized. The Ross Barnett Reservoir Lower Dam, also known as the “Low head dam” is upstream of the Ross Barnett Reservoir and is in disrepair. This structure primarily supports recreation. This structure or a nearby site could be modified to add storage, while preserving the recreational aspects of the existing structure. Further this would limit mitigation damages, as this would replace rather than add an additional structure to the waterway. It may also afford additional recreational access to the waterway.

A sensitivity analysis shows that reducing the flows from the Ross Barnett Reservoir by 20 percent, would reduce damages to the project, similarly but a little less effectively than that of alternative C.

Water Supply- Programmatic Agreement

The EPA and USACE are currently working with the city of Jackson to address local water and wastewater infrastructure under existing federal authorities. This work addresses the immediate and to some extent long standing problems with aging local environmental infrastructure. The J.H. Fewell Water Treatment Plant is 90 years old and remains in service, and under court order is being upgraded. The Ross Barnett Reservoir and Pearl River surface water are the two primary sources of drinking water for the surrounding communities. Flood control projects in the area must directly account for substantive work occurring and ensure alignment with such infrastructure modernization work.

Additional Future Projects could consider potential water supply options:

- No action. Water supply is currently adequately supplied but concerns for future water supply needs would not be supplied.
- Water Supply Conveyance to a site selected by local utilities/municipalities via a pipeline from existing J.H. Fewell weir, with improvements to or replacement of

existing weir to ensure water supply requirements, and longevity of the existing 100+ year old structure.

- Water Supply via a weir similar to the feature described in Alternative C or CTO to provide for water supply. Limited channel cleanout and dredging may occur, to limit environmental damages. Site locations should be selected in consideration of the following:
    - Weir site location in consideration of groundwater or other HTRW contamination.
    - Seepage and Interior Drainage Mitigation for impacted existing levees would be required proportional to final weir height.
    - Constant water supply during and after construction of new weir.

Operational Changes at the Ross Barnett Reservoir

The Pearl River Valley Water Supply District operates the water control features of the Ross Barnett Reservoir and in their vision for operation of the reservoir acknowledges there is a flood reduction capability associated with the reservoir. The Ross Barnett Reservoir, a non-Federal project operated by the Pearl River Valley Water Supply District, was constructed in 1962 for the purposes of water supply and recreation. Although the reservoir was not designed for flood control, it has been actively reducing peak flows during large inflow events since at least 1979 with an estimate that peak flows are reduced by as much as 28% due to these operations. Public comments across the watershed highlighted concerns with reservoir operations. State and local entities may consider operational changes at the Ross Barnett Reservoir and revising the Ross Barnett Water Control Manual to formalize continued flood reduction capacity inform future discharge operations. A sensitivity analysis shows that reducing the flows from the Ross Barnett Reservoir by 20 percent, would reduce damages to the project area, similarly but a little less effectively than that of Alternative C.

Due to the structural components, significant upstream inducements, and known seepage concerns, a raise in pool due to flood storage is not likely a realistic opportunity. Sandbagging was required due to weak points caused by higher pool loading in 1979, and other minor seepage concerns have since occurred. A permanent lowering of pool is considered to have strongly negative local perception and risks the current water supply mission. However, a formalization of the current future informed release process with documented Operational Changes could be undertaken by the Pearl River Valley Water Supply District and applied to the Ross Barnett Water Control Manual to ensure continuation of this flood reduction capacity. It is likely that the downstream reach would not see any significant improvement in flow reduction due to the lack of storage capacity and the fact that the Ross Barnett is already operating to this purpose.

SECTION 2
Statistical Analyses

STATISTICAL MODELING

USACE used the Hydrologic Engineering Center Statistical Software Package (HEC-SSP) version 2.3 to update the flow frequencies to Bulletin 17C at key gaged locations within the Basin. HEC-SSP includes tools to perform annual peak flow frequency analyses, volume frequency analyses, duration analyses as well as produce balanced hydrographs.

The USACE developed peak flow frequencies and scaled discharge hydrographs discussed in this section are used as input to the hydraulic modeling at the Ross Barnett Outflow into the Pearl River. The hydrologic model discussed was used to develop incremental local flows within the project area and are also included within the project area.

PEARL RIVER GAGE

The Pearl River at Jackson is the longest dataset within the project area, with data available on the USGS gage site from 1874 to 2022. 1874 to 1900 are peak measurements, and 1901 to present are gage recordings. The peak annual flow data is shown below (Figure E3-1). USACE selected a perception threshold of 60,000 cfs as the likely level of event below which a measurement would have not been recorded.

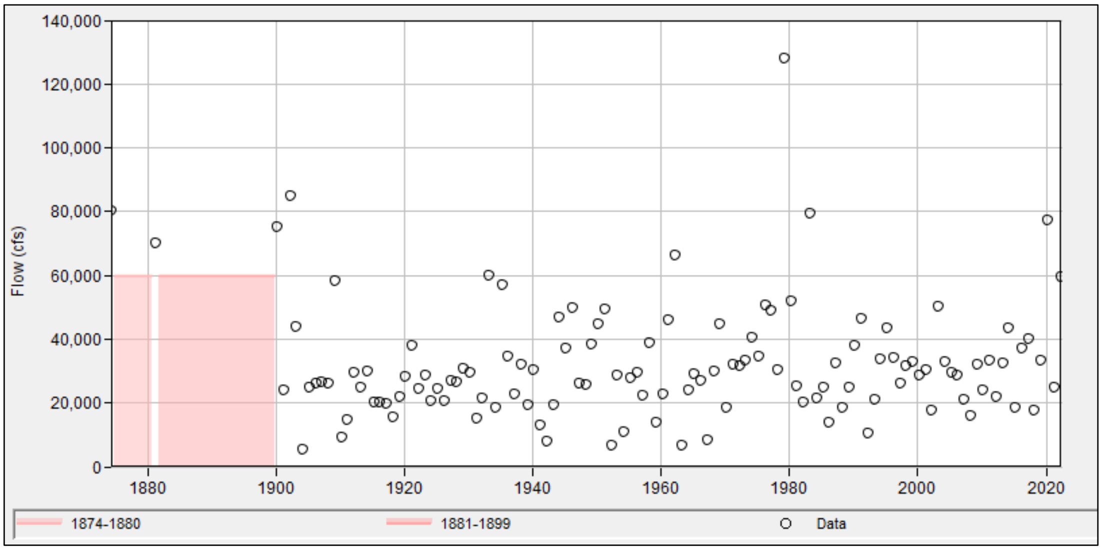


Figure E3-1. Annual Peak Flows at the Pearl River at Jackson Gage

Flow Frequency

A Bulletin 17C flow frequency was completed on full period of record observed data using HEC-SSP (1874-2022). This modeling effort does not account for regulation at the Ross Barnett reservoir. Discussion with the project NFI, the local National Weather Service (NWS), and USGS officials confirmed continued historical operations at the Ross Barnett Reservoir. This assumption is consistent with the NFI study. Table E3-1 lists the peak annual flow frequency results for the Pearl River at Jackson Gage. Figure E3-2 shows the peak flow relationship at the Jackson Gage.

Table E3-1. Peak Annual Flow Frequency Results for the Pearl River at Jackson Gage

Percent Chance Exceedance	Computed Flow in CFS	Variance Log (EMA)	0.1 Confidence Limit (CFS)	0.9 Confidence Limit (CFS)
0.1	147000	0.0089	215000	118000
0.2	129000	0.0067	179000	106000
0.5	108000	0.0044	140000	91900
1.0	93500	0.0030	115000	81500
2.0	80100	0.0020	94300	71400
4.0	67700	0.0013	76600	61600
10.0	52700	0.0007	57300	48900
20.0	42000	0.0005	45000	39400
50.0	28000	0.0004	29700	26400
80.0	19200	0.0004	20300	18000
90.0	16000	0.0007	17100	14500
95.0	13800	0.0012	15000	12100

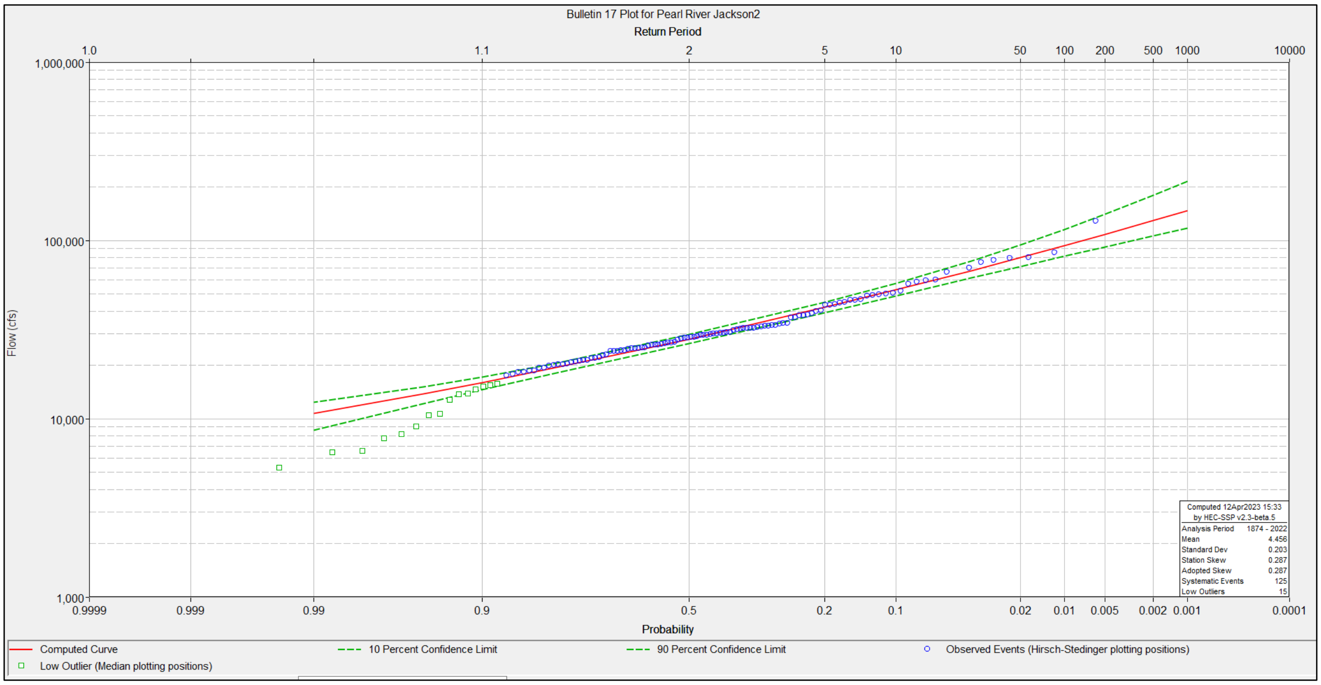


Figure E3-2. Peak Flow-Frequency Relationship at the Pearl River at Jackson Gage

ROSS BARNETT RELEASES

HEC-SSP analysis were developed with period of record data (1874 to 1978-local, and 1979 to 2022-at site) to update the flow frequency values. The 1979 and 1983 discharge values were corrected within the period of record data.

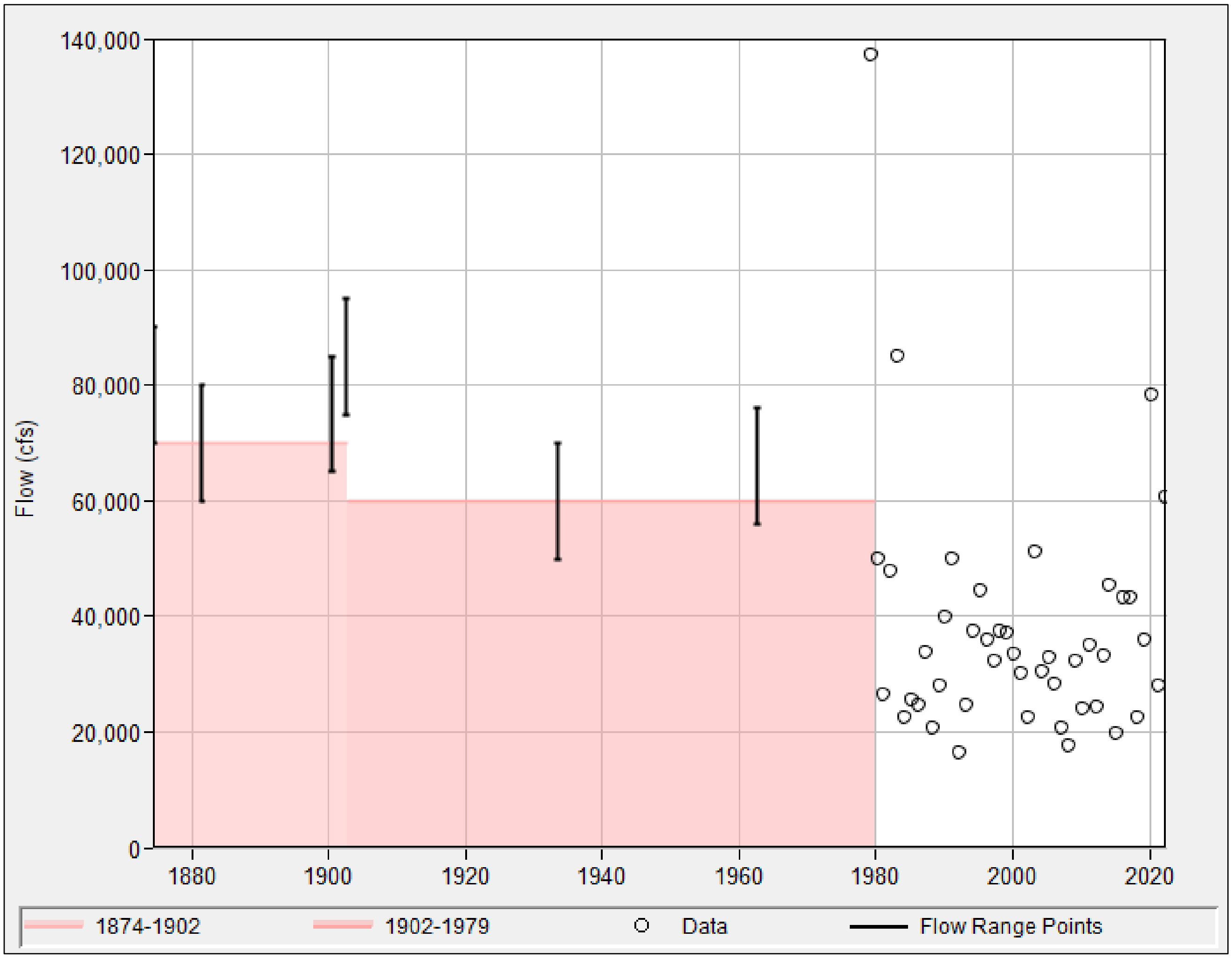


Figure E3-3. Annual Peak Flows at the Pearl River at Ross Barnett Reservoir

Flow Frequency

USACE completed Bulletin 17C flow frequency on full period of record existing data using HEC-SSP. The period of record was supplemented with data from the downstream Jackson gage, using the same assumptions on perception thresholds. USACE added a 10,000 cfs. range for the major historical flood events, as the impact of attenuation and local tributary inflows vary due to the shape of each individual storm pattern. This modeling effort does not account for any regulation that the Ross Barnett reservoir and simply utilizes the reservoir output datasets. The Ross Barnett reservoir generally acts as run-of-river but does somewhat limit peak flows. Discussion with the project NFI, the local National Weather Service (NWS), and USGS officials confirmed continued historical Ross Barnett Reservoir Operation. This assumption is consistent with the NFI study. An additional sensitivity for flow releases is discussed in the section 3.3.2. Reference Table E3-2 for a list of the Pearl River at Ross Barnett Reservoir gage flow frequency relationship and Figure E3-4.

Table E3-2. Pearl River at Ross Barnett Reservoir Gage Flow Frequency Relationship

Percent Chance Exceedance	Computed Flow in CFS	Variance Log (EMA)	0.1 Confidence Limit (CFS)	0.9 Confidence Limit (CFS)
0.1	155000	0.0115	353000	117000
0.2	135000	0.0084	264000	106000
0.5	111000	0.0052	181000	91200
1.0	95700	0.0034	138000	80900
2.0	81800	0.0021	106000	71000
4.0	69300	0.0013	82300	61400
10.0	54500	0.0008	60800	49000
20.0	44400	0.0007	48700	39700
50.0	31500	0.0006	34400	28300
80.0	23800	0.0005	25900	21800
90.0	21000	0.0006	22800	18800
95.0	19100	0.0009	21300	16800

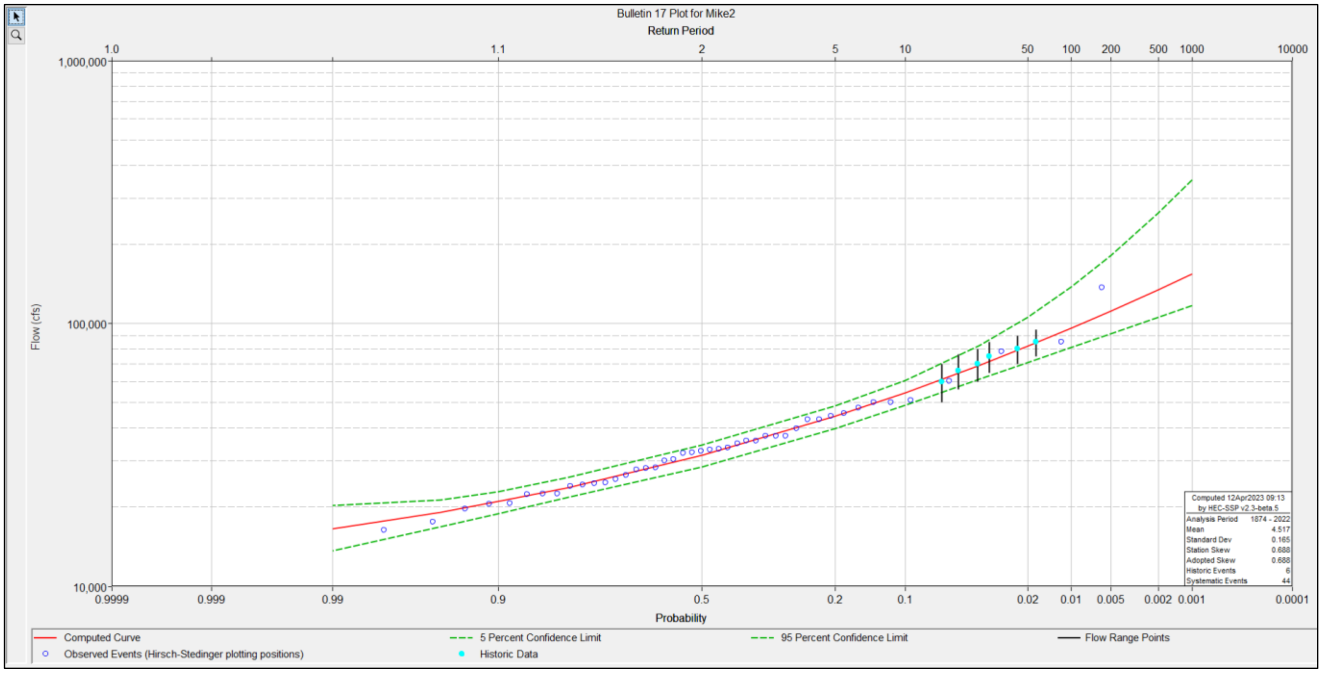


Figure E3-4. Peak Flow-Frequency Relationship at the Pearl River at the Ross Barnett Reservoir

Ross Barnett Releases Sensitivity/Updates

USACE completed a Bulletin 17C flow frequency sensitivity on the full period of record of observed data using HEC-SSP. This sensitivity uses the data in section 3.3.1 but assumes that the Ross Barnett at some point in the future may not be able operate as it currently does for inflows over 75,000 CFS (Table E3-3). Therefore, the 1979, 1983, and 2020 events are set as historical events with flow-interval ranges ranging up to the reported inflow value. The SSP model would select the geometric mean of these two bounding parameters, for an estimate that is removing roughly half of the regulating capacity.

Table E3-3. Pearl River at Jackson, MS Gage Flow Frequency Relationship with Adjustment over 75,000 cfs

Percent Chance Exceedance	Computed Flow in CFS	Variance Log (EMA)	0.1 Confidence Limit (CFS)	0.9 Confidence Limit (CFS)
0.1	163000	0.0129	394000	122000
0.2	141000	0.0094	294000	109000
0.5	115000	0.0058	196000	93600
1.0	98400	0.0038	146000	82600
2.0	83500	0.0023	110000	72100
4.0	70300	0.0014	84200	62100
10.0	54800	0.0008	61400	49100
20.0	44400	0.0007	48800	39500
50.0	31300	0.00066	34300	28100
80.0	23600	0.00048	25800	21700
90.0	20900	0.00058	22700	18800
95.0	19200	0.00096	21400	16900

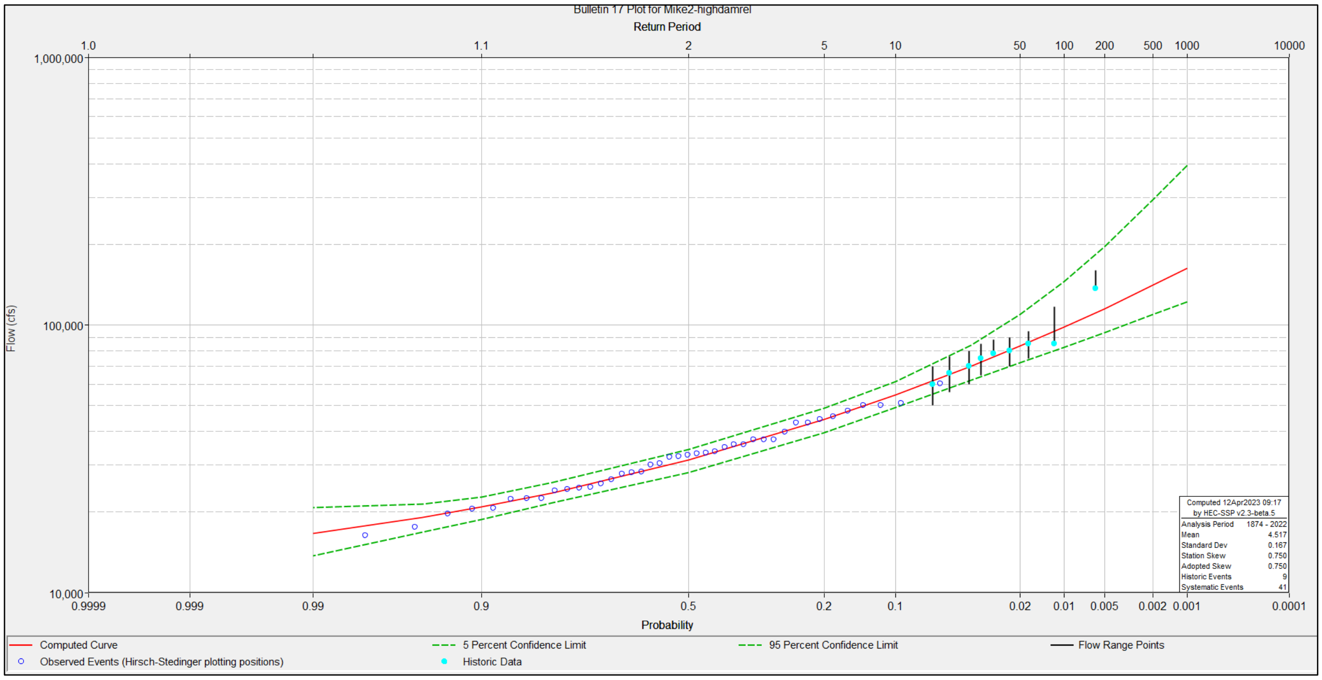


Figure E3-5. Peak Flow-Frequency Relationship at the Pearl River at the Ross Barnett Reservoir with Adjustments to the Ross Barnett High Flow Release

COMPARISON TO PREVIOUS NFI FREQUENCY DATASET

Table E3-4 presents the differences in NFI and current Flow datasets. NFI data incorporated a single flow value throughout the study reach, which is compared to the input at the upstream of the project boundary.

Table E3-4. Comparison of Updated Values to NFI Dataset

Frequency- Return Interval	NFI Reported Flow- CFS, Data Though 1988	Updated Flow- Ross Barnett Operation as Current	Updated Flow-Ross Barnett Operation Reduced by Half
100-Year	106,000	93,800	97,200
200-Year	125,000	108,400	113,300
500-Year	148,000	130,000	137,600
1,000-Year	N/A	148,400	158,600

HYDROGRAPH PATTERNS FOR ROSS BARNETT INFLOWS

Due to the limited time available to complete the existing condition scenarios and the nature of the data available for the Ross Barnett inflows, balanced hydrographs at this location from a previous study were not completed for use within the Hydrologic Engineering Center's River Analysis Software (HEC-RAS) modeling effort. Instead, USACE considered a series of three observed hydrograph shapes to represent the Ross Barnet Dam inflows. Hydrograph patterns were from the 1979, 2020, and the 2022 flood events and a balanced flood hydrographs completed in a pervious study downstream of the Pearl River at Jackson gage were considered for template patterns.

The 1979 event was initially considered as a pattern but later dismissed because, although it was the highest event, it likely does not represent current condition reservoir release operations occurring with more modern forecasting technology and current water conditions and channel geometry. USACE removed the 2022 event hydrograph from the study as well because it is the lowest of the events considered. Both the past study balanced hydrographs at the Jackson gage and the 2020 flood event was considered reasonable. However, USACE adopted the 2020 hydrograph pattern to represent inflows because the balanced flood hydrograph from the previous study already accounted for the flood attenuation occurring between the dam and the Highway 80 gage. The peak of the 2020 event hydrograph was scaled to match the peaks for the frequency events determined from the statistical flow frequency analysis. These scaled 2020 pattern frequency hydrographs were used as input into the hydraulic model.

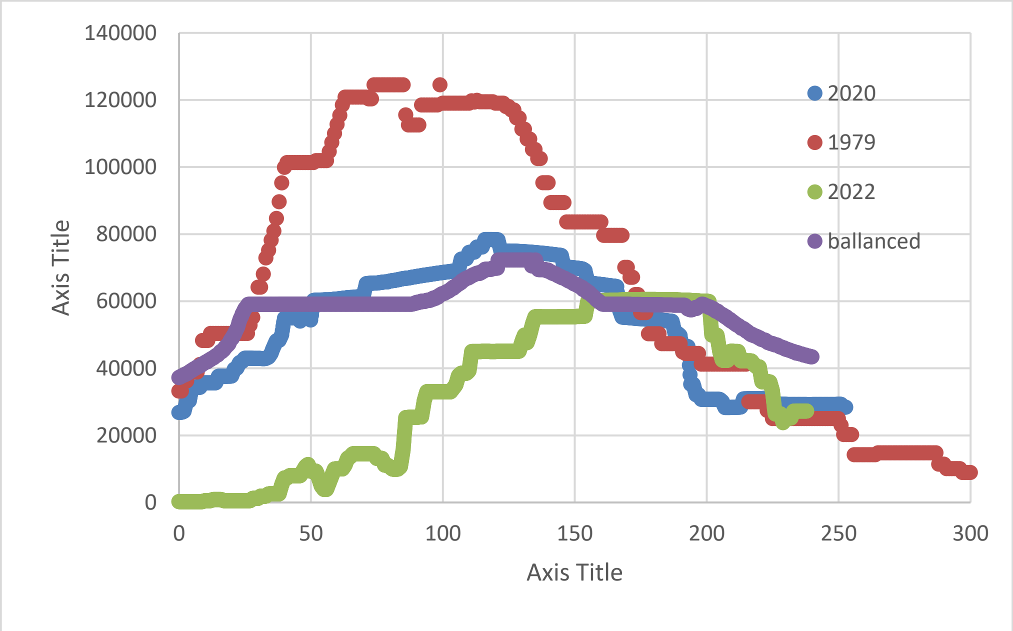


Figure E3-6. Sample Hydrographs at the Ross Barnett (flow vs time (hrs)

LOCAL TRIBUTARIES

Table E3-5 lists the mainstem and tributary gages within the Pearl River project area. The initial intent was to use both stage and flow hydrographs where available, in addition to supplemental flow/stage annual peaks. However, it was determined though the calibration process that the local drainage gages of concern are all backwater influenced at high Pearl River stages.

Figure E3-7 shows an example plot illustrating this backwater influence for the Hanging Moss, Lynch Creek, and Pearl River at Jackson Gages. The Lynch Creek enters the Pearl River just downstream of the Pearl River at Jackson Gage, and the Hanging Moss enters the Pearl River well upstream of the Pearl River at Jackson Gage. Figure E3-7 shows that even without accounting for slope, the Pearl River backwater leaves a signature on upstream tributary gages. This backwater signature is seen in six of the observed hydrographs at the Hanging Moss Creek gage and two times at the Lynch Creek gage between October 2019 and May 2020. USGS verified that the ratings used to calculate flow have known issues when stages on the Pearl River are high. Therefore, flow was not considered in the calibration of the tributaries but completed in the hydraulic model with reference to observed stages. This was an iterative process that involved changing parameters in the hydrologic model to adjust flow and then adding the adjusted flows to the hydraulic model to see the impact on stages.

Table E3-5. Gage Data Available in Local Tributaries

Gage Stream	Identifier	Drainage Area	Used?
Belhaven Creek	Laurel Street	Unknown	No
Belhaven creek	River Side Drive	Unknown	No
Cany Creek	Jackson, MS	8.38	Yes
Eubanks Creek	Eagle Avenue	4.11	No
Eubanks Creek	Jackson, MS	5.2	Yes
Hanging Moss Creek	Jackson, MS	16.8	Yes
Lynch Creek	Jackson, MS	12.1	Yes
Pearl River	HWY 25 at Jackson, MS	3,130	Yes
Pearl River	Jackson, MS (HWY 80)	3,171	Yes
Purple Creek	Jackson, MS	6.12	Yes
Ross Barnett Reservoir	Jackson, MS	3,050	No
Town Creek	Jackson, MS	11.4	Yes
White Oak	Westbrook Road at Jackson, MS	8.21	Yes

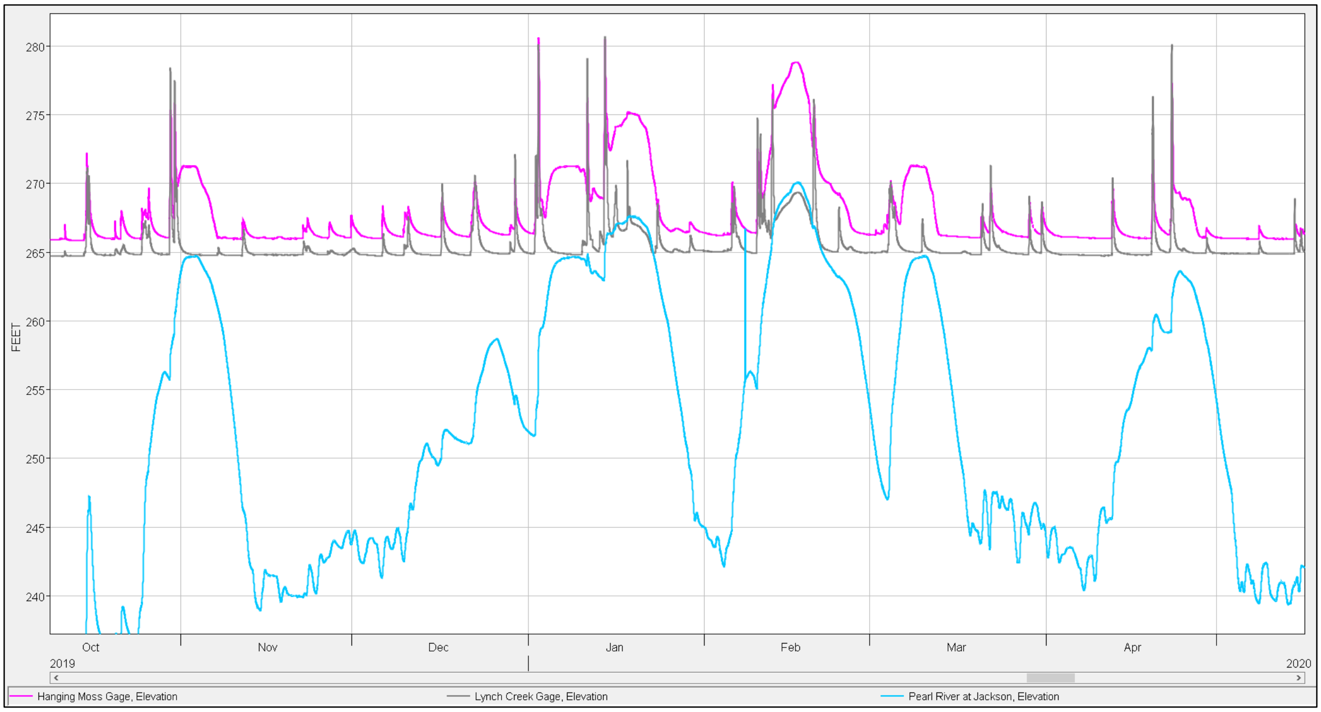


Figure E3-7 Local Rainfall vs Peak River Stage

Status of Selected Local Tributaries

As of the writing of this report, many of the local tributaries experience frequent flash flooding, and the hydraulic and hydrologic modeling discussed later in this report show significant damages in these areas.

USACE completed a quick analysis of this discrepancy to validate the results. This analysis focused on Town and Lynch creeks. While the study values are higher than the published Federal Emergency Management Agency (FEMA) frequency datasets, the FEMA datasets are dated (some dating back to the 1970’s), there has been increased urbanization allowing for faster runoff. The Hydraulic and Hydrologic models are also calibrated low for stage to observed events, though to lower flows within the tributaries, and without consideration to observed data. Both streams have experienced a lack of maintenance as shown in the image below. Further there are multiple news articles referenced that note frequent flooding at more common events than were historically experienced.

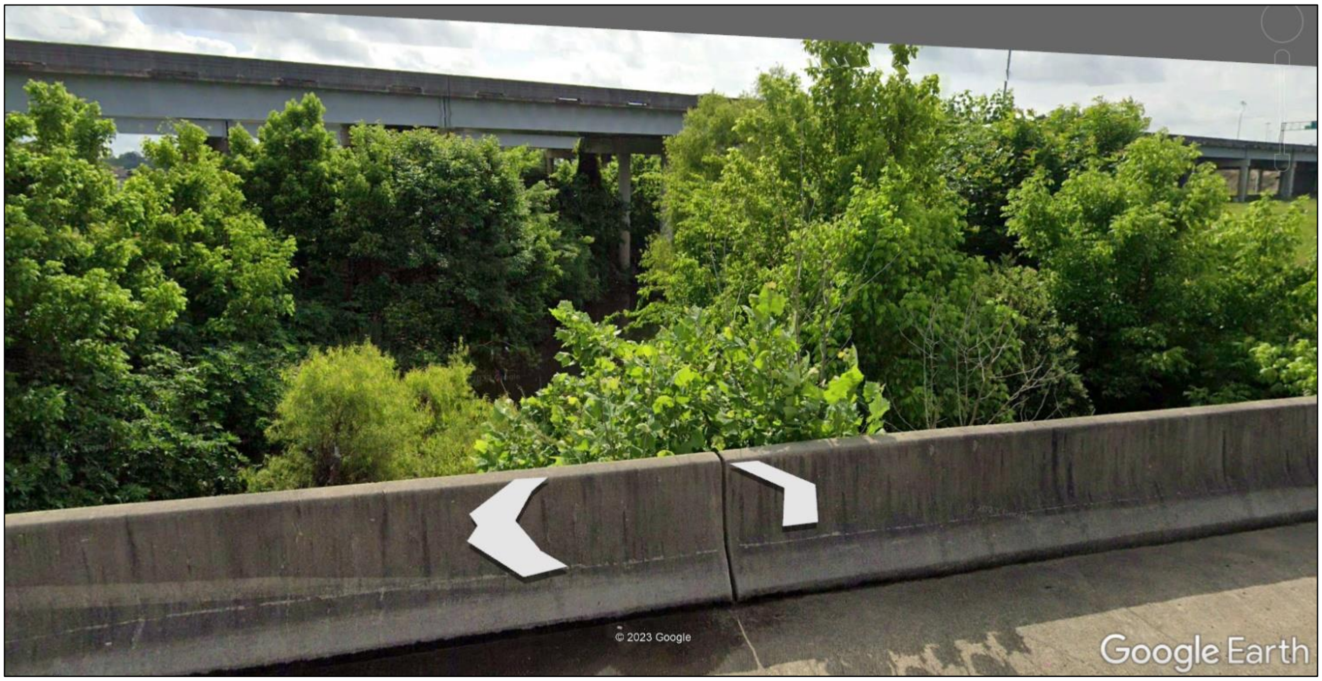


Figure E3-8 Lynch Creek Looking Toward 1-20 from Valley Street

Figure E3-9 Town Creek at an Abandoned Road/Bridge Just Upstream of State Street, Looking Downstream at State Street

Table E3-6. News Articles Describing Local Tributary Flooding

https://www.jacksonfreepress.com/news/2013/sep/18/revisited-town-creek/
https://www.wlbt.com/story/31870644/homeowners-fed-up-with-town-creek-flooding/
https://mississippitoday.org/wp-content/uploads/2022/09/Capital-Infrastructure-Plan.pdf
https://www.wapt.com/article/flash-flooding-alerts-in-place-as-heavy-rain-continues/40978596
https://www.wlbt.com/2020/01/29/coolers-tires-flooding-leaves-behind-piles-trash-along-local-waterways/
https://www.wapt.com/article/residents-cope-with-flooding-on-westbrook-road/30589660
https://www.northsidesun.com/hanging-moss-creek-floods-near-jackson-academy
https://www.wjtv.com/news/local-news/flooding-along-old-canton-road-appears-maintenance-related/
https://www.wlbt.com/story/35061739/several-richland-businesses-along-highway-49-dealing-with-flood-water/
https://www.clarionledger.com/story/news/local/2017/04/06/jackson-woman-my-house-flooded-due-citys-poor-maintenance/99995150/
https://www.wjtv.com/news/richland-avenue-flooding-in-pearl/

COINCIDENT FREQUENCY MODELING

Due to the time limitations of this effort and with consultation with USACE leads, it was determined to be conservative to assume full coincidence with a three-day lag. This coincidence and timing pattern were observed in the case of the catastrophic 1979 flood event.

To adequately size interior drainage structures through selected alternatives if alternatives are available to continue this effort, it is recommended that a Watershed Analysis Tool (WAT) model be developed to combine meteorological inputs, Hydrologic Modeling System (HMS) rainfall-runoff calculations, and Reservoir Simulation Software (HEC-ResSim) reservoir operations and routing later in the project. It is recommended this modeling of interior drainage be developed in later phases of design.

A coincident frequency analysis considering the timing of peak flows between the tributaries and the Pearl River mainstem was started but not completed due to time constraints. Full coincidence was assumed in later modeling. To validate this a correlation analysis was completed for local precipitation (flow/stage in tributaries could not be used due to the backwater issues noted above), the analysis was completed by event and by time. Both analyses reported results below the limit used by USACE standards to indicate coincidence.

SELECTED DATA TO BE INCORPORATED IN THE HEC-RAS MODELING EFFORT

Full coincidence was assumed as a conservative estimate for this modeling effort, and therefore the HMS model incorporated the full frequency rainfall matching the frequency peak flow as determined by the SSP model. The peak flow was routed through the system using a scaled February 2022 event hydrograph. The frequency scenario with the reduced flood protection from the Ross Barnett was used as final. This was considered a conservative option, as although the Ross Barnett does participate in flood reduction, it is not required to operate to any specific standard.

SECTION 3
Hydrologic Analyses

HEC-HMS MODEL CONSTRUCTION

A HEC-HMS version 4.10 (HEC, July 2022) model was developed to model the incremental local flows downstream of the Ross Barnett dam. HEC-HMS stimulates the rainfall-runoff process in a watershed, and includes many traditional hydrologic analysis processes, such as infiltration, baseflow contribution, and hydrologic routing. Advanced capabilities are also provided for gridded runoff simulation using the ModClark methodology.

The HEC-HMS model was calibrated to four events. Selected calibration events included the April 2017, January 2020, February 2020, and August 2022 events.

The study HMS model was built for this study. An existing model was available for the area but was too coarse spatially to be of use (one subbasin per study area of interest). Steps included to develop the initial HEC-HMS model included:

- Determining that the HEC-HMS model extents to be the Hydrologic Unit Code (HUC) for Pearl River at Jackson and the two downstream HUCS. The HEC-HMS model was extended further downstream to allow for better downstream consequence analysis if needed, at a later phase of this study.
- Using tools within the HEC-HMS model to create an initial basin layout.
- Importing key gage locations and features in alternatives B and C as subbasin breaks.
- Making corrections via Geographic Information Software (GIS) where terrain issues routed water incorrectly (bridges/culverts/outlet structures/etc. that were not represented within the terrain)
- Simplified the original basin delineation by combining as many basins/reaches as was reasonable for the purpose of the project.
- Initial routing, loss, and baseflow estimation.

The following sections describe the estimation of initial and calibrated basin parameters. All initial and final model parameters are submitted with this report in an excel document labeled Appendix E.2.

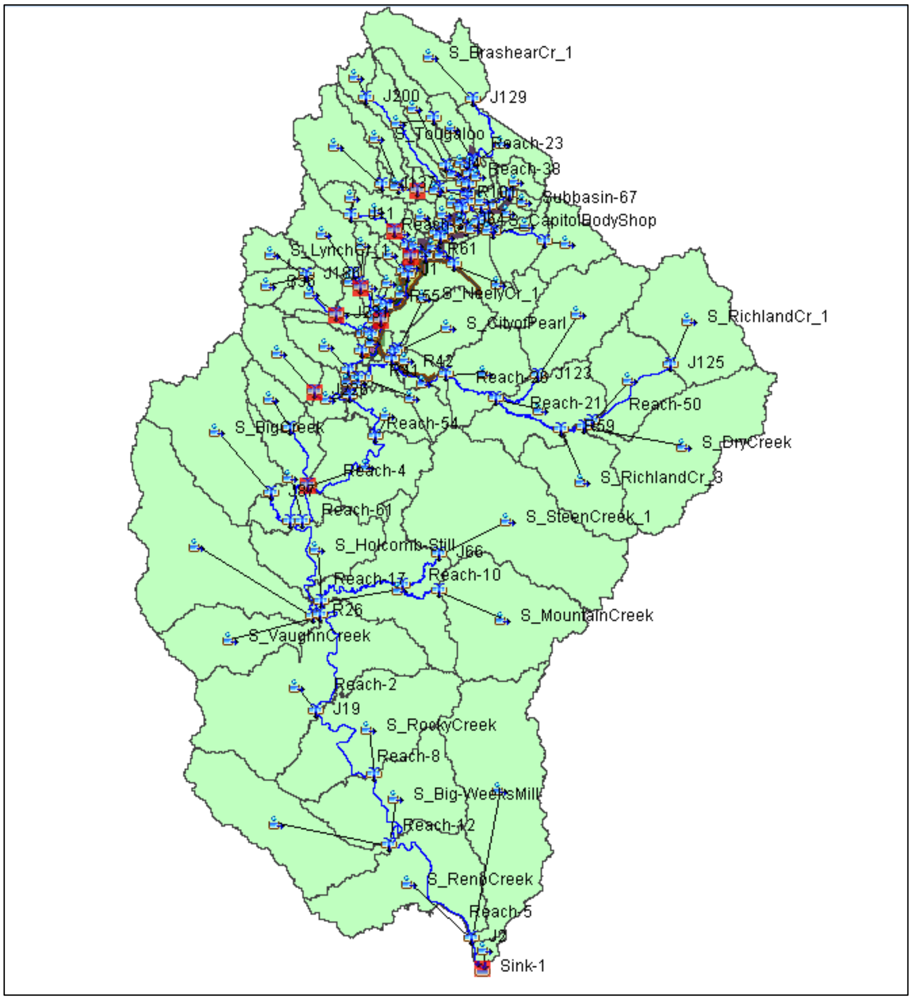


Figure E 4-1. HEC-HMS Basin Layout

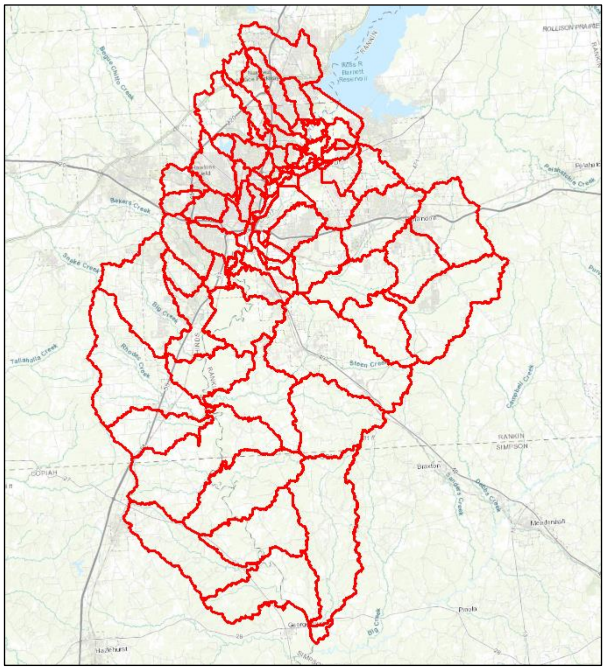


Figure E4-2. HEC-HMS Basin Layout with Background Map

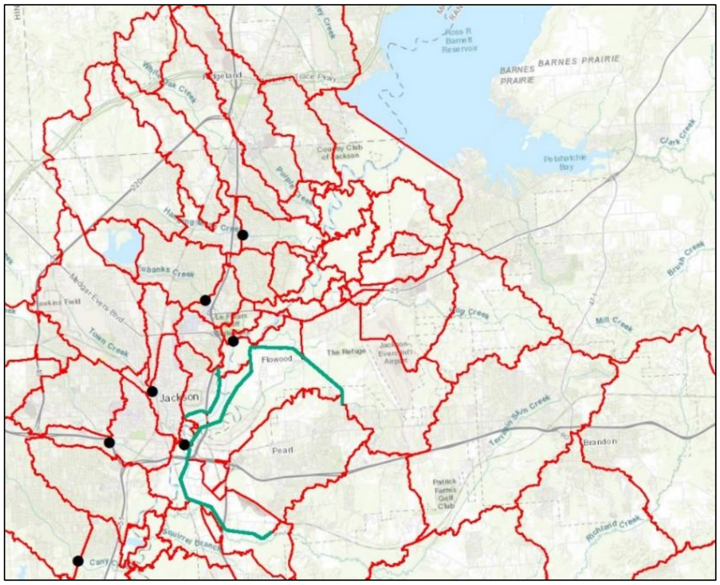


Figure E4-3. HEC-HMS Basin Layout with Background Map at Study Area

Table E4-1. Listing of HMS Subbasins with Drainage Areas

Subbasin Name	Area (MI2)	Subbasin Name	Area (MI2)
Subbasin-1	1.3139	S_Pearl_HogCreek	0.99059
S_BigCreek	26.85	S_Pearl_Hwy25	0.7645
S_Big-WeeksMill	21.083	S_Pearl_HWY80	0.23581
S_BrashearCr_1	12.994	S_Pearl_I55	0.96278
S_BrushyCreek	23.908	S_Pearl_PrarieBranch	0.58603
S_CaneyCreek_2	3.033	S_Pearl_Purple	1.6932
S_CanyCreek_1	8.5408	S_PrarieBranch_1	9.4389
S_CapitolBodyShop	0.23585	S_PrarieBranch_2	0.7813
S_ChristwayChurch	2.859	S_PurpleCreek_1	6.1148
S_CityofPearl	8.4798	S_PurpleCreek_2	0.7878
S_DryCreek	29.601	S_RenoCreek	23.437
S_EubanksCr_1	1.7129	S_RhodesCreek	37.116
S_EubanksCr_2	3.8206	S_RichlandCr_1	20.975
S_EubanksCr_3	1.2694	S_RichlandCr_2	13.713
S_EubanksCr_4	0.64261	S_RichlandCr_3	14.736
S_Fairgrounds	1.5873	S_RichlandCr_4	14.932
S_FlowoodYMCA	1.5456	S_RichlandCr_5	11.384
S_GallatinStDump	1.2697	S_RichlandCr_6	2.0173
S_Haley-Chestnut-Bear	37.595	S_RichlandCr_7	4.0709
S_HangingMossSouth	0.16996	S_RiverRoadN	0.1444
S_HangingMoss_1	11.24	S_RockyCreek	26.633
S_HangingMoss_2	1.8912	S_RossBarnett	6.1657
S_HangingMoss_3	2.2186	S_SavannaStWWTP	0.4843
S_HardyCreek	5.6221	S_SPearOrchardRd	3.4262
S_HogCreek_1	7.3102	S_SteenCreek_1	42.204
S_HogCreek_3	0.29562	S_SteenCreek_2	20.671
S_HogCreek_4	0.41722	S_TerrapinSkinCr	18.005
S_HogCreek2	4.9705	S_TheVault	1.5586
S_Holcomb-Still	14.046	S_Tougaloo	4.1197
S_Howard-Steamboat-Hawkins	16.799	S_TownCr_1	8.3137
S_JacksonHewitt	0.4858	S_TownCr_2	0.33194
S_LimestoneCreek	37.909	S_TownCr_3	2.0979
S_LynchCr_1	4.5075	S_TrahonCreek	4.7718
S_LynchCr_2	4.5603	S_Trahon-Big	12.19
S_LynchCr_3	3.6818	S_TwinLakeA	1.1689

Subbasin Name	Area (MI2)	Subbasin Name	Area (MI2)
S_MountainCreek	25.39	S_TwinLakeB	1.4737
S_NeelyCr_1	5.8296	S_UMMC	1.3031
S_NeelyCr_2	2.3688	S_VaughnCreek	14.36
S_Pearl-CanyCr	5.9005	S_WestsidePark	3.1609
S_Pearl-RichlandCr	0.88588	S_WhiteOakCr_1	2.6847
S_Pearl_EubanksCr	0.72277	S_WhiteOakCr_2	5.6652
S_Pearl_HangingMoss	1.5052		

Initial Values for Subbasins

Key basin parameters were calculated via the HMS GIS parameter toolbox including size, centroid, grid cells, flow paths, and slopes.

3.1.1.1 Initial Values for Loss Rates (Deficit and Constant Method)

Initial loss values were generic assumptions based off HEC-HMS tutorial suggestions. Impervious grids were downloaded from National Land Cover Database (NLCD)-2019 edition and processed to estimate the percent imperviousness of the subbasins.

Gridded Soil Survey Geographic (gSSURGO) data were downloaded and joined by soil type. These were indexed against the soil type table (Table E4-2) documented in the HMS training tool (https://www.hec.usace.army.mil/confluence/hmsdocs/hmsguides/applying-loss-methods-within-hec-hms/applying-the-initial-and-constant-loss-method). The resulting raster dataset was processed to produce basin-average loss vales for the subbasins. H&H and a GIS team member created the raster data set which provided the subbasin averaged values for the constant loss rate. (USDA 2020)

Table E4-2. Soil Texture and Conductivity (USDA 2020)

Soil Texture	Saturated Hydraulic Conductivity (in/hr)
Sand	4.6
Loamy Sand	1.2
Sandy Loam	0.4
Loam	0.1
Silt Loam	0.3
Sandy Clay Loam	0.06
Clay Loam	0.04
Silty Clay Loam	0.04
Sandy Clay	0.02
Silty Clay	0.02
Clay	0.01

3.1.1.2 Initial Values for Transform Parameters (Mod Clark)

Initial values for the Mod Clark Transform method parameters Time of Concentration (T_C) and Storage Coefficient (R) were calculated from formulas in the HEC-Training Manual based on physical parameters of the subbasins, which were calculated within the HEC-HMS Subbasin Characteristics Tool.

$$\mathrm{Tc} = 2.2 * \left(\frac{L * L_C}{\sqrt{Slope_{10-85}}}\right)^{0.3}$$

$$\frac{R}{\mathrm{Tc} + \mathrm{R}} = 0.65$$

Where: Tc is the time of concentration in hours, L is the longest flow path in miles, L_C is the centroidal flow path in miles, $Slope_{10\text{-}85}$ is the slop of flow path represented by 10 to 85 percent of the longest flow path in feet per mile and R is the storage coefficient in hours.

3.1.1.3 Initial Values for Baseflow

Initial baseflow values were generic assumptions based off HEC-HMS tutorial suggestions. Baseflow parameters for the initial and constant loss method were estimated from the Calibrated Pearl River Corps Water Management System (CWMS) model. The CWMS model had one basin covering the study area, and these values are shown in Table E4-3. Estimated baseflow parameters then underwent further calibration for the purposes of this project.

Table E4-3. CWMS Model Baseflow Parameters

Value	Parameter
100	Initial Discharge (cfs/mi2)
0.61	Recession Constant
0.1	Ratio to Peak

Initial Values for Reaches

Reach parameters were set to Muskingum-Cunge computation method. Parameters are physically based, other than the Manning's N value, and therefore were calculated within the HEC-HMS module, unless otherwise described here. The Manning's N values were assumed to be 0.05 prior to calibration. Stream Bottom Width was estimated from Google Earth Imagery. Side slope was estimated as 2 feet/feet for all small streams and 7.5 feet/feet for the Pearl River, from a selection of cross-sections taken from the LiDAR terrain. Index celerity was set to 5 and adjusted based on initial run error messaging.

MODEL CALIBRATION

As discussed in section 3.5, recorded flows at location gages were determined to be reporting incorrect flow values at high Pearl River stages. Therefore, the hydrologic model was not calibrated to observed flows. Instead, parameters in the hydrologic model (HMS) were adjusted to calibrate to the stage hydrographs in the hydraulic model (RAS).

A zone configuration was set to help facilitate adjustments. These groupings, which are by the closest gage location, are shown in Table E4-4.

Table E4-4. Calibration Regions

Zone	Subbasins:
Cany Creek Gage	S_RichlandCr_1, S_RichlandCr_3, S_TerrapinSkinCr, S_DryCreek, S_RichlandCr_2, S_GallatinStDump, S_SavannaStWWTP, S_CaneyCreek_2, S_Pearl-RichlandCr, S_RichlandCr_7, S_RichlandCr_4, S_Pearl_EubanksCr, S_CanyCreek_1, S_Pearl-CanyCr, S_RichlandCr_6, S_HardyCreek, S_RichlandCr_5
Eubanks Creek Gage	S_EubanksCr_1, S_EubanksCr_2, S_EubanksCr_3, S_PrarieBranch_1, S_PrarieBranch_2, S_EubanksCr_4, S_Pearl_PrarieBranch, S_UMMC, S_Tougaloo,
Lynch Creek Gage	S_LynchCr_3, S_NeelyCr_2, S_LynchCr_1, S_LynchCr_2, S_WestsidePark, S_Pearl_HWY80,
Ross-Hanging Moss Gage	S_BrashearCr_1, S_WhiteOakCr_1, S_WhiteOakCr_2, S_HangingMoss_2, S_HangingMoss_1, S_PurpleCreek_1, S_PurpleCreek_2, S_HangingMoss_3, S_Pearl_Purple, S_SPearOrchardRd, S_RossBarnett, S_ChristwayChurch, S_FlowoodYMCA, S_JacksonHewitt, S_CapitolBodyShop, S_Pearl_HangingMoss, S_HangingMossSouth, S_RiverRoadN, S_HogCreek_1, S_HogCreek2, S_HogCreek_3, S_HogCreek_4, S_TwinLakeA, S_TwinLakeB, S_Pearl_HogCreek, S_Pearl_Hwy25,
South of Project-Not Calibrated	Subbasin-1, S_RenoCreek, S_LimestoneCreek, S_Big-WeeksMill, S_BrushyCreek, S_RockyCreek, S_Haley-Chestnut-Bear, S_VaughnCreek, S_Holcomb-Still, S_SteenCreek_2, S_MountainCreek, S_SteenCreek_1, S_Trahon-Big, S_TrahonCreek, S_BigCreek, S_Howard-Steamboat-Hawkins, S_RhodesCreek,
Town Creek Gage	S_NeelyCr_1, S_CityofPearl, S_TheVault, S_TownCr_1, S_TownCr_2, S_TownCr_3, S_Pearl_I55, S_Fairgrounds,

Rainfall Datasets

Precipitation Datasets were collected to incorporate into the model simulations. These included the following:

- Hourly point precipitation gage data for the 1979 event at the Pearl, MS gage from the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) at https://www.ncdc.noaa.gov/cdo-web/datasets/PRECIP_HLY/stations/COOP:224472/detail. This point data was applied evenly throughout the basin in lieu of better spatial approximations.
- Gridded Next Generation Weather Radar (NEXRAD) 1-hour resolution quantitative precipitation estimates (QPE) were collected for events between 2017 and 2022 from Iowa State University's Environmental Mesonet at https://mtarchive.geol.iastate.edu/ .This data covered the continental United States. An example link for an increment of data is https://mtarchive.geol.iastate.edu/2016/03/11/mrms/ncep/RadarOnly_QPE_01H/
- Sub-daily gridded precipitation data for 2011 covering the continental United States was requested via email to NCEI. The NEXRAD Estimates (QPE) Climate Data Record (CDR) provides radar-only and radar-gauge merged precipitation products, as well as ancillary information on precipitation type and radar quality. https://download.avl.class.noaa.gov/download/8290586605/001 ; https://www.ncei.noaa.gov/products/climate-data-records/precipitation-nexrad-qpe for documentation

Calibration Methodology and Final Parameters

As discussed in section 3.5, recorded flows at location gages were determined to be reporting incorrect flow values at high Pearl River stages. Therefore, the hydrologic model was not calibrated to observed flows. Instead, parameters in the hydrologic model (HEC-HMS) were adjusted to calibrate to the stage hydrographs in the hydraulic model (HEC-RAS). All initial and final model parameters are submitted with this report in an excel document labeled Appendix E.2.

SIMULATED FREQUENCY BASED EVENTS-LOCAL DRAINAGE

Atlas 14 gridded datasets were downloaded from the NOAA site (NOAA, March 2023) at https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ms or all frequencies and durations between 15 minutes and the three-day interval. All frequencies were annual maximum series. These grids were imported in the HEC-HMS model. The model was used to calculate individual depth duration curves for each subbasin. Depth Area Reduction factors were set to each subbasin for a conservative approach.

The Atlas 14 gridded frequency precipitation was routed within the HEC-HMS model and used as coincident local drainage inputs into the HEC-RAS model for all frequency-based events. Results of these simulations are provided in the Hydrology portion of the report.

No changes were made to the inflows and routing with either HEC-SSP or HEC-HMS for existing or future conditions, for with or without projects. All adjustments to routings for the with-project alternatives are made within the HEC-RAS modeling effort.

Adjustments for Large Events

Typically, a unit hydrograph adjustment via a peaking factor is made when calibrated events are significantly smaller than the series of events to be modeled. However, no adjustments were made to the HEC-HMS basin routing to account for the for large events, as the system model calibrated well to a recent large flood event, the 2020 event. This event is between a 50- and 100-year event and is within the range of the series of frequency events analyzed for design.

LOCAL DRAINAGE LIMITATIONS

Due to the time limitations of this effort, it was determined to be conservative to assume full coincidence with a three-day lag, as did occur most notably in the 1979 event.

To better refine any structure necessitated to pass interior drainage in the selected alternative, it is recommended that a WAT model be developed for Meteorology Inputs, HMS Routing and Res-Sim routing of the reservoir, and balanced hydrographs / with matching interior drainage be developed in later phases of study.

It should also be noted that the current model setup does not consider stormwater drainage within the interior drainage and may need to be further investigated during later phases of study.

SECTION 4
Hydraulic Analyses

HEC-RAS MODEL UPDATES

HEC-RAS-Version 6.3.1 unsteady state hydraulic modeling with a combination of one- and two-dimensional elements is used throughout the analysis. The software tool was developed and is maintained by IWR-HEC. Unsteady flow is necessitated in locations where complex flow networks exist, events are very dynamic with respect to time (e.g., dam or levee overtopping and/or breaching), extremely flat rivers systems where gravity may not be the significant forcing, tributary flow reversals due to backwater, and systems with a tremendous amount of storage in the overbanks. Each item listed is present within the study reach. HEC-RAS 1D is commonly used for water surface profiles over long reaches; depth averaged velocities; rainfall impact; sediment transport. HEC-RAS 2D is commonly used for 2D flow simulation over large domains such as rivers, canals, floodplains, estuaries, rainfall catchment areas, large scale simulations with long durations. HEC-RAS 2D is recommended for use when modeling behind levee systems, areas where flow is multi-directional, and wide floodplains, all of which exist within the project area. Both one dimensional (1D) and two dimensional (2D) features have been used extensively in the project area.

The existing HEC-RAS model is being developed and calibrated to four unsteady events, as well as a published rating curve and USGS mapped flood extents. These events will be selected from the April 2017, Jan 2020, Feb 2020, and August 2022 time periods. The HEC-RAS Model would then ingest the frequency data set to calculated from the expected rainfall runoff relationship for the selected study frequency events as well as Ross Barnett Reservoir outflows.

The model is being updated with 2D features within the overbanks of the system to simulate leveed areas more accurately. The model is extended slightly downstream to better verify any potential inducements or impacts. The dam feature within the With-Project geometry will be updated to current design standards.

Sensitivities on project features will be analyzed, as described in previous portions of this document, for use in updated economic and cost values for the subset of scenarios.

Initial / Base Data

Rankin-Hinds provided the Base model and Terrain to USACE. Mendrop Engineering received the model from USACE in the 2004-2007 timeframe. The project area and cross-section layout are shown in Figure E5-1. This model was an unsteady one-dimensional effort.

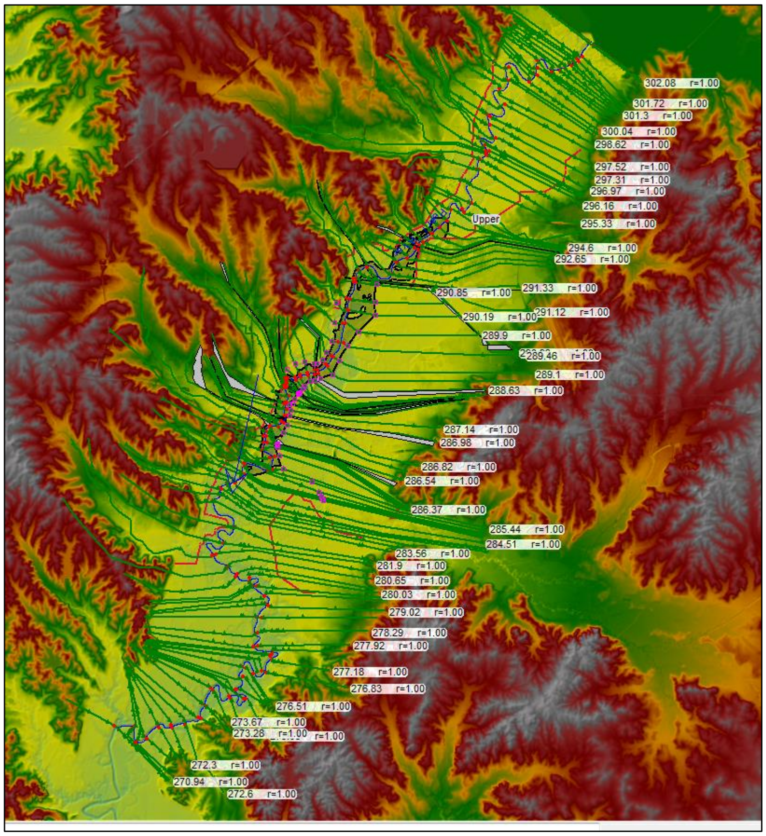


Figure E 5-1.NFI Model Geometry

Terrain and Bathymetric Data Sources

USACE used USGS 1-m LiDAR terrain in this effort to replace the Rankin-Hinds provided terrain, as the model needed to be extended. USACE collected terrain via RasMapper and merged the latest 1m data available for a given location from the USGS Natchez Trace (2016), Madison-Yazoo (2012), and MS NRCS East (2018) collects. Both terrain datasets are recent LiDAR and are similar. Though this process the model was converted to Albers equal area, and all elevations were converted to the North American Vertical Datum of 1988 (NAVD 88) if datum is known. Otherwise, proposed elevations were all assumed to be in the NAVD 88 datum.

Land Cover Datasets

USACE retrieved Land Cover from the 2019 NLCD and HEC recommended values were used for this effort within the overbanks. Modification layers were added in the two-dimensional flow areas to represent the tributary flow roughness. These modification layer N values were used as a factor for calibration to gages data, where a gage was available.

Existing Levees

Existing levees were taken when available from the Levee Database. Jackson Fairgrounds and Jackson East had elevation data available. However, Brashear's Creek Levee, Parsons Levee, and the Savanna Street Wastewater Treatment Plant levee system elevation data were cut from the 1-m LiDAR terrain. A small levee located within the Jackson East levee was also represented with a breakline.

UPDATES TO EXISTING CONDITION AND ALTERNATIVE A GEOMETRY (FROM BASE GEOMETRY)

HEC-RAS Model updates to the provided NFI model include:

- The addition of one and two-dimensional storage areas to refine the movement of water at the outer extents of the floodplain.
- The addition of existing levee profile data from the National Levee Database (NLD) and Terrain when the top of levee survey was not available.
- Cross section layouts are adjusted to accommodate other routing options (e.g., storage areas)
- Initial Manning's were updated to Chow/HEC Estimates, and the National Land Cover Database (NLCD) land cover dataset was applied to the two-dimensional flow areas. Additional refinement areas were used to further define Manning's estimates for the tributaries within two-dimensional areas.
- The boundary condition was set to normal depth at the downstream extent to allow fluctuation between plans, where the previous model was held to a single downstream hydrograph.
- Ineffective areas were updated to match updated one-dimensional cross-section.
- A low flow weir at the Fewell plant (at elevation 250.0 feet) was added to the model. This elevation was provided by the NFI, the datum and original source are unknown.
- Breaklines were included to better represent features that are expected to impact flow patterns within the two-dimensional geometry. These include bridge embankments, levees, and areas of high ground.
- Terrain modifications were added were appropriate to represent culverts, bridges, and tunnels. The Town Creek tunnel was approximated, with consideration to calibration results. If additional study or projects are added to this area, further fidelity is needed to this feature.
- Additional bridge calculation methods were incorporated to factor in losses more accurately though piers given the transition from steady to unsteady routing methodology.
- Converted the inflow and routings from a steady to unsteady regime. Inflow at the head of the model was moved to be based off the Ross Barnett Reservoir Releases at the head of the model, instead of the Pearl River at Jackson Gage, which is near the bottom of the study area.
- Local tributary inflows were added and routed though the project area.

- The addition of 3 additional miles of routed river to better define any downstream consequences.

The updated geometry extent with one-dimensional cross-sections, one-dimensional storage-areas, and two-dimensional flow areas is shown in the image below.

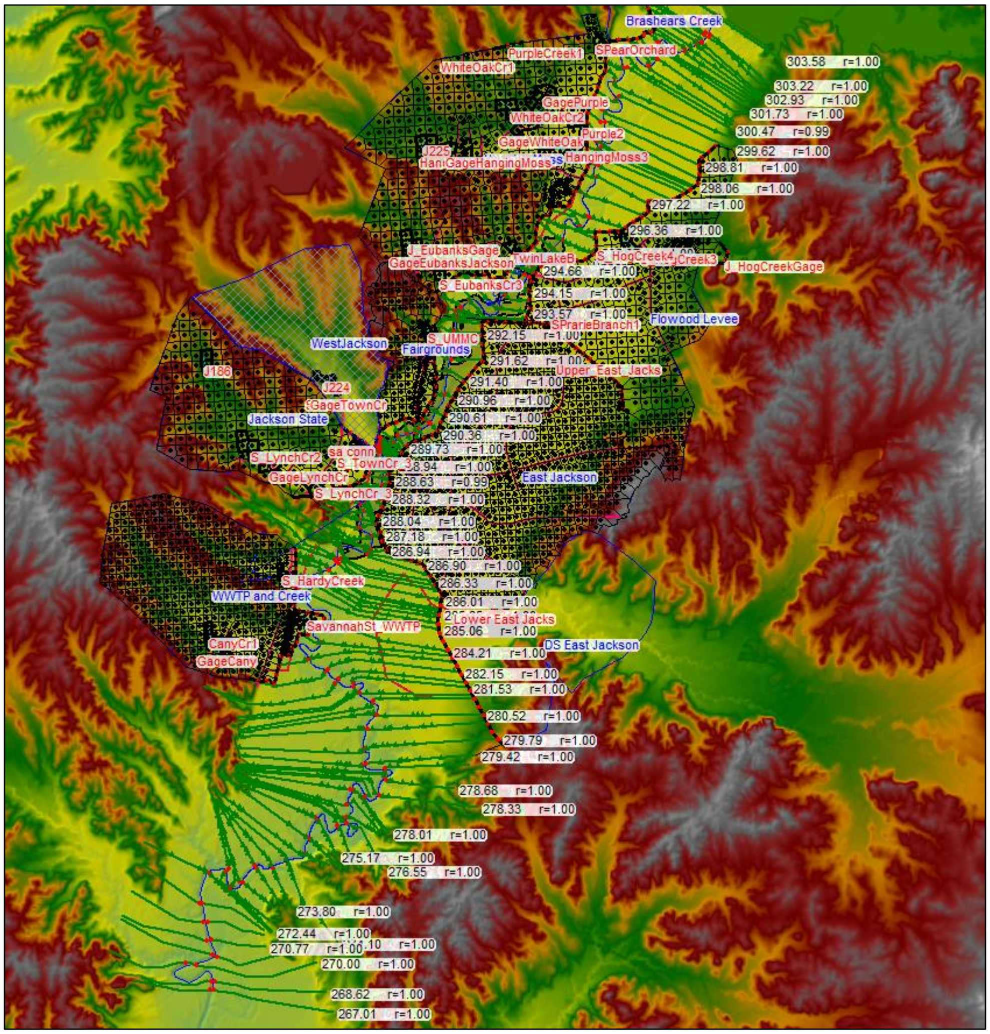


Figure E5-2. HEC-RAS Geometry Layout with Terrain at Study Area

MODEL CALIBRATION

HEC-RAS Model Calibration of existing condition included:

- Adjustments of the local inflows within the HEC-HMS model
- Adjustments to the manning's flow values in the one-dimensional areas and the addition of refinement regions within the two-dimensional areas of the model.
- Adjustments to the bridge inputs to better simulate backwater.
- Adjustments to the flow roughness factors.

- Adjustments to ineffective areas

USACE compared model results to the selected gage data, Rankin-Hinds high water marks, and a USGS February 2020 inundation event downloaded from https://www.usgs.gov/data/flood-inundation-maps-and-water-surface-elevation-data-february-17-2020-flood-pearl-river . Complete comparisons of gage data and the 2020 Inundation are in Appendix E.1

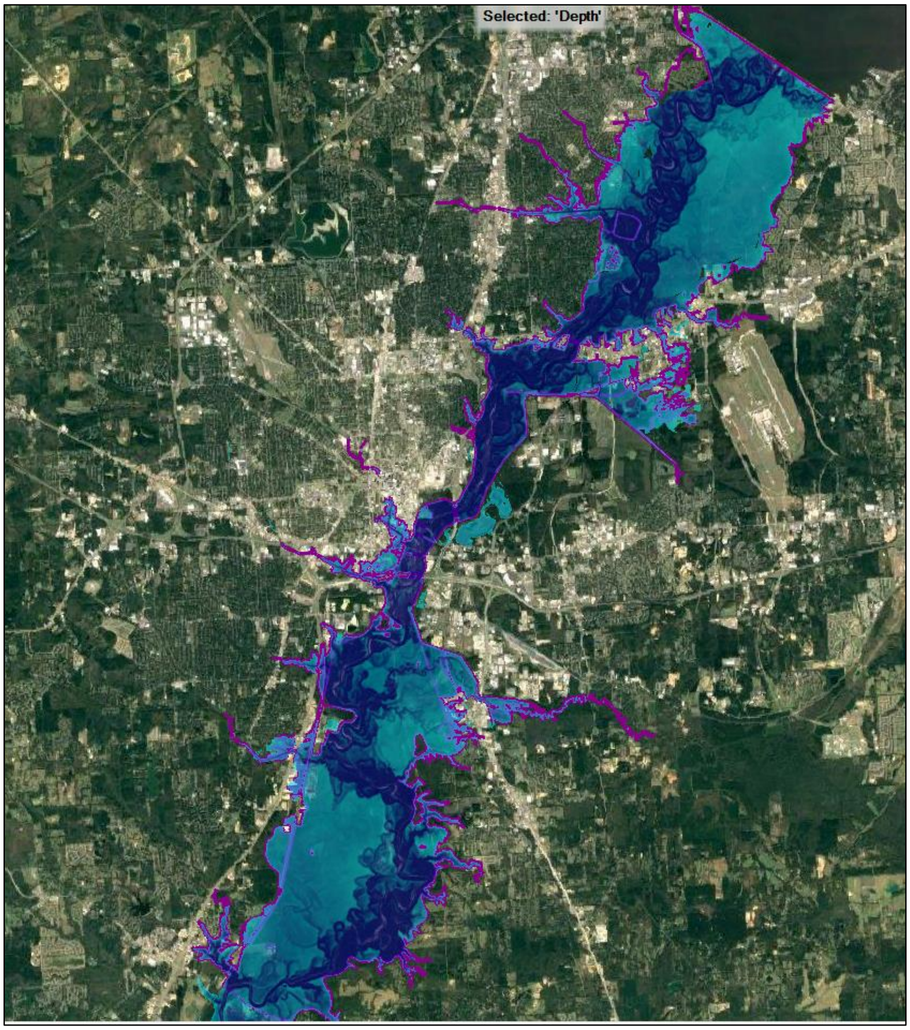


Figure E5-3. USGS Maximum Inundation for the February 2020 Event vs the HEC-RAS Simulation Results

Table E5-1. Calibration Summary

Gage	Calculated-2017	Obs 2017	Calculated Jan 2020	Observed Jan 2020	Calculated Feb 2020	Observed Feb 2020	Calculated-2022	Obs 2022	Average Difference
Pearl @ 80-stage	265.95	266.71	264.92	264.86	270.11	270.06	268.69	268.77	-0.18
Pearl @ 80 – flow	40465	40000	33,157	32200	72874.83	77300	59089	56600	-128.54
Pearl @ 25 Stage*	-	-	-	-	276.83	277.5	274.84	274.18	-0.01
Hanging Moss	279.25	282.04	278.84	280.61	278.37	278.82	280.29	280.31	-1.26
Purple	274.43	276.74	-	-	278.7	279.19	--	--	
White Oak	--	--	276.37	274.99	278.37	279.15	276.78	277.01	0.12
Eubanks	272.57	272.63	271.59	272.26	276.44	275.34	274.4	273.21	0.39
Town	276.11	276.1	274.75	274.65	270.69	270.63	274.21	274.46	-0.02
Lynch	279.36	279.25	277.45	280.11	273.47	276.13	278.19	280.39	-1.85
Cany	266.34	267.79	266.11	268.18	266.89	265.21	--	--	-0.61

*Rating not developed until after all calibration events occurred / Flow not published till late 2022.

Red is from preliminary or annual peak data.

Priority was also given to the 2020 flood extent map created by USGS. (Outline in purple)

FINAL EXISTING CONDITION PARAMETERS

A Summary of Existing Condition model parameters are populated in Tables E5-2 through E5-8. Some tables are large and were included in Appendix E.2.

Table E5-2. Roughness Coefficients from Cross Section 290.96 to 267.01

Flow	Roughness Factor
1	0.95
11000	1.2
35000	1.3
50000	1.17
75000	1.07
100000	0.97

Table E5-3. Roughness Coefficients from Cross Section 303.58 to 290.96

Flow	Roughness Factor
1	0.95
11000	1.1
35000	1.1
50000	0.9
57000	0.85
75000	0.8

Table E5-4. Land Cover Range within Cross Sections- Full Table in Appendix E.2

Land Type	Manning's N
Channel	0.04-0.0425
Overbanks	0.07-0.2

Table E5-5. Land Cover Range by Land Cover Type in Two-Dimensional Areas, Specified Roughness for Tributaries are included.

Name	Default Manning N
No Data	0.06
Cultivated Crops	0.035
Woody Wetlands	0.1
Developed, Open Space	0.04
Developed, Low Intensity	0.08
Mixed Forest	0.15
Deciduous Forest	0.15
Shrub-Scrub	0.11
Pasture-Hay	0.04
Grassland-Herbaceous	0.04
Open Water	0.035
Barren Land Rock-Sand-Clay	0.025
Developed, Medium Intensity	0.12
Evergreen Forest	0.12
Emergent Herbaceous Wetlands	0.07
Developed, High Intensity	0.16
CanyCreek	0.085
HardyCreek	0.06
Hog	0.06
Purple	0.075
Hanging Moss	0.085
EubanksCr	0.06
Town	0.03
Lynch	0.085
RichlandCreek	0.045
Eubanks	0.06

Table E5-6. Weir Coefficients for Lateral, Inline Structures, and Storage Area Connections

Location	Overflow Weir Coefficient
Pearl River Upper 303.01	2
Pearl River Upper 301.	2
Pearl River Upper 299.45	2
Pearl River Upper 293.4	2
Pearl River Upper 292.37	2
Pearl River Upper 291.9	2
Pearl River Upper 291.55	2
Pearl River Upper 291.05	3
Pearl River Upper 289.58	1
Pearl River Upper 289.1	1
Pearl River Upper 286.05	3
Pearl River Upper 285.9	2
SA Conn: Lower East Jacks	2
SA Conn: Upper_East_Jacks	2

Table E5-7. Bridge Coefficients

Reach	River Sta	Drag Coef (Cd)	Peir Shape K
Lakeland	294.5	1.5	1.05
Abandoned Railroad	292.39	1.5	1.05
I-55	290.1	1.2	1.05
Old Brandon Road	289.35	1.5	1.05
KCS Railroad	289.16	2	1.25
HWY 80	288.8	2	1.25
I20	288.4	2	1.25
CN Railroad	288.035	2	1.6

Table E5-8. Pump Station Characteristics

Pump Stations	Profile	Q Pump Station(cfs)	Pump On Elevation (feet)
Jackson East Upper_East_Jacks	Max WS	600	250
Fairgrounds Pump Upper_East_Jacks	Max WS	107	250

UPDATES TO THE ALTERNATIVE C GEOMETRY

An updated analysis of the NFI locally preferred plan, known as "Alternative C" was completed. HEC-RAS Model updates include:

- The addition of proposed weir as prescribed by NFI alternatives.
- Updated cross sections, storage areas, bridges, and ineffective areas to mimic proposed channelized features. This included modifying the terrain to excavate portions of the channel overbanks to 248.0 ft, following the NFI provided shapefile. The cross-sectional elevation data were then updated from the modified terrain file.
- Updated manning's values to adjust to proposed conditions using provided clearing shapefiles.

The Cross Section data does not include a side slope at the extent of excavation, if this modeling effort continues or specific modeling is needed to size features, this slope should be added into the model.

Table E5-9. Land Cover Range within Cross Sections for Alternative C. Full Table in Appendix E.2

Land Type	Manning's N
Channel	0.04-0.0425
Overbanks	.05-.2

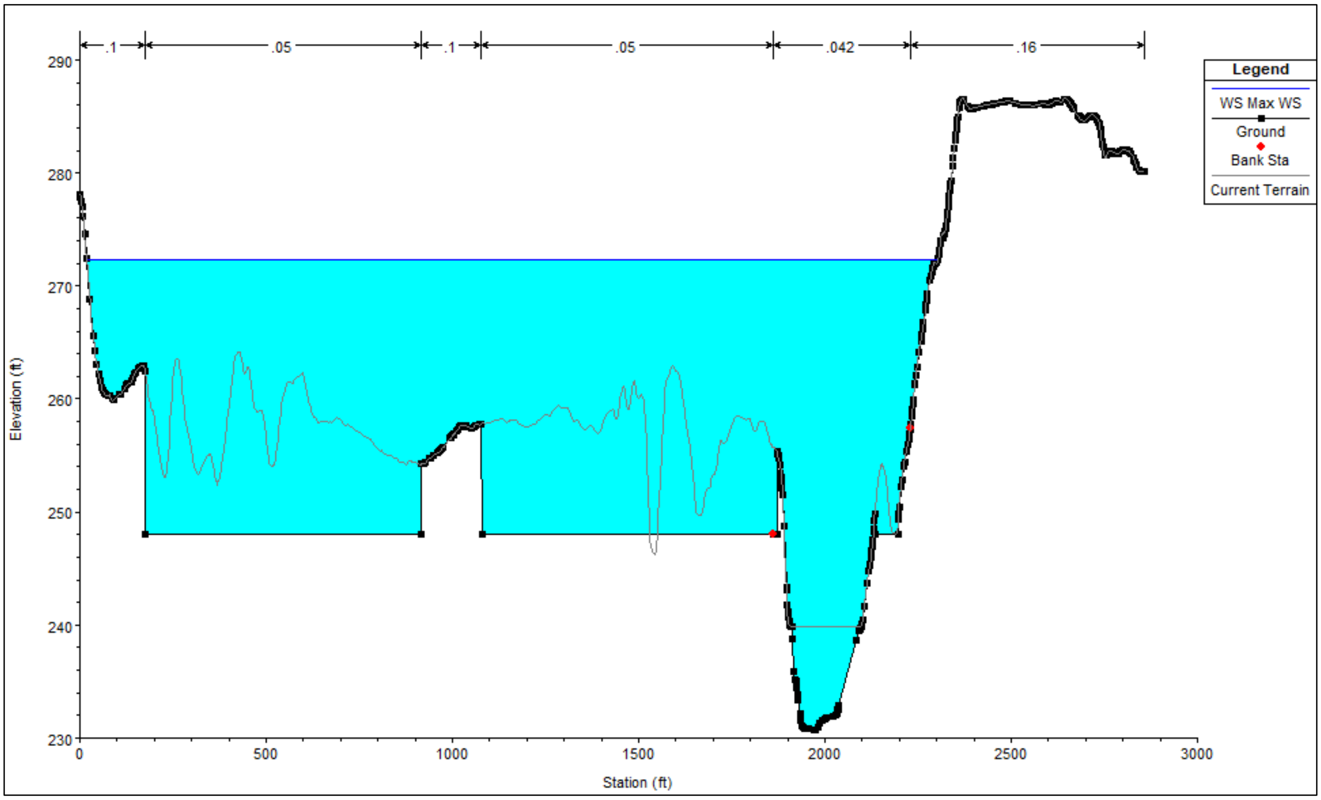


Figure E5-4. Sample Cross Section Adjustments

Development of Rating Curve in 2D Modeled Area

As part of the development of the C Alternative a two-dimensional HEC-RAS model was developed to generate a rating curve to route flow across the "U" Shaped portions of the proposed dam, shown below as an area built with concrete, on the NFI alternatives.

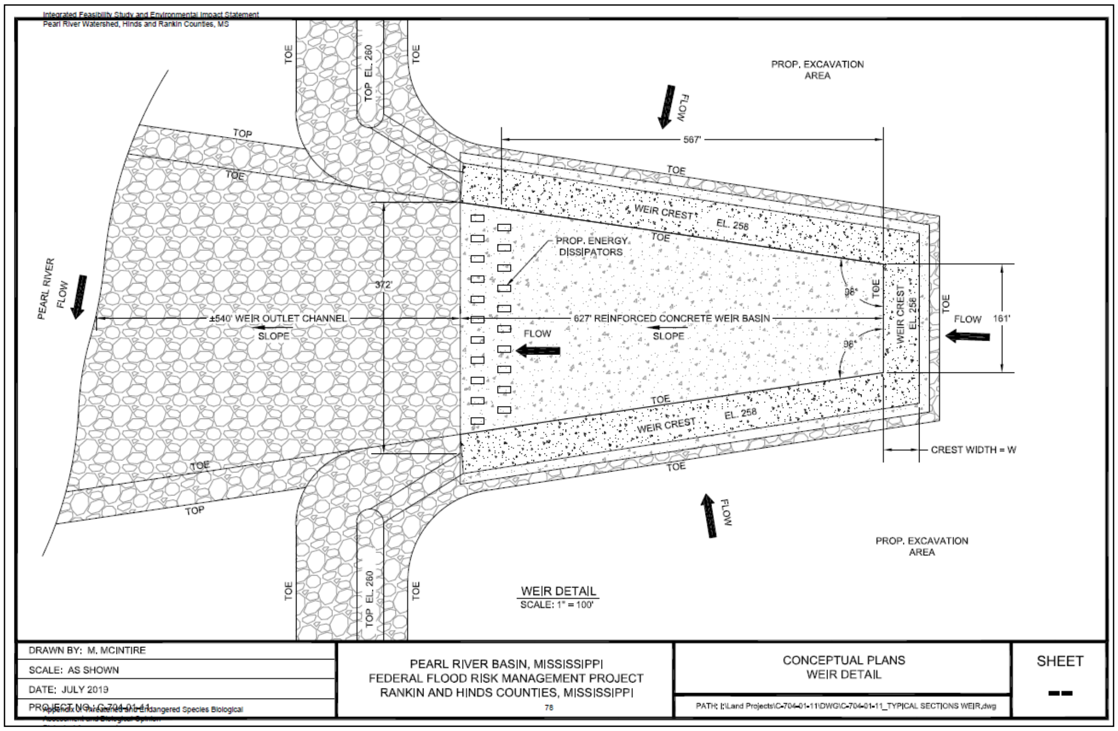


Figure E5-5. Weir Plan Provided by NFI

The upstream boundary of the two-dimensional model extended upstream to approximately cross-section 288.03 from the larger study model. This cross-section is located right downstream of the Canadian National Railroad, represented with a gray line in Figure E5-6. The blue line in Figure E5-6 represents the upstream model boundary. The downstream boundary condition of the two-dimensional model is located approximately at cross-section 267.01, which is the same downstream boundary location of the larger study model. A Normal depth condition with a 0.0002 slope was used for the downstream boundary condition, which is the same slope used in the larger Pearl River model.

A February 2020 storm hydrograph from the USGS Pearl River at Jackson Gage (02486000) with a peak flow close to 77,000 cfs was used to generate the rating curve upstream of the proposed dam. This hydrograph was scaled using a factor of 1.3 to increase the peak discharge to 100,000 cfs, which approximately represents a 500-year event at this location. The Richard Creek confluence with the Pearl River is located approximately 2 miles downstream of the proposed dam. Because of the proximity to the dam, an internal boundary condition for Richland Creek was included in the two-dimensional model to account for the discharge coming from this tributary. Since there is no gage at Richland Creek, an estimated constant inflow hydrograph of 27,300 cfs was used as input for Richland Creek. This discharge is about 16% larger than the peak discharge used for the 100-year event in the Pearl River larger model.

The mesh was developed with a Channel Resolution of about 50 feet, overbank resolution of 300 feet, with the overbank near the dam varying between about 50 to 100 feet. A NFI provided shapefile was used to delineate the dam location. A storage area connection was used to represent the dam feature, where the “U” shaped portion was set to an elevation of 258.0 feet and the straighter rip-rap sections were set to an elevation of 260.0 feet. The fill areas located on the overbanks were delineated using a NFI provided shapefile and were set to an elevation of 270.0 feet. The elevation of the fill areas was assumed near the 100-year flood frequency as a NFI value was not provided. An assumed weir coefficient of 2.5 and a width of 30 feet was used.

The existing study model terrain was modified to represent the excavation area upstream of the proposed dam at 248 feet. A NFI shapefile was used to delineate the excavation area. Additional modifications were completed to connect the downstream area at the dam face to the original Pearl River channel bed. Further modifications were completed to add the proposed dam features to the project, including the fill areas on overbanks at 270.0 feet elevation, Outer dam at 260.0 feet elevation, and Inner Dam at 258.0 feet of elevation, Drawings included in the NFI Plans were used as reference to make terrain modifications immediately downstream of the dam and baffle blocks were added along the proposed dam’s downstream face.

The modifications described above are illustrated in Figure E5-6. The brown areas represent the fill areas and the brown hatched area represent the excavation area upstream of the proposed dam. Figure E5-7 shows a closer view of the proposed dam.

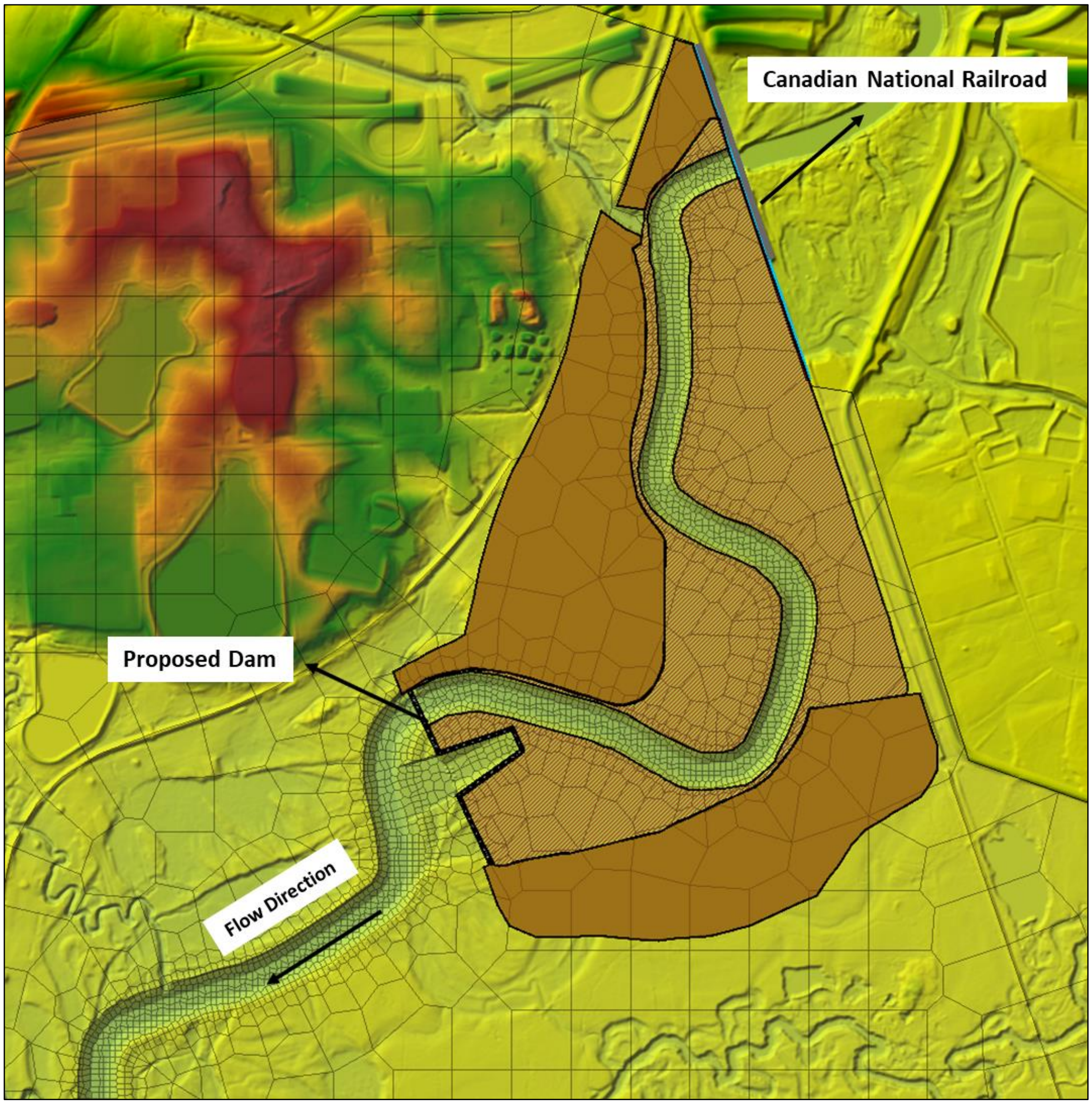


Figure E5-6. Alternative C. View of the Proposed Weir, Fill Areas, Excavation Area, and Upstream Model Boundary in RAS Mapper

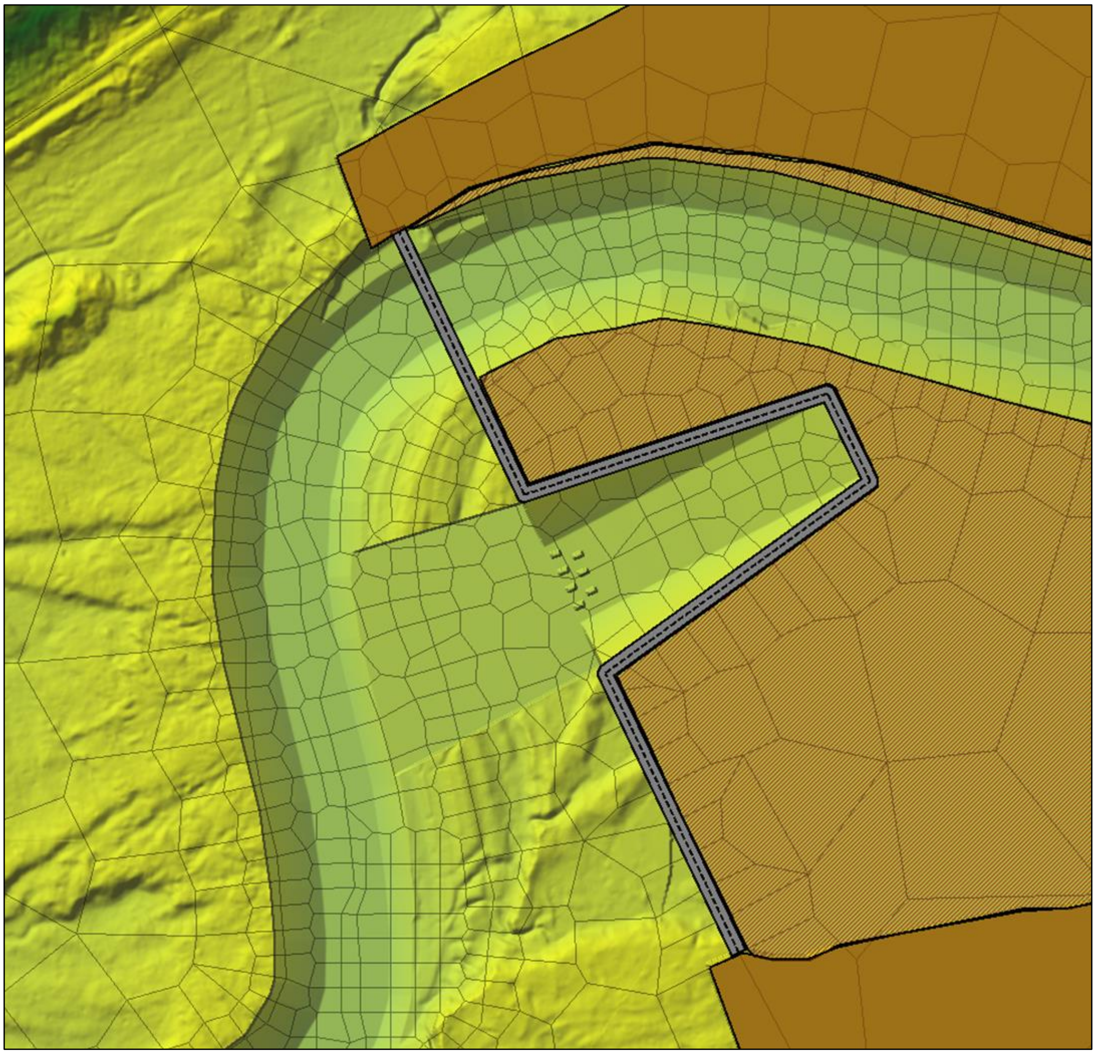


Figure E5-7. Closer View of the Proposed Dam in RASMapper

The existing study area land cover data was taken and refined for use in the two-dimensional model. A classification region was added and assigned the calibrated channel value to the proposed excavated areas and immediate downstream areas of the dam.

Flow though this model simulation is shown in Figures E5-8 and E5-9.

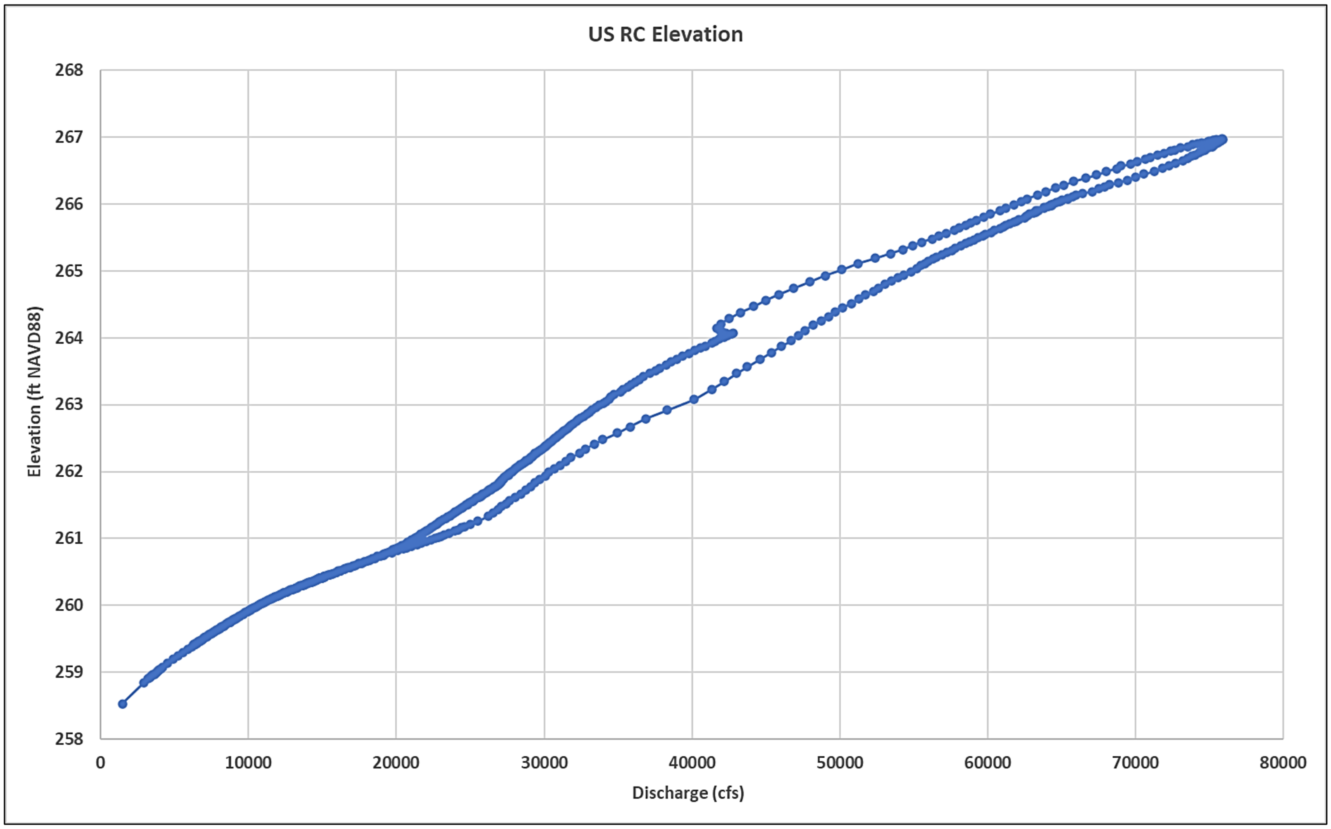


Figure E5-8. Rating Relationship at Dam with Routing the February 2020 Flood Event

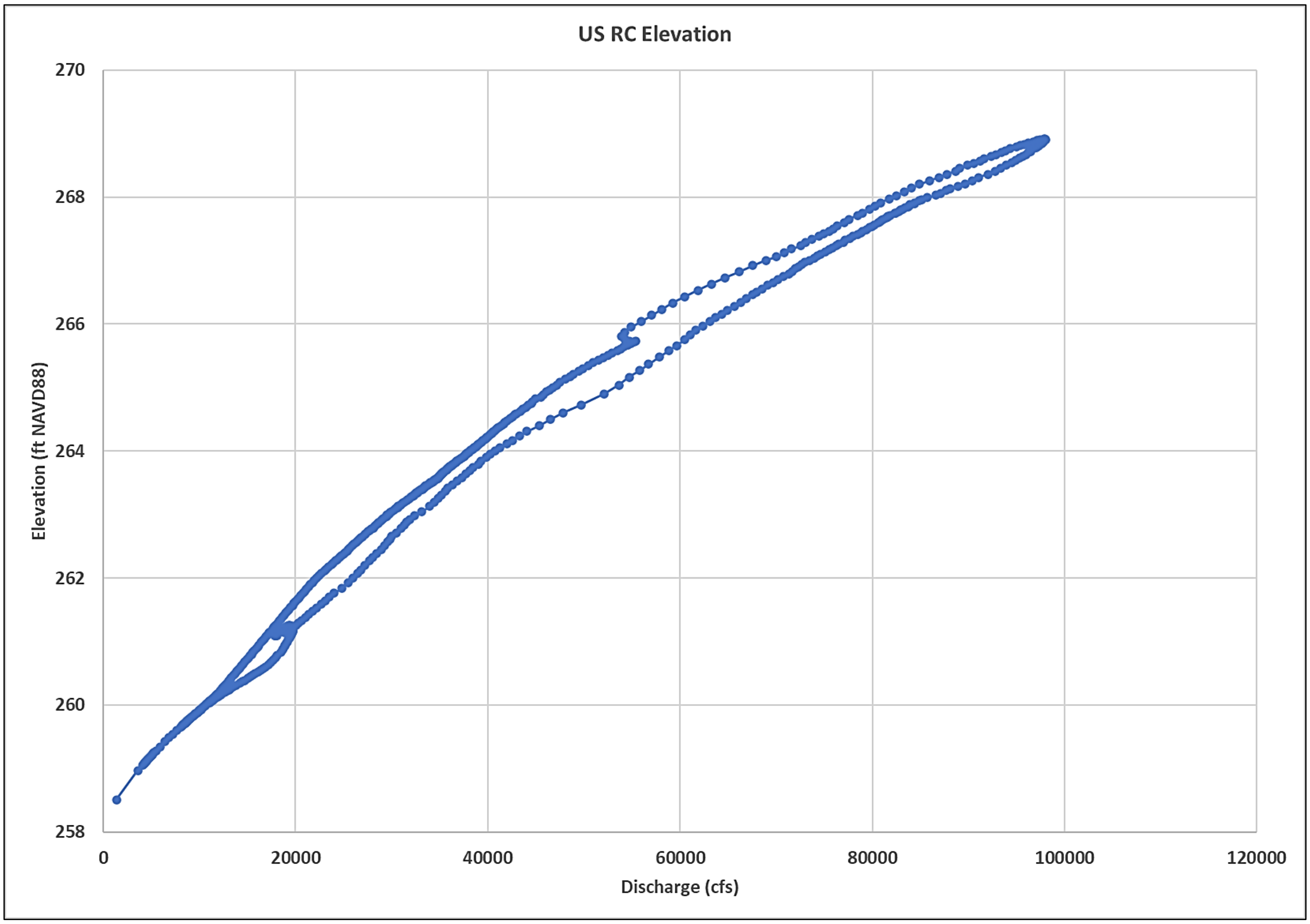


Figure E5-9. Rating Relationship at Dam with Scaled Hydrograph to 100,000 cfs on Pearl and 27,300 cfs from Richland Creek

The inundation map produced by the two-dimensional model using the February 2020 storm hydrograph was compared with the inundation map from the Pearl River calibrated model for the 100-year event to verify if the two-dimensional model produced reasonable results. The peak discharge for the 100-year event is approximately 10% higher than the peak discharge for the February 2020 storm near the upstream boundary of the two-dimensional model. The inundation maps look similar and the inundation extent slightly further for the 100-year event than the February 2020 storm.

Development of C Sensitivity

The USACE hydraulics modeling team completed a simplified analysis of a modification to the Alternative C. HEC-RAS Model updates from the existing geometry include:

- Updated cross sections, storage areas, bridges, and ineffective areas to mimic proposed channelized features. This included modifying the terrain to excavate portions of the channel overbanks to 251.0 ft, following the NFI provided shapefile.

The cross-sectional elevation data were then updated from the modified terrain file.
- Updated manning's values to adjust to proposed conditions using provided clearing shapefiles.

The cross-section data does not include a side slope at the extent of excavation, if this modeling effort continues or specific modeling is needed to size features, this slope should be added into the model.

UPDATES TO THE ALTERNATIVE CTO GEOMETRY

The USACE hydraulics modeling team completed a simplified analysis of a modification to the Alternative C to maintain flood reduction, while minimize constructed features, as a cost saving measure. This modeling effort started with the Alternative C geometry. HEC-RAS Model updates include:

- The moving of proposed weir upstream of the NFI original location, maintaining the existing weir at the J W Fewell Water Treatment Plant.
- Updated cross sections, storage areas, bridges, and ineffective areas to mimic proposed channelized and fill features. This included modifying the cross sections show excavation to 250.0 ft and fill on portions of the channel overbanks (reduced from the Alternative C extent), following the NFI provided shapefile.
- Updated manning's values to adjust to proposed conditions.
- Raising and adding levees (Savannah Street Wastewater Treatment Plant and Canton Club Levee) as described in the Alternative CTO description.

The Cross Section data does include a 1:2 side slope at the extent of excavation, if this modeling effort continues or specific modeling is needed to size features, this slope should be refined, and likely extended.

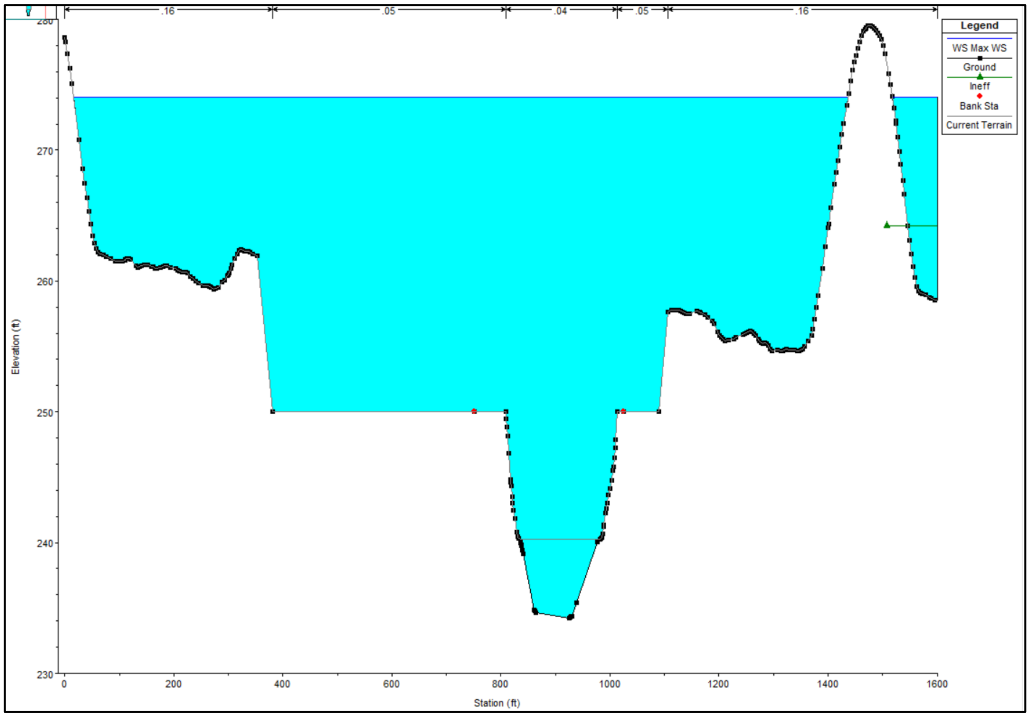


Figure E5-10. Sample Cross Section Dataset

CTO Dam Modeling Approach

Due to the limited time allowed to model the Alternative CTO, the proposed weir, shown in the figure below was modeled directly within the cross-section as a blocked obstruction with the top elevation matching the top of the weir (elevation 256.0), and no separate rating curve was developed.

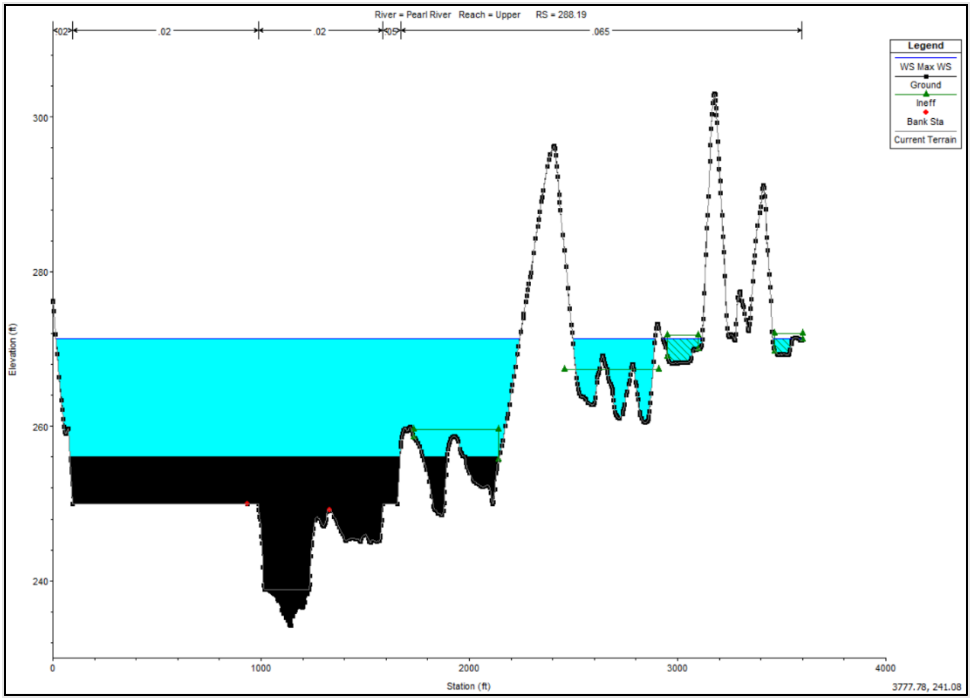


Figure E5-11. Modeled Weir Geometry

EXISTING CONDITION FREQUENCY ROUTINGS

Addition of HEC-HMS and HEC-SSP Data Sets

Final sensitivity routings employed the 2020 hydrograph pattern ratioed to match peak frequency flow estimates from the Ross Barnett Reservoir, this was supplemented by the assumption of a full coincidence local inflow, set 3 days prior. **No changes were made to the inflows and routing with either HEC-SSP or HEC-HMS for existing or future conditions, for with or without projects. All adjustments are made within the HEC-RAS modeling effort**.

SENSITIVITIES ROUTING/ASSUMPTIONS FOR FUTURE CONDITION

Several sensitivities were caried forth throughout this study to reduce uncertainty in future routing.

100 year No Inflow

One sensitivity was run to estimate the extreme scenario of a drought on the lower end of the system, while a major flood occurred above the reservoir. This is not expected based on typical weather patterns for large events. This scenario includes inflows only from the Ross Barnett Reservoir releases.

Manning's/Clearing

In the 2013 – 2014 timeframe Rankin-Hinds accepted O&M responsibility for several areas previously maintained by the Pearl River Basin Development District. This district lost funding over time due to decreased participation and federal funding and lack of grants. Funding for these areas is uncertain in the future.

While it is not the USACE responsibility to maintain these areas, this sensitivity is completed to help determine impact to the project if these areas are no longer maintained.

Ross Barnett Operations

Since at least 1979 the Ross Barnett Reservoir has been working with local and federal entities to help reduce peak flows downstream of the project. While optics and political pressure, make this practice extremely likely to be continued throughout the near future, there is a possibility that the reservoir would no longer operate in this manner in the future for large inflows over 75,000 CFS. The reservoir has previously encountered stress at its highest historic peak pools.

Therefore, the 1979, 1983, and 2020 events are set as historical events with ranges from the event release ranging up to the reported inflow value. The SSP model would select the geometric mean of these two bounding parameters, for an estimate that is removing roughly half of the regulating capacity. These resulting frequency values are used to inform the HEC-RAS sensitivity scenario.

1979 EVENT COMPARISON

The historic 1979 event was devastating and is the point of comparison for many local citizens and government officials. Therefore, additional simulations of this event were completed to show the impact of the various flood reduction projects completed throughout the 1980s as well as the know system response changes.

Table E5-10. 1979 Elevation Results in Routing Comparison

Scenario	Elevation - HWY 80 Gage, Feet
1979 Event	277.0
Observed Simulation (Ross Barnett releases)	273.7
Updated Simulation (Ross Barnett releases)	274.6

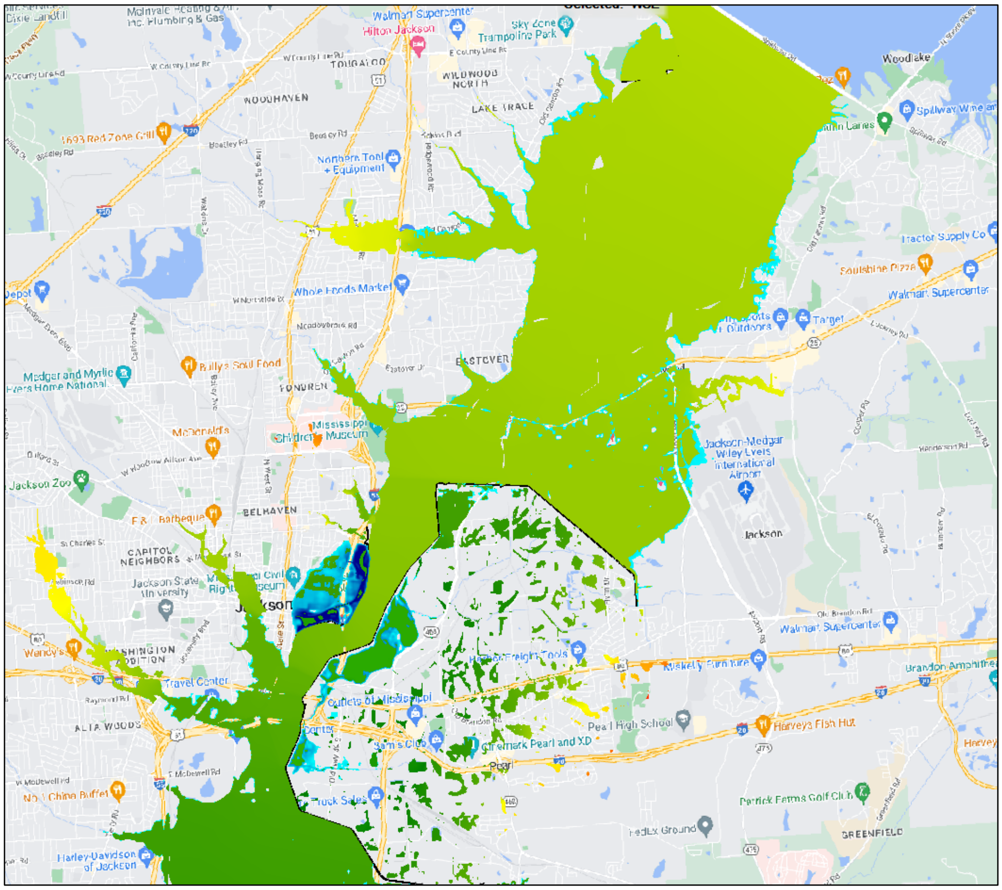


Figure E5-12. Comparison of Routing of the 1979 Flood Event Historic Flooding (Blue) to Routing with Present Day River Conditions (Green)

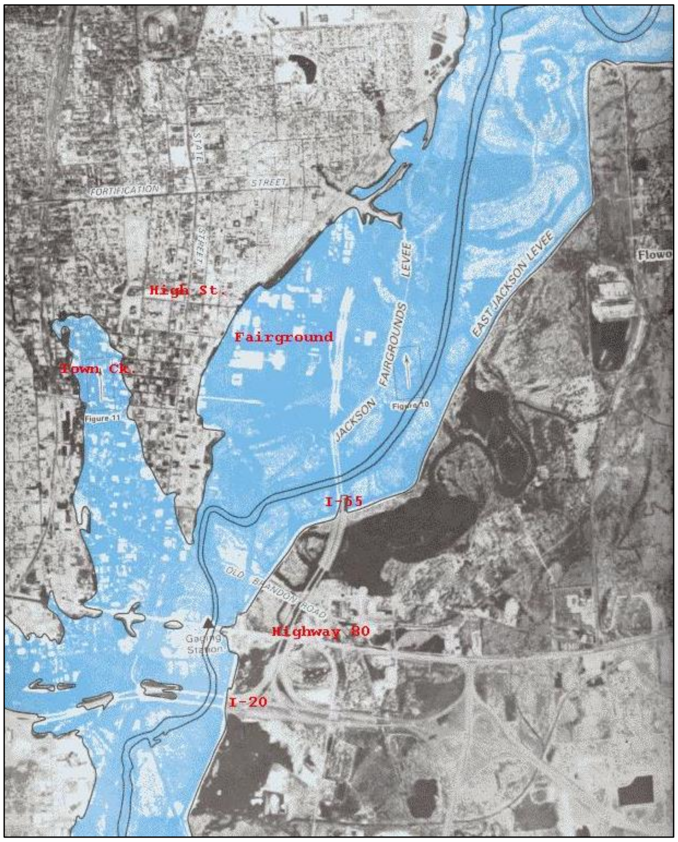


Figure E5-13. 1979 Flood Event Inundation Extent (USGS 2023a)

1979 - Losses

An additional model scenario was run reducing the calibrated loss rate by 75% help simulate a very saturated basin. This had minimal to no impact on peak stages within the Pearl River.

MODEL FREQUENCY RESULTS FOR EXISTING, ALTERNATIVE C, C SENSITIVITY, AND CTO

A summary of modeled results for Routed events, and Frequency events for Existing, Sensitivity, and Alternative C at the Upstream, Downstream, Gage location, and at Proposed Dam are shown in Table E5-11.

Table E5-11. Elevation Results for Selected Routings

	Upstream Extent of Model (Ross Barnett Outflow)		HWY 25		HWY 80		Proposed Dam (Alt C Location)		Downstream Extent of Model	
Scenario Name	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**
February 2020	78110	280.8	73590	276.8	72950	270.1	73570	267.9	72700	256.5
1979 event with current routing	131500	286.1	117100	282.8	121900	274.6	128000	271.6	127900	259.6
500year Existing	140500	286.4	119800	283.0	120100	275.3	127800	272.7	142600	260.4
500yearhigh-DamReleases	134200	286.0	115300	282.7	117200	275.0	124700	272.5	139200	260.2
200year Existing	115000	284.3	105100	280.7	102600	273.6	107800	271.2	120600	259.1
200yearDamOperation	108100	283.8	100300	280.2	99150	273.3	103600	270.9	116200	258.9
100Year Existing	98240	283.0	92000	279.3	87760	272.2	90900	269.9	104200	258.1
100year-High-DamOperation	95470	282.7	90000	279.0	86090	272.0	89040	269.8	102500	258.0
50Year Existing	83350	281.5	79450	277.6	76610	271.0	78480	268.9	88160	257.3
25year Existing	70160	280.3	67020	276.1	64810	269.9	66100	268.0	72310	256.5
10year Existing	54790	278.7	52580	273.9	51600	268.3	52110	266.5	54580	255.3
5year Existing	44390	277.6	42590	272.5	41170	266.6	41530	264.9	43460	253.8
Manning’s Test @ 100 year	98330	283.3	90970	279.7	86660	273.5	92270	270.0	104600	258.1
1979 event-lower losses	131500	286.1	118800	282.8	121800	274.6	128200	271.6	127800	259.5
100year-no local inflow	93150	282.8	91030	279.1	90650	271.6	91530	269.1	91290	257.5
C-500year	140600	284.5	133100	279.2	125900	274.5	131100	273.0	145300	260.9
C-200year	115000	282.6	106300	276.8	107100	272.9	110400	271.5	123000	259.7
C-100year	98320	281.3	92340	275.0	93710	271.5	96540	270.4	108200	258.8
C-50year	83440	280.0	80730	273.5	82070	270.4	83260	269.4	93550	258.0
C-25year	70220	278.8	69090	272.2	69300	269.3	70010	268.4	76490	257.1
C-10year	54800	277.2	53980	270.1	53510	267.6	54110	266.9	56100	255.8
C-5year	44390	276.3	44610	268.3	43040	266.1	43390	265.4	43850	254.3
CTO-500year	140740	284.5	135340	279.3	130730	275.0	*	273.2	145990	261.0

	Upstream Extent of Model (Ross Barnett Outflow)		HWY 25		HWY 80		Proposed Dam (Alt C Location)		Downstream Extent of Model	
Scenario Name	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**	**Flow (CFS)**	**W.S. (Feet)**
CTO-200year	115200	282.7	113030	277.1	109830	273.3	*	271.7	123430	259.7
CTO-100year	98420	281.4	97380	275.5	97490	271.9	*	270.6	108160	258.8
CTO-50year	83530	280.1	83650	274.0	84370	270.7	*	269.5	93310	258.0
CTO-25year	70290	278.9	73500	272.65	71700	269.6	*	268.6	76690	257.1
CTO-10year	54850	277.3	60540	270.67	57660	267.9	*	267.0	56100	255.8
CTO-5year	44430	276.3	49530	268.8	46200	266.2	*	265.5	43796	254.3
*Specific Feature not in CTO model										

Inducements - Alternative C and CTO

Descriptions of inducements were calculated for Alterative C but can be assumed to be the same for Alternative CTO. Peak Stage differences at the downstream extent of the design model (downstream of Byram) show between 0.02 and less than 0.1 feet for the C and CTO frequency simulations.

Initial Assessments were conducted to identify downstream impact to the Alternative C construction. The calibrated and reviewed project model was extended 43.4 miles downstream just past the confluence of Copiah Creek and the Strong River to approximate River Mile 223.

The model was extended downstream by creating additional cross sections and storage taken from the LiDAR terrain for both the with and without project geometries. The extended downstream boundary condition was taken from the slope of the terrain and was held constant for both geometries. An assumed channel based on upstream channel survey data was incorporated into the cross sections using the Channel Design/Modifications Editor.

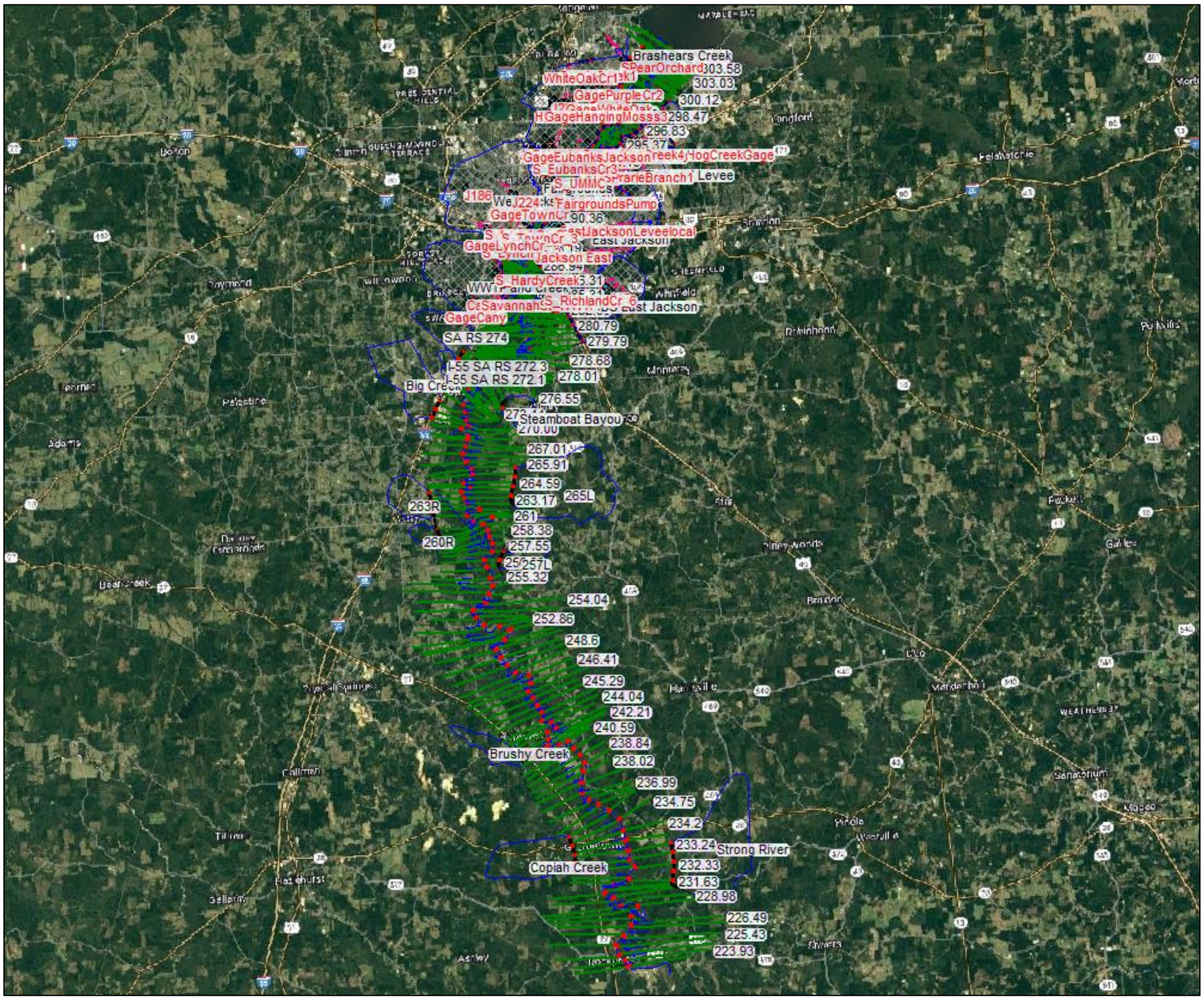


Figure E5-14. Model Geometry Extension

Initial assessments for downstream reach inducements were assessed at the 5- and 100-year frequencies, to represent a relatively frequent event as well as a more extreme scenario. While inflow calculations were available through a HEC-HMS model developed for the larger project effort, a simplified assumption of a frequency event was applied to the larger tributaries.

Table E5-12. Coincident Frequency Assumptions

Frequency Event	Coincident Frequency
5-year	50% AEP
100-year	10% AEP

For this reach and assessment, there was flow and stage inducements for both the 5- and 100-year frequency events. The inducements due to the 5-year event appear to resolve just prior to the Copiah Creek confluence, approximately 32 miles downstream of the project.

Table E5-13. Impacted Areas from Project Area to Confluence with Copiah Creek

Increment of Inducement (Feet) – to Confluence with Copiah Creek	100-year event- Impact Acres	5 year- Acres
0 - 0.25 Feet (unlikely inducement)	Up to 16,200	Up to 33,200
0.25 - 0.5 Feet (expected inducement)	38,800	2,330

The table above show estimated acres impacted due to construction of Alternative C or CTO for both the 5- and 100-year events. These were classified as either expected inducements or unlikely inducements. Modeled areas with an additional 0.25 feet or more of inundation are considered to be a measurable inducement. (Approximately 38,800 acres at the 100-year Frequency, and 2,330 acres at the 5-year frequency). Impacted areas in the 0.25 feet or less range are considered not likely to have any measurable negative impacts. These areas, however, will require further modeling in later phases of design to confirm this initial assessment.

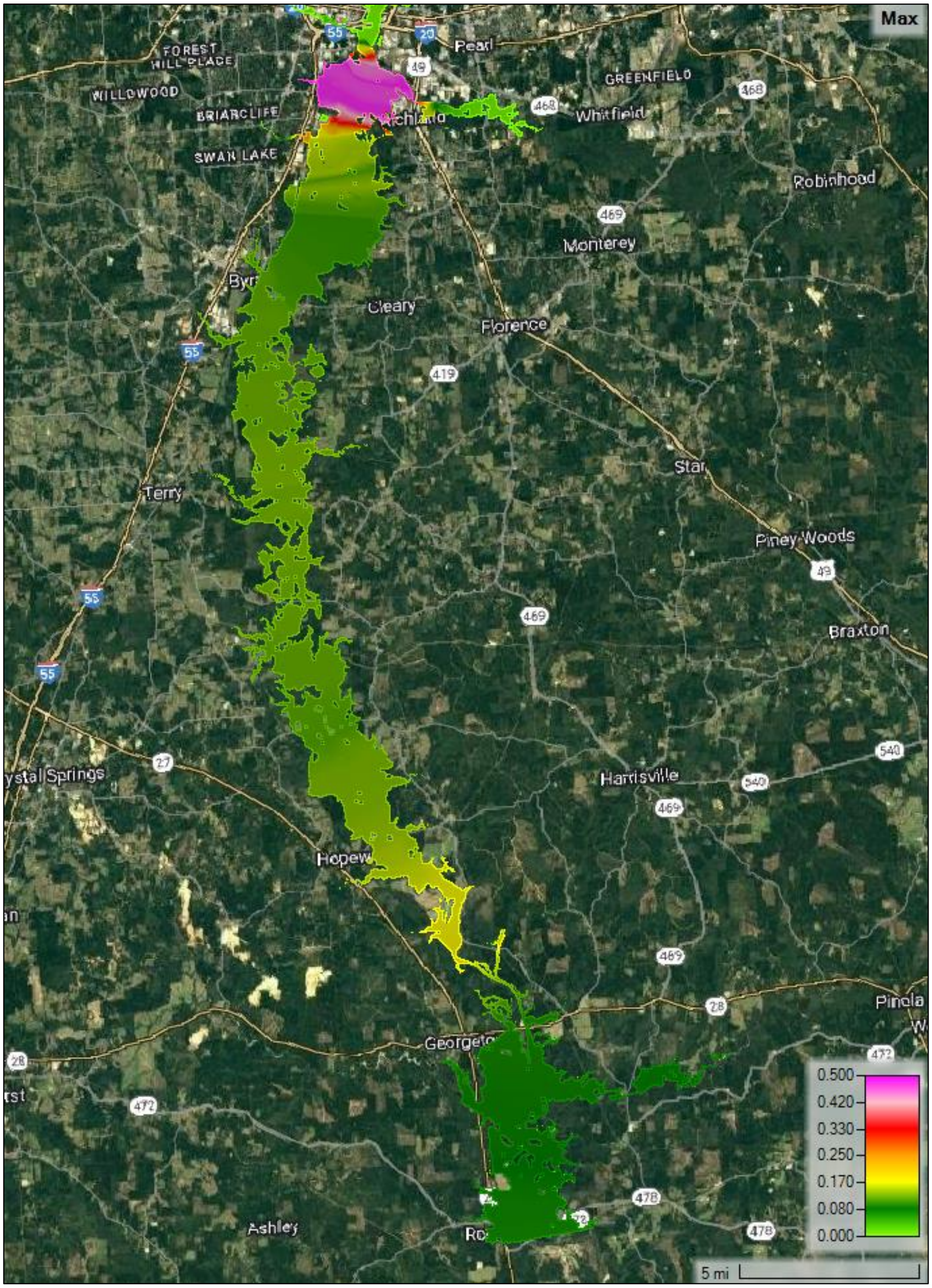


Figure E5-15. 5-year Frequency Absolute Differences (Feet) for With and Without Project Figure shows the additional height due to Alternative C or CTO construction added to the maximum water surface elevation for the 5-year frequency event. (All areas in yellow or green are less than the 0.25 feet, which is considered unlikely to have substantive inducements after further analysis.)

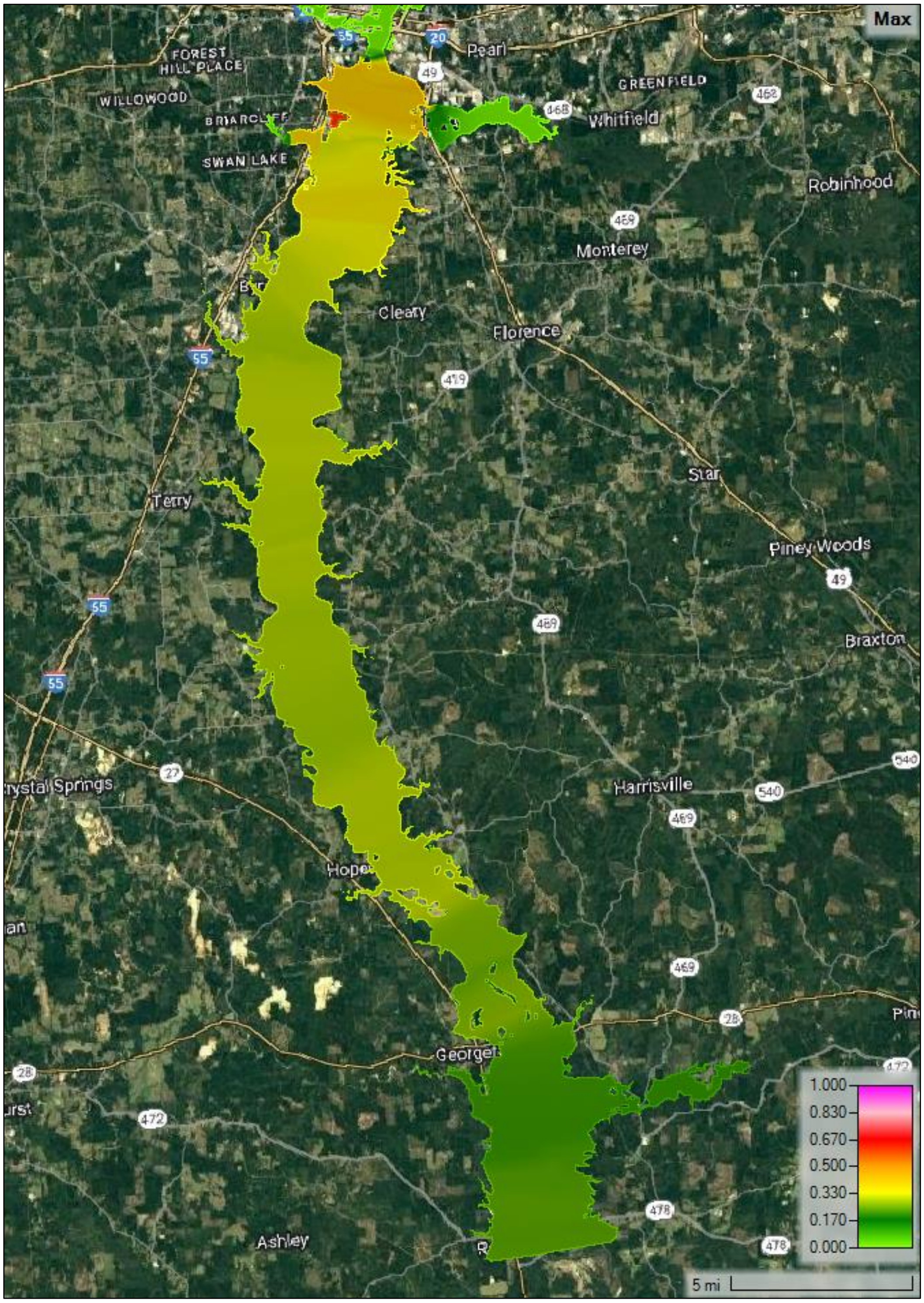


Figure E5-16. 100-year Frequency Absolute Differences (Feet) for With and Without Project. Figure shows the additional height due to Alternative C or CTO construction added to the maximum water surface elevation for the 100-year frequency event. (All areas in green are less than the 0.25 feet, which is considered unlikely to have substantive inducements after further analysis.)

Additional assessment of the changes to downstream boundary was conducted for the 100-year frequency event by taking the flows from the project model and inserting them into the Calibrated Pearl River CWMS model. The Bogue Chitto River was the only major tributary modeled with a separate reach. Due to the distance away from the study area, it was assumed that any major rainfall would not extend to this reach and a mean annual flow of approximately 2,000 cfs was applied to this reach. The mean annual flow was pulled from the USGS Streams tats application for the Bogue Chitto River near Bush, LA. From this assessment, impacts extending to the Mississippi Gulf Coast cannon be ruled out until finalized features to construct are selected, further analysis would be needed to validate the total impacts; however, significant impacts to the downstream watershed beyond the RM 200 are highly unlikely.

Table E5-14 Impacted Areas from Confluence with Copiah Creek to Coastal Boundary, 100-year Frequency.

Range of Inducements in Feet	River Mile
less than 0.2	RM 15 to 223.6

Data Provided to Other Disciplines

Final raster datasets were provided to other disciplines to complete various aspects of this effort. **For Hydraulic Modeling Purposes, current and future condition were reasonably considered to be unchanged**. **This is as significant development is not expected throughout the basin upstream of the Ross Barnett Reservoir, climate change is not expected to induce flooding. For Hydraulic Modeling Purposes Alternatives, A and A1 are the same as existing Conditions.**

Table E5-15. Hydraulic Model Scenario to Alternative

	Future	Current
Alternative A	Existing	Existing
Alternative A1	Existing	Existing
Alternative C	C	C
Alternative CTO	CTO	CTO

SECTION 5

Life Safety and Hydraulic Design Requirements

LIFE SAFETY AND LEVEL OF DESIGN EFFORTS

It was originally scoped to complete a dam screening and simple breach analysis at the proposed dam in the LPP to verify assumptions of life loss, update the Levee Safety Tool screenings for the existing levees in the system, and complete simple Levee Safety Tool style breaching if any of levee features from Alternative B that remain after the hydraulic updates. Additionally, a ½ and full PMF from the Ross Barnett will be modeled using existing data to verify the impacts on design requirement. (It is currently assumed that the proposed dam will need to be designed to survive either a ½ or full PMF; this is separate than the level of design that it is expected to offer flood benefits.)

ANALYSIS OF PROPOSED DAM- ALTERNATIVE C ONLY

Life Safety – Breach

Four pool loadings were modeled with a breach / non-breach pair using the loading and parameters listed below. All scenarios were breached at the peak of the hydrograph. A proxy ½ PMF (2022) provided by the Ross Barnett Staff was routed downstream to mimic a ½ PMF that would be calculated at the proposed dam location. Breaching data is shown in Figure E6-1.

Note that this analysis was only completed for the Alternative C geometry due to the time constraints associated with the addition of Alternative CTO modeling. It is reasonable to assumed that the Alternative CTO has less impact due to a breach of a structure, given the smaller dam size, and smaller impounded water volume. It is probable but not proven that the Alternative CTO proposed weir may be considered a low hazard dam.

Table E6-1. Hydraulic Loadings for Breach Testing (Alternative C)

Pool Loading (ft)	Flow Ratio	Breach Bottom Elevation (ft)	Breach Width (ft)	Breach Formation Time (hr.)
260.1 (approximately top of dam)	0.01% AEP x 0.15	248	1900	0.1
260.3	0.01% AEP x 0.2	248	1900	0.1

260.8	0.01% AEP x 0.3	248	1900	0.1
275.2	½ PMF*	248	1900	0.1

As shown in Figure E6-1 the breach at 260.1ft showed some damages focused within the leveed area. Figure E6-2 provides a zoomed-in figure of one of the structures and the incremental difference in inundation mapping for the breach and non-breach pair. The identified structures near the inundation (structures 1 and 2) appear to be hunting cabins or temporary raised structures. The orange point further downstream in Byram, MS is the location of a local junkyard.

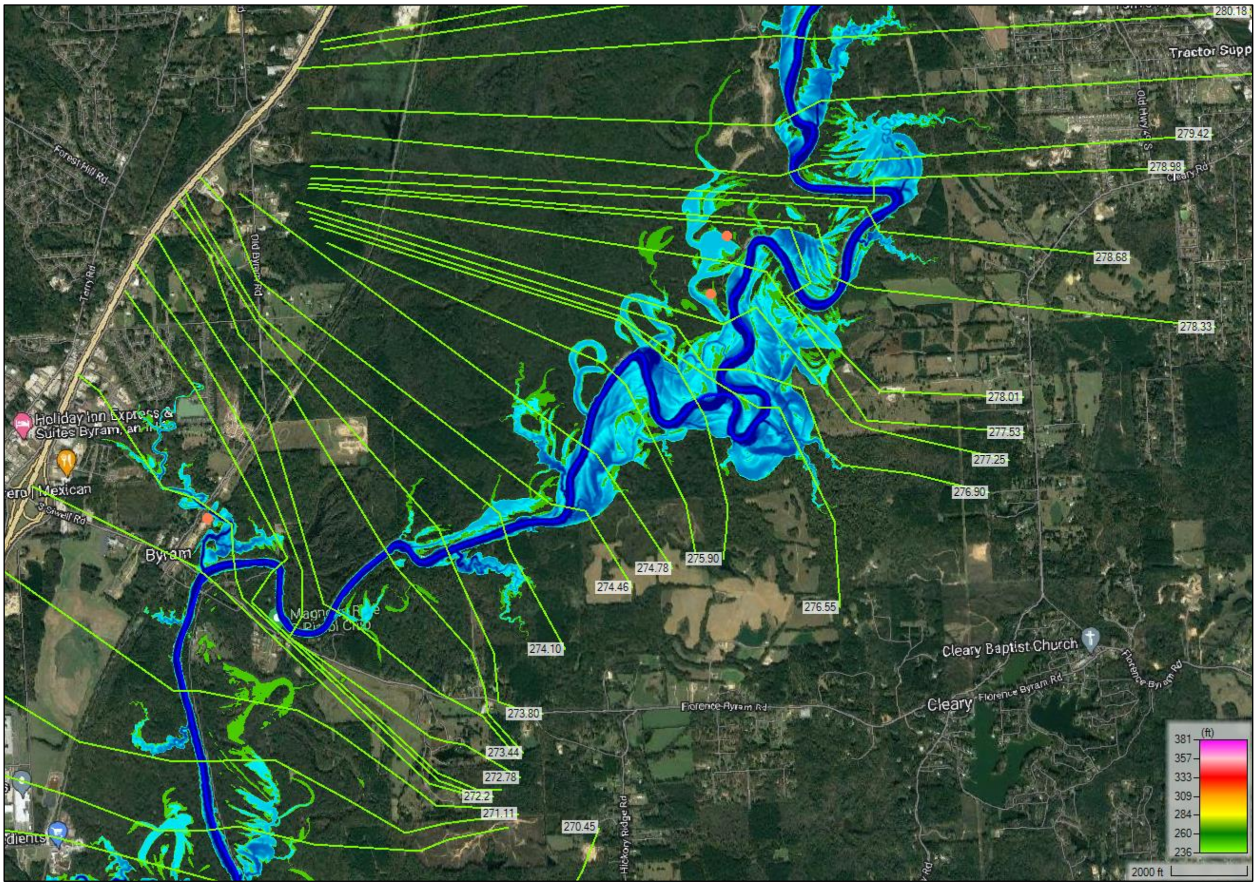


Figure E6-1. Comparison of 260.1 ft Non-Breach (blue) and Breach (green) Indicates a Difference in Inundation Mapping Between the Breach and Non-Breach Scenarios

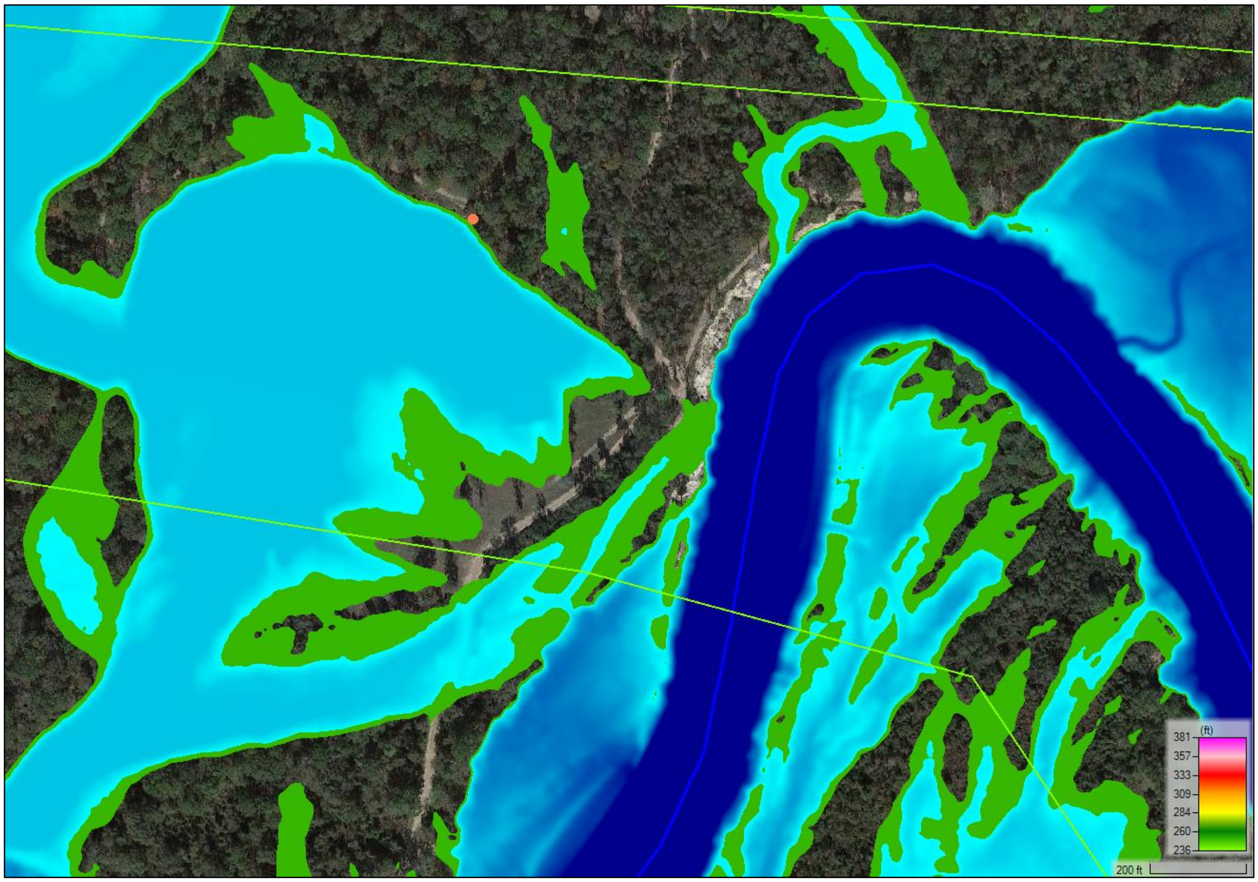


Figure E6-2. An Example of an Incremental Difference in Inundation Mapping (structure is located under orange point) for the 260.1ft pool loading (approximately top of dam) for breach and non-breach pair.

As shown in Figure E6-3, the breach at 260.3 ft indicated an incremental difference in the breach and non-breach pair. Figure E6-4 provides a zoomed-in figure of one of the structures and illustrates that the inundation is closer to the structure for the breach scenario.

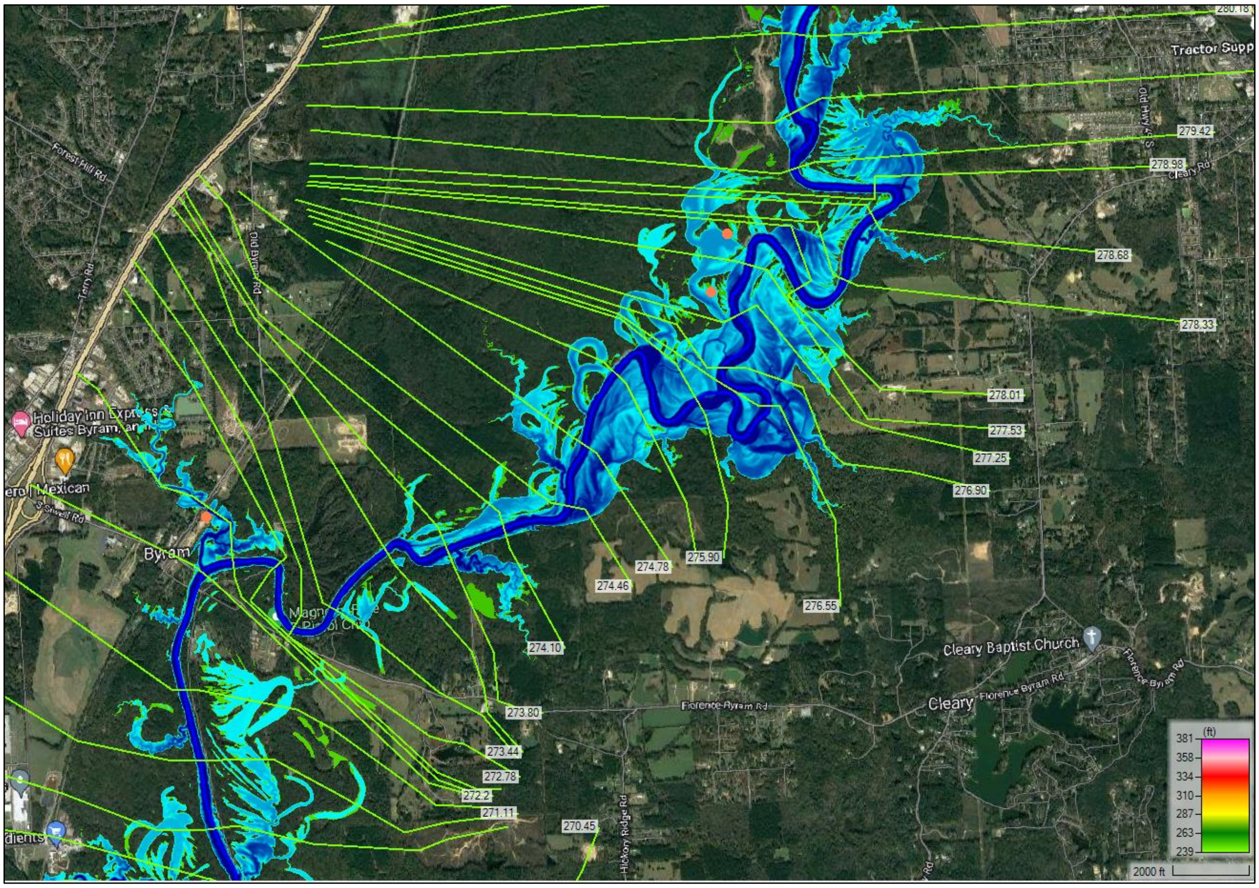


Figure E6-3. Comparison of 260.3 ft Non-Breach (blue) and Breach (green) Indicates a Difference in Inundation Mapping between the Breach and Non-Breach Scenarios

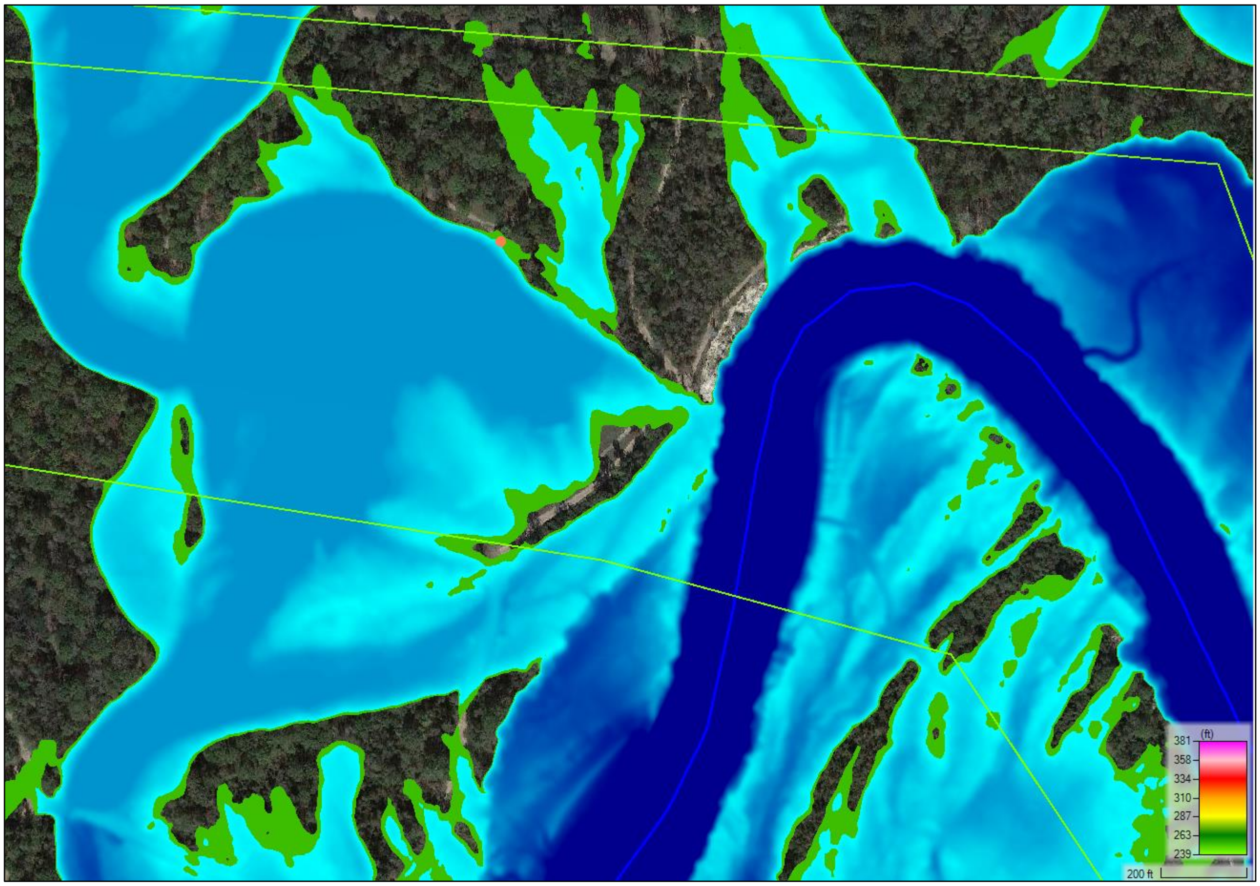


Figure E6-4. An Example of an Incremental Difference in Inundation Mapping (structure is located under orange point) for the 260.3ft pool loading (0.01% AEP x 0.2) for breach and non-breach pair.

As shown in Figure E6-5, the breach a 260.8ft (0.01% AEP x 0.3) showed a minimal incremental difference in the breach and non-breach pair. No structures appeared to be impacted by the 260.8ft breach scenario.

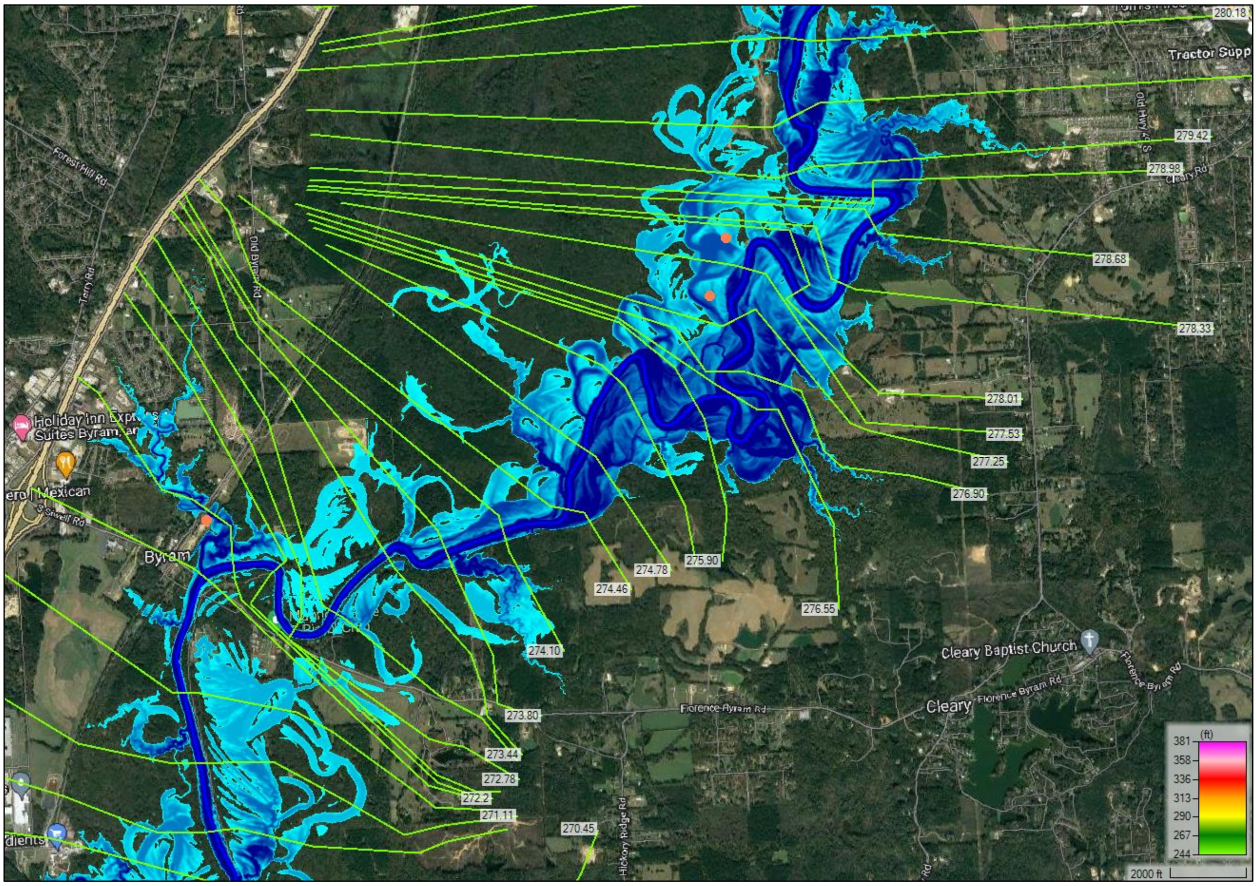


Figure E6-5. Comparison of 260.8 ft Non-Breach (blue) and Breach (green) Shows Minimal Difference between the Breach and Non-Breach Scenarios

As shown in Figure E6-1, the breach at 275.2 ft (1/2 PMF) showed no incremental difference in the breach and non-breach pair.

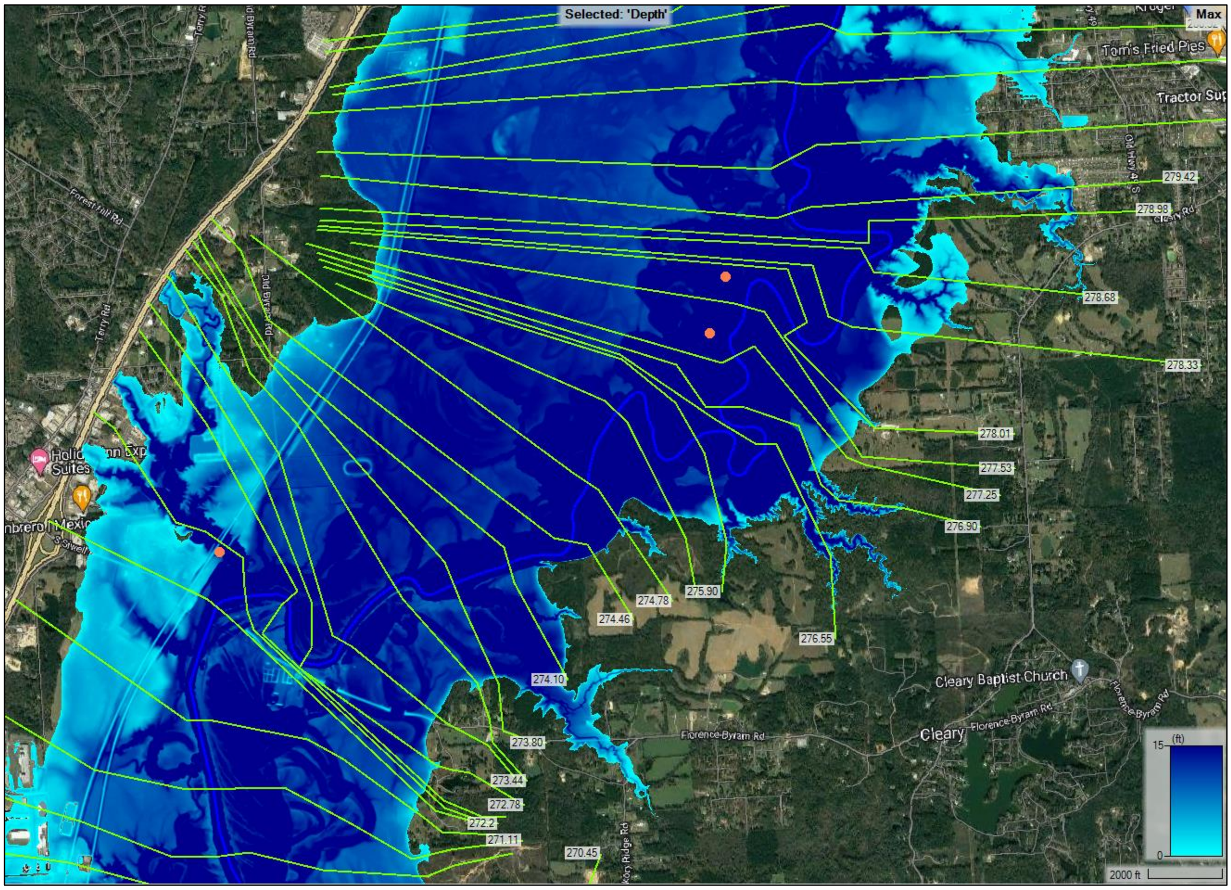


Figure E6-1. Comparison of 275.2 ft (1/2 PMF) Non-Breach (blue) and Breach (green) Shows no Difference Between the Breach and Non-Breach Scenarios

Table E6-2. Non-Breach Modeling Results at Structure 1 (RS 278.33) and Byram Junkyard (RS 272.2)

Loading	Location	Flow	Stage	Location	Flow	Stage
260.1 (approximately top of dam)	RS 278.33	11,354	247.9	RS 272.2	11,336	244.7
260.3	RS 278.33	14,970	250.7	RS 272.2	14,939	247.4
260.8	RS 278.33	22,030	254.8	RS 272.2	21,962	251.1
275.2 (1/2 PMF)	RS 278.33	185,631	270.9	RS 272.2	185,440	267.1

Table E6-3. Breach Modeling Results at Structure 1 (RS 278.33) and Byram Junkyard (RS 272.2)

Loading	Location	Flow	Stage	Location	Flow	Stage
260.1 (approximate top of dam)	RS 278.33	14,530	250.29	RS 272.2	14,181	246.93
260.3	RS 278.33	16,635	251.59	RS 272.2	16,429	248.4
260.8	RS 278.33	22,302	254.82	RS 272.2	22,237	251.3
275.2 (1/2 PMF)	RS 278.33	185,637	270.74	RS 272.2	185,456	267.1

Design Requirement Estimation – Simulation of Full and ½ PMF

Four breach scenarios were completed with the Alternative C model, to confirm dam safety hazard classification. Per FEMA's federal guidelines to dam safety report 333, there are three hazard classifications as shown below in Figure E6-7, ranging from high to low. Per USACE guidelines 1110-8-2(FR) there are 4 classifications (Table E6-4), 1-4. Given that the proposed dam retains a large volume of water, a high hazard dam would automatically be a standard 1, a significant hazard dam would be either a Standard 1 or 3 depending on amount of property impacts, and low hazard dam would be a standard 2. (FEMA 2004)

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low	None expected	Low and generally limited to owner
Significant	None expected	Yes
High	Probable. One or more expected	Yes (but not necessary for this classification)

Figure E6-7. Hazard Potential Classifications

Table E6-4. USACE Design Standards for Dams

Standard	Description	Inflow Design Flood
1	Risk to life and property	Probable Maximum Flood (PMF)
2	Run of river projects (e.g., Navigation)	Standard Project Flood (SPF)
3	Negligible incremental impacts due to failure	Base Safety Condition *** (Minimum ½ PMF)
4	Small dams	1% Annual Exceedance

Two structures that are not listed within the study structure inventory were incrementally damaged by this event. Therefore, there would be no life loss associated with these structures. They appear to be tractor sheds or deer camps that would not be significantly impacted by the additional water when shallow, and at higher flow/elevation breaches, there are no structures that are incrementally damaged. Therefore, for current study purposes the proposed weir for Alternative C will be considered to a significant hazard, standard 3 dam, which requires a ½ PMF design storm.

A more formal legal review of terms and damages incurred will be needed to confirm this determination and for any other alternative including a dam moved forward to further study.

BREACH ANALYSIS OF EXISTING LEVEES

This effort was paused after reviewing the elevation profiles along the river with the weir in place and additional risk at the existing levee features. As the flows increase in the river, risk would be attributed to a riverine flow regime, rather than a ponded body of water. The images below (E6-8) show elevations within the existing levees and show that there would be very little structure impact and very reasonably no life loss if a structure were to breach due to the low flow ponded surface.

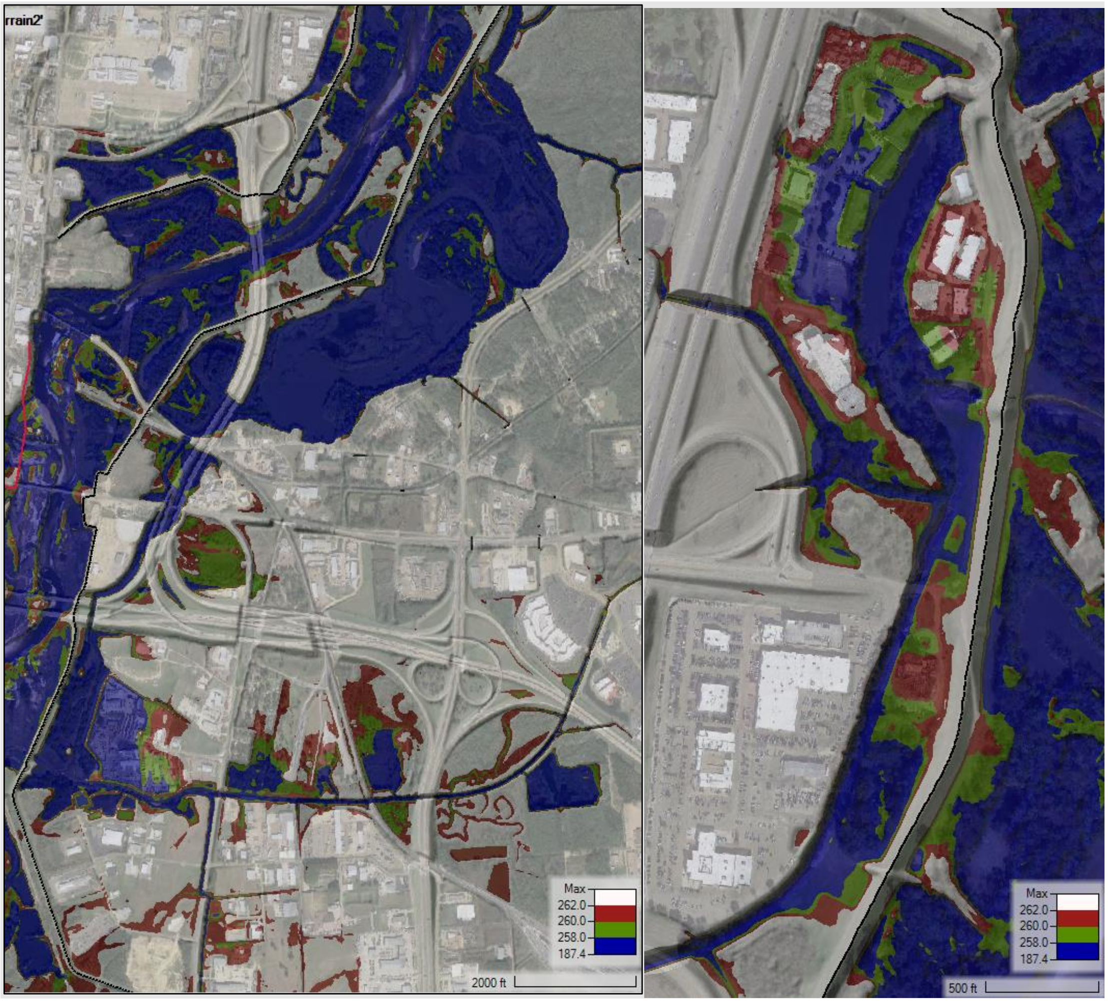


Figure E6-8. Terrain Mapping at Existing USACE Levees

Levee Safety Risk Analysis- Pearl River Project

A risk assessment was not completed or documented in any of the completed feasibility reports to understand the life safety risks for any of the proposed alternatives for this project. This includes the recent feasibility study prepared by the Non-Federal Interest (NFI) as well as past feasibility studies by USACE. USACE engineering and planning policies require that risk assessments be completed to evaluate the life safety risks during feasibility studies that include levees or dams. The scope and scale of the required risk assessment during feasibility studies may vary; however, an explicit evaluation of life safety is required for projects that include levees or dams.

As part of the USACE review of the current study report, a qualitative evaluation of the potential life safety impacts only considering available information is included. This evaluation focusses on the Alt C plan(s) in terms of levee risk. Additionally, there is insufficient information to assess the life safety risks associated with much of the Alt B plan originally proposed by USACE. A discussion of these limitations is documented. Alternative CTO was not considered for this assessment and any dam or levee features selected not covered as part of this effort would need to be fully assessed during later phases of study.

Please note that the Alternative CTO plan is not included in this assessment, and further investigation will need to be completed after final selection of CTO features. Alternative CTO with Weir can be assumed to have the same order of magnitude life safety concerns as Alternative C (ranging from same results to less risk to life loss). Alternative CTO without the weir will have less impacts from a Life Safety perspective.

There are three existing levee systems that are impacted as part of the Alt C and Alt B plans that are shown in the National Levee Database (NLD).

1.) Jackson Fairgrounds MS (NLD System # 5905000002)
2.) East Jackson MS (NLD System # 5905000015)
3.) Jackson-East Jackson Flood Control Project (NLD System # 1405000124)

USACE has completed screening level risk assessments for the Jackson Fairgrounds MS and East Jackson MS levee systems evaluating the life safety risks associated with the existing levees. These risk assessments evaluated the existing levee systems only and do not provide any evaluation of alternatives included current and past feasibility studies.

USACE developed the following sections using the available data in the NLD, the data included in the feasibility report, screening level risk assessments of the existing Jackson Fairground MS and East Jackson MS levee systems completed by USACE, and evaluation of this data. A discussion of each of the existing levee systems and the current understanding of these levees and their risk is risks is included. Additionally, the uncertainties and impacts of each of these alternatives are included, along with recommendations to reduce these data gaps and comply with USACE policy as the project advances to later phases of study.

Jackson Fairgrounds MS (NLD System # 5905000002)

Description of the levee system from the NLD: “The Jackson-Fairgrounds Levee System was constructed in 1968 by USACE to provide flood risk reduction to the eastern portion of Jackson, Mississippi. It is locally maintained by the Rankin-Hinds Pearl River Flood and Drainage Control District. The levee has an average height of 21 feet and has a length of approximately 2 miles. The levee system provides benefits to approximately 1,000 people that work and live behind the levee, with more than $173 million in land and property value. The primary flood risk concerns are based on local storm runoff, with flooding on the Pearl River being the main source. During past flooding events, seepage (water penetrating through or under the levee) has been noted in isolated areas of the levee. The Levee routinely performs well during yearly flood events, with no breaches, including during an overtopping flood event in 1979.”

The project description information included in the NLD are based on the results of a Screening Level Risk Assessment that was approved by Headquarters USACE (HQ

USACE) in January 2017. The population at risk information and land/property value that are reported in the NLD have changed since 2017 and may not be reflective of current conditions and consistent with numbers presented in the feasibility report. Both values have likely increased.

Existing Overtopping Risks:

The estimated overtopping frequency in the 2017 Screening Level Risk Assessments has about a 500-year annual chance exceedance probability (AEP). The levee overtopped in 1979 near Fortification Street (~ NLD Station 15+00) and did not breach. A small raise of the levee at the overtopping location was completed after the 1979 flood. The current estimated incipient overtopping location is at NLD Station 76+00 near I-55. The levee elevation at this location is about 277 ft which correlates to a Highway 80 gauge reading of 42.02 ft.

Estimated life loss in the event of an overtopping breach is one person or less based on the results of the screening level risk assessment. Most of the levee area would be inundated during an overtopping event and flood depths would be greater than 15 feet in some areas. While inundation depths are high in some areas, the potential overtopping event would be known in advance of the flood and most of the leveed area is commercial with a smaller residential population. The levee board and local government have a plan for warning and evacuating flood prone areas.

Alternative C – Overtopping Risks:

The currently proposed Alt C being evaluated by USACE does not include any alignment or height changes to the existing Jackson Fairgrounds Levee. The proposed plan would *decrease the overtopping risk* to the system by reducing the frequency of overtopping. The new, less frequent, overtopping frequency of the system cannot be accurately determined based on information included in the current feasibility study. It is also unknown whether the proposed alternative will change the overtopping location on the levee system. This overtopping frequency and location would need to be calculated in later design phases.

Existing Prior to Overtopping Risks:

Levee performance and potential lost benefits documented in the NLD that were developed based on the 2017 Screening Level Risk Assessment: “The major performance risk identified with the levee is failure due to the seepage issues observed during historic flood events. The USACE and the Levee District have a plan to address seepage issues as they occur and past efforts to “flood fight” seepage issues have been successful. However, the presence of seepage issues can increase the risk of a levee failure. A levee failure due to seepage would occur suddenly, which reduces the time to warn people and evacuate the area. A reduction in warning time may increase the likelihood of property damage and human fatalities. Another risk driver is a sewer line that had significate inflow and infiltration from flood water prior to The city of Jackson West Bank Interceptor rehabilitation projects. The city’s projects have reduced the risk significantly. The leveed area lacks a flood warning system. The Levee District maintains an Emergency Action Plan that includes notification of Rankin County, Hinds County, and affected municipalities’ Emergency Operations Centers.

Flooding of the leveed area would also result in significant property losses and economic damages."

Estimated life loss in the event of a breach prior to overtopping, such as a levee failure due to seepage, is on the order of one person based on the results of the 2017 screening level risk assessment. It is expected that the estimated life loss due to a breach prior to overtopping would be higher today due to increases in population and likely in the range of 1 to 10. Most of the levee area would be inundated during an overtopping event and flood depths would get greater than 15 feet in some areas. Seepage would be the most likely cause of a failure prior to overtopping. This type of failure can occur rapidly, which reduces can reduce the effectiveness of warning and evacuation. USACE and the local levee Sponsor actively patrol the levees at critical stages and detection and intervention would likely be successful if a seepage problem initiates during a flood event.

Alternative C – Prior to Overtopping Risks – Jackson Fairgrounds MS Levee System:

The proposed Alt C plan would reduce the frequency of loading on the levee which does ***reduce*** the probability of high loading levels that could trigger a failure of the levee due to seepage.

Adjacent to the Jackson Fairgrounds MS levee system, the Alt C plan includes placement of fill areas on the riverside of the levee. The Alt C plan also includes construction of a minimum 40-ft wide maintenance berm on the riverside of the levee where there is a permanent pool. It is unknown where this maintenance berm will be a requirement The riverside fill and maintenance berm will not have a negative impact on the seepage performance of the existing levee system and may reduce the risk of the levee from a seepage failure.

The channel excavations within the Pearl River floodway provide the economic and life safety benefits for this project by reducing the frequency of loading on the existing levee system. The only potential negative impact of the channel excavations is their proximity to the existing levee system. Excavations within the channel have the potential to remove riverside fine-grained blanket soils and create an effective seepage entry point closer to the levee. These excavations have the potential to increase the probability of initiation and progression of a seepage failure mode that can lead to breach. The Alt C plan does include the construction of a 40-ft wide maintenance berm on the riverside of the levee where there is a permanent pool. It is expected that the final design will be optimized during later design phases to widen the berm towards the riverside to eliminate the potential negative impacts of the channel excavation negatively impacting the performance of the existing levee system. (Figure E6-9).

The one area on the levee system where the minimum 40-ft wide maintenance berm cannot be constructed and where permanent pool may be against the levee is at an existing pump station (see image below). At this location the presence of the permanent pool may require additional seepage control measures that presently do not exist. Those measures would potentially include cutoff walls and/or relief wells. The overall length of existing levee that may require mitigation at the existing pump station is in the range of 500 to 1000 ft. If required, these mitigation measures would reduce the probability of failure of the existing levee system to a tolerable level compared with the overall levee overtopping risks.

Figure E6-9. Potential Seepage Mitigation Area-Jackson Fairgrounds Levee

East Jackson MS (NLD System # 5905000015)

Description of the levee system from the NLD: “The East Jackson Levee System, located within Rankin County, Mississippi, was federally constructed in 1968 along the left descending bank of the Pearl River and provides risk reduction to the towns of Pearl, Flowood, and Richland. The levee system is approximately 13.5 feet tall and has an approximate length of 11.4 miles. The East Jackson Flood Control Project provides benefits to more than 10,000 people that work and live behind the levee, with more than $972 million in land and property value. The primary flood risk concerns are based on local storm runoff, with flooding on the Pearl River being the main source. Minor seepage (water penetrating through or under the levee) has been noted in isolated areas of the levee in the past, but none during the most significant high-water events. The levee routinely performs well during yearly flood events with no breaches, including during the record flood of 1979.”

The project description information included in the NLD are based on the results of a Screening Level Risk Assessment that was approved by HQ USACE in May 2016. The population at risk information and land/property value that are reported in the NLD have changed since 2016 and may not be reflective of current conditions and consistent with numbers presented in the feasibility report. Both values have likely increased.

Existing Overtopping Risks:

The estimated overtopping frequency in the 2016 Screening Level Risk Assessments has about a 500-year annual chance exceedance probability (AEP). The East Jackson levee did not overtop in 1979 when the Jackson Fairgrounds system on the west side of the river overtopped. Since a small raise of the overtopping location on the Jackson Fairgrounds system did occur after 1979, it is unknown whether the East Jackson system still has superiority over the Jackson Fairgrounds system. The current estimated incipient overtopping location is at NLD Station 384+00. The levee elevation at this location is about 274.6 ft which correlates to a Highway 80 gauge reading of 41.65 ft.

Estimated life loss in the event of an overtopping breach is about one person based on the results of the screening level risk assessment in 2016. The daytime and nighttime population at risk has increased within the leveed area since completion of the 2016 risk assessment and the estimated life loss has likely increased to within the range of 1 to 10. Most of the levee area would be inundated during an overtopping event and flood depths would get greater than 15 feet in some areas. While inundation depths are high in some areas, the potential overtopping event would be known in advance of the flood and most of the leveed area is commercial with a smaller residential population. The levee board and local government have a plan for warning and evacuating flood prone areas.

Alternative C – Overtopping Risks:

The currently proposed Alt C being evaluated by USACE does not include any alignment or height changes to the existing East Jackson Levee. The proposed plan would *decrease the overtopping risk for a majority* of the system by reducing the frequency of overtopping. However, inducements below the CN railroad raise the overtopping frequency by up to 0.4 feet for the 1% ACE. The new overtopping frequency of the system cannot be accurately determined based on information included in the current feasibility study. It is also unknown whether the proposed alternative will change the overtopping location on the levee system. This overtopping frequency and location would need to be calculated in later design phases.

Existing Prior to Overtopping Risks:

Levee performance and potential lost benefits documented in the NLD that were developed based on the 2016 Screening Level Risk Assessment: “The major performance risk identified with the levee is failure due to the seepage issues observed during historic flood events. The USACE and the Levee District have a plan to address seepage issues as they occur and past efforts to “flood fight” seepage issues have been successful. However, the presence of seepage issues can increase the risk of a levee failure. A levee failure due to seepage would occur suddenly, which reduces the time to warn people and evacuate the area. A reduction in warning time may increase the likelihood of property damage and human fatalities. The leveed area lacks a flood warning system. The Levee District maintains an Emergency Action Plan that includes notification of Rankin County, Hinds County, and affected municipalities' Emergency Operations Centers. Flooding of the leveed area would also result in significant property losses and economic damages."

Estimated life loss in the event of a breach prior to overtopping, such as a levee failure due to seepage, is on the order of 1 to 10 people based on the results of the 2016 screening level risk assessment. It is expected that the estimated life loss due to a breach prior to overtopping would be higher today due to increases in population and likely in the range of 3 to 30. Most of the levee area would be inundated during an overtopping event and flood depths would get greater than 15 feet in some areas. Seepage would be the most likely cause of a failure prior to overtopping. This type of failure can occur rapidly, which reduces can reduce the effectiveness of warning and evacuation. USACE and the local levee Sponsor actively patrol the levees at critical stages and detection and intervention would likely be successful if a seepage problem initiates during a flood event.

Alternative C – Prior to Overtopping Risks – East Jackson MS Levee System:

The proposed Alt C plan would reduce the frequency of loading on the levee which does *reduce* the probability of high loading levels that could trigger a failure of the levee due to seepage.

Adjacent to the East Jackson MS levee system, the Alt C plan includes the construction of spoil disposal areas on the landside of the levee. These soil disposal areas will effectively function as "seepage berms" in the areas where they are constructed (Figure E6-10). Thus, the probability of breach due to seepage at a given flood stage will likely *decrease* in areas where spoil disposal is placed on the landside of the levee. This decrease would only occur in areas where the "seepage berms" are placed as part of spoil disposal. The feasibility study does not identify whether the proposed locations of the spoil piles are in the most critical seepage areas of the existing levee. Therefore, the overall probability of a seepage failure of the levee system during a given flood stage may not decrease but would certainly not increase because of the placement of spoil piles on the landside with the Alt C plan.

The channel excavations within the Pearl River floodway provide the economic and life safety benefits for this project by reducing the frequency of loading on the existing levee system upstream of the CN railroad Bridge. The channel excavations within the Pearl River floodway induce flooding and increase the frequency of loading on the existing levee system downstream of the CN railroad Bridge. Another potential negative impact of the channel excavations is their proximity to the existing levee system. Excavations within the channel have the potential to remove riverside fine-grained blanket soils and create an effective seepage entry point closer to the levee. These excavations have the potential to increase the probability of initiation and progression of a seepage failure mode that can lead to breach. The Alt C plan does include the construction of a 40-ft wide maintenance berm on the riverside of the levee where there is a permanent pool. It is expected that the final design will be optimized during later phases of study to widen the berm towards the riverside to eliminate the potential negative impacts of the channel excavation negatively impacting the performance of the existing levee system.

Similar to the Jackson Fairgrounds system, the one area on the East Jackson levee system where the minimum 40-ft wide maintenance berm cannot be constructed and where permanent pool may be against the levee is at an existing pump station and major sump area (see image below). The existing levee south of the pump station may also be subject to a permanent pool as well, but the most critical location will be near the pump station. The presence of the permanent pool will likely require additional seepage control measures that presently do not exist. Those measures would potentially include cutoff walls and/or relief wells. The overall length of existing levee that may require mitigation at the existing pump station and sump is in the range of 500 to 1000 ft. Although unlikely, there is the potential that isolated areas along the existing levee may require seepage mitigation south of the pump station, but that is unknown at this time and would need to be evaluated during later phases of design. If required, these mitigation measures would reduce the probability of failure of the existing levee system to a tolerable level compared with the overall levee overtopping risks.

Figure E6-10. Potential Seepage Mitigation Area- Jackson East Levee

Jackson-East Jackson Flood Control Project (NLD System # 1405000124)

The NLD has limited information regarding this levee system. The Jackson-East Jackson Flood Control Project is a non-Federal levee system. The condition of the levee is unknown by USACE, and a risk assessment has not been completed for this levee. The levee is approximately 2.69 miles long and provides flood risk reduction to the wastewater treatment facility for the city of Jackson, MS. The levee system is believed to not have overtopped or breached during past flood events, in part due to flood fighting. Anecdotally, there may be potential seepage concerns for the existing levee. Upgrades to the existing levee will likely be required to bring the existing levee up to USACE standards. The extent of these potential upgrades is unknown but could be extensive. The improved upstream flow capacity for the Alt C plan will increase the probability of loading and overtopping on this system, which will necessitate a raise of the levee. The amount of the raise is unknown.

Frequency of Overtopping

A formal re-analysis of specific overtopping frequency by plan was paused for the purposes of this study.

The HEC-RAS modeling shows that the Jackson East, Jackson Fairgrounds, Pearson, the local levee behind Jackson East, and the Savanna Street WWTP Levees protect to the 100-year level of protection for Existing Conditions. The Brashear's Creek Levee does not protect to the 100-year level of protection.

Jackson East will have flood elevations both raised and lowered along the levee profile. The Jackson Fairground and Pearson Levees will not have flood elevations raised along the levee profile. However, constant loading along the Jackson East and Jackson Fairground will be raised significantly. The Savanna Street WWTP levee will require a levee raise that has not yet been designed to combat inducements for Alternative C. The Local levee behind the Jackson East Levee may have impacts, depending on the final design of Alternative C. The impact to the local levee will be father defined and mitigated to Alternative C in a later phase of study, as needed. The overtopping frequency and location would need to be calculated in later design phases as well.

SECTION 6
Climate Change

PERIOD OF RECORD DATA/ FORECASTED PERIOD

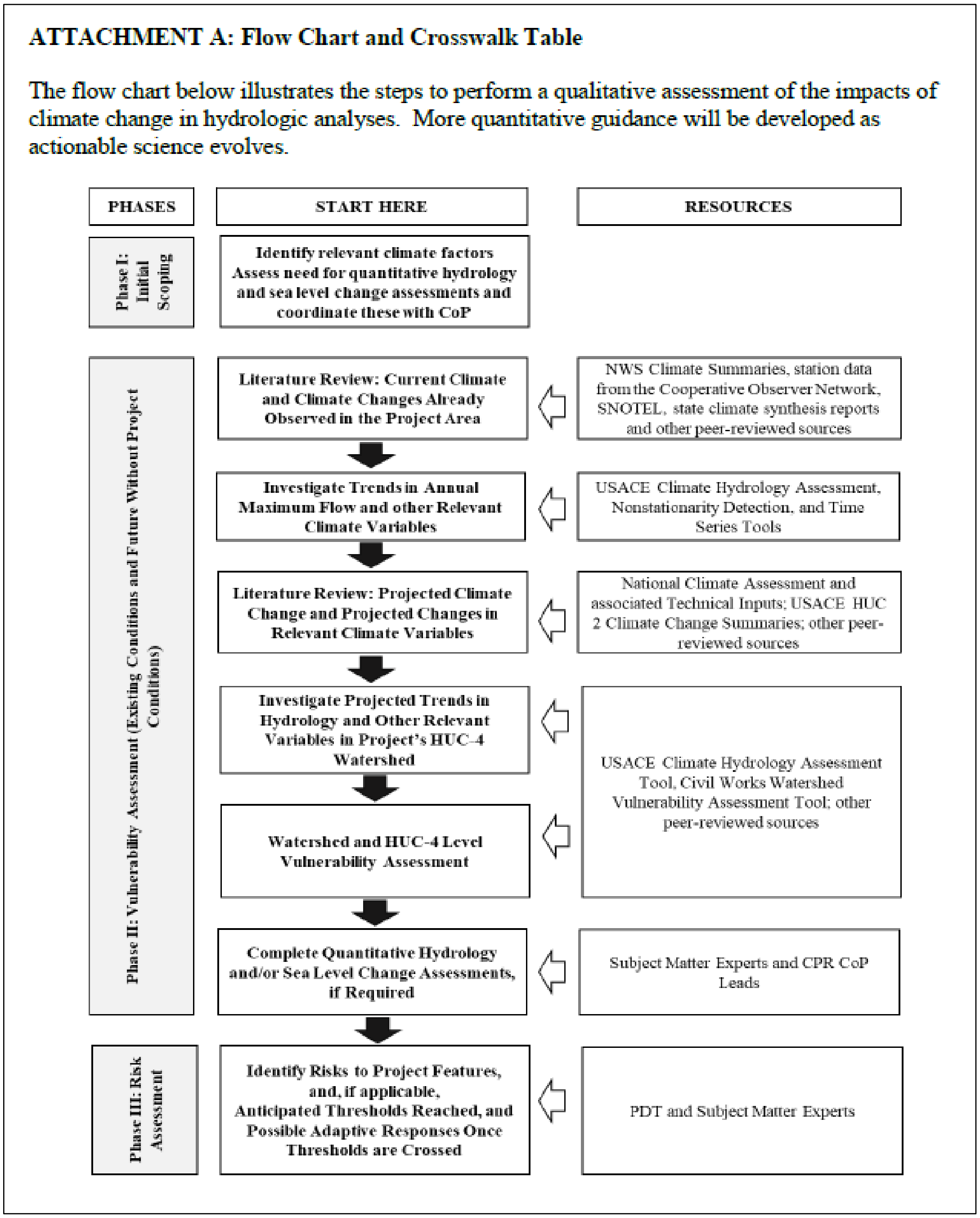
The USACE overarching climate adaptation policy requires consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of USACE water resources infrastructure and to ensure the DOD can operate under changing climate conditions, while preserving operational capability and enhancing the natural and man-made systems essential to the Department’s success

To meet the USACE climate adaptation policy, project delivery teams (PDTs) must assess climate change impacts when a study involves inland hydrology, coastal analysis and/or a boundary condition impacted by sea level. The assessment should be carried out at an appropriate, scalable level based on the complexity, size and level of risk associated with the project. Sea level change (SLC) and riverine hydrology should be assessed to determine if the project is vulnerable to climate change. SLC is not applicable to this study. Figure E7-1 presents a flowchart that illustrates the steps that need to be taken to do a qualitative assessment.

The climate assessment for inland hydrology follows the USACE guidance of Engineering and Construction Bulletin (ECB 2018-14), Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects and the 2021 DOD Climate Adaptation Plan. For most USACE projects and studies, a qualitative assessment provides the necessary information to support the assessment of climate change risk and uncertainties to the project design or constructed project. Per the guidance, a hydrologic literature review of observed climate trends and projected climate trends in the project area is required. USACE and NWS hydrologic and meteorologic tools are used for this assessment. The tools detect non-stationarities in sea level change, riverine hydrology, and meteorology (precipitation).

The climate change to inland hydrology was assessed qualitatively following the three phases outlined in Engineering and Construction Bulletin (ECB) 2018-14.

1. Scoping
2. Vulnerability assessment
3. Risk assessment



ATTACHMENT A: Flow Chart and Crosswalk Table

The flow chart below illustrates the steps to perform a qualitative assessment of the impacts of climate change in hydrologic analyses. More quantitative guidance will be developed as actionable science evolves.

Figure E7-1. Climate Change Flow Chart

The riverine flood component is the major source of climate change risk, scoping was reduced to literature review and assessment with the USACE Climate Hydrology Assessment Tool (CHAT), and the Time Series Tools.

CHAT

The CHAT (https://climate.sec.usace.army.mil/chat/) was used to analyze a sample reach (0300617) within the Middle Pearl-Strong HUC 8 Basin. As shown in Figure E7-2 from the Modeled Time Series Trend Analysis Plot, there is not expected to be negative impacts due to climate change in the projected timeframe.

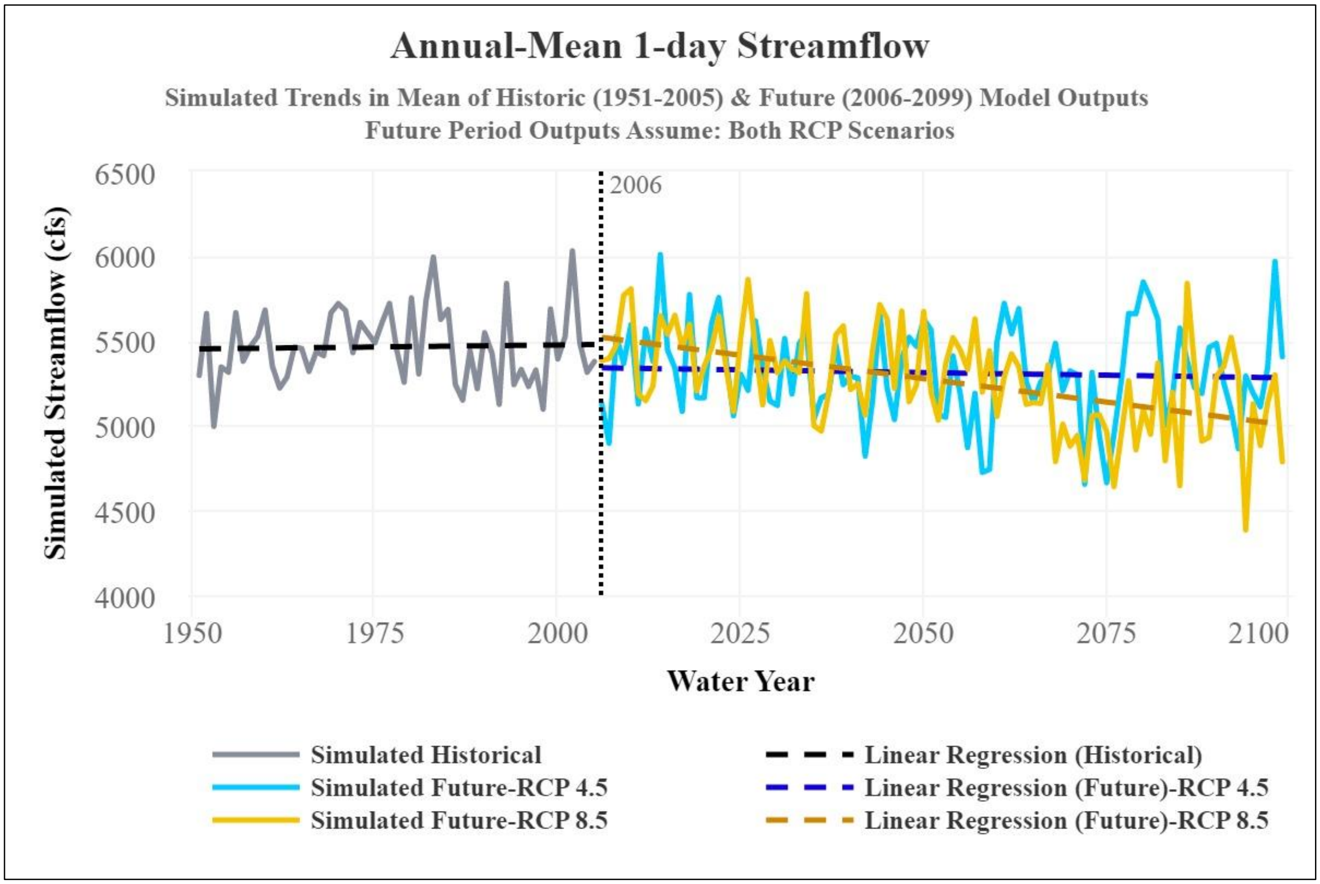


Figure E7-2. CHAT Results for Annual Mean 1-day Streamflow for Reach 0300617

Time Series Toolbox

The Time Series Toolbox (https://climate.sec.usace.army.mil/tst_app/) was used to analyze multiple time periods of concern, including the entire period of record for the Pearl River at Jackson, Mississippi Gage, from the construction of the Ross Barnett Reservoir to Present, and from 1980 to present (period since last extreme event) (Figure E7-.3 and E7-4)

For all time periods analyzed no statistically significant trends were detected by the t-Test, Mann-Kendall Test, or the Spearman Rank-Order Test.

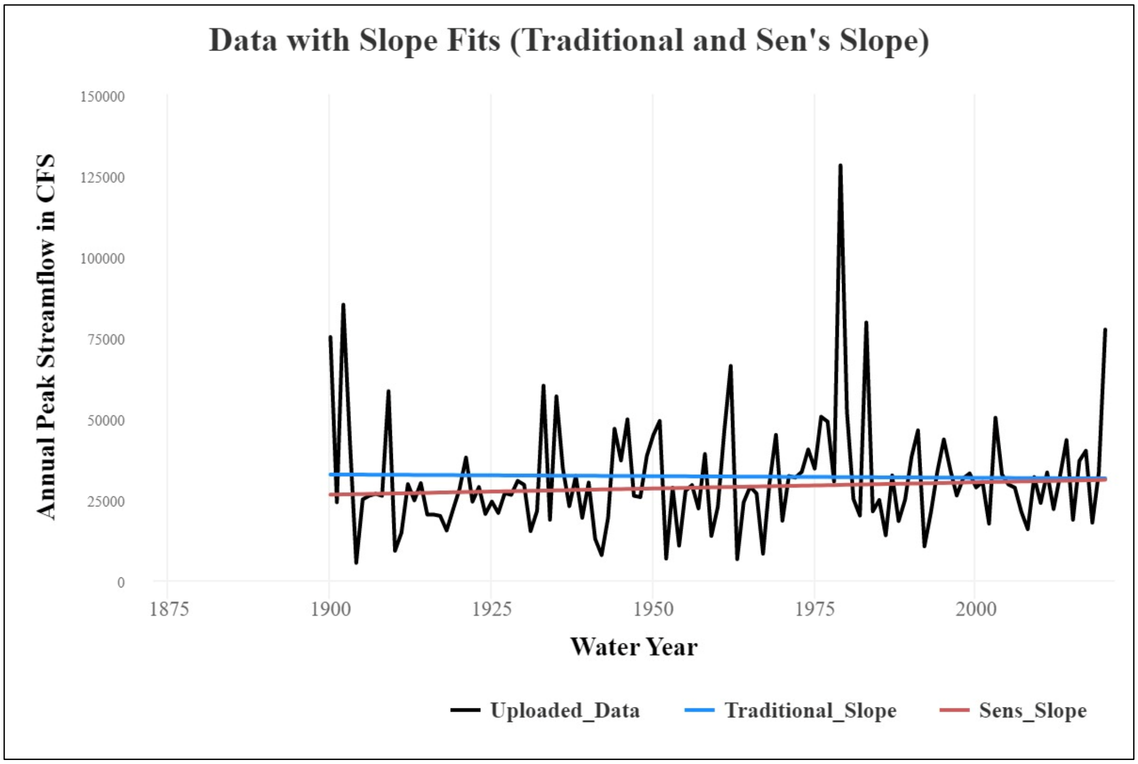


Figure E7-3. Time Series Toolbox Results with Slope Fitting for the Pearl River at Jackson Gage

The Time Series modeling tab shows no prediction of a future change to mean values.

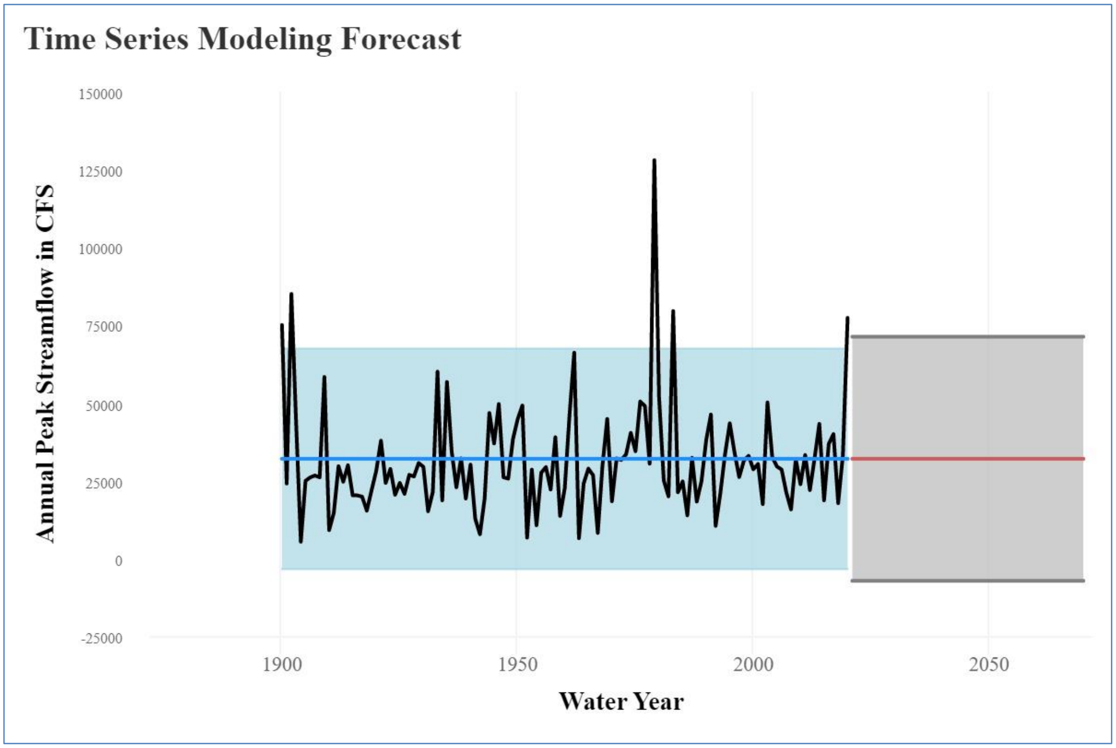


Figure E7-4. Mean Peak Annual Flows Projected

CONCLUSION

Future climate change and the impact to precipitation is not expected to impact frequency flows for the design life of this project.

Risk Assessment

Urbanization, farmland/forest conversions in the upstream or local vicinity could impact the rainfall runoff relationship and the frequency in the project vicinity. Localized impacts to the project area due to this proposed project or others could also impact the stage discharge relationship at the Pearl River in the project vicinity.

SECTION 7
Items Deferred to Future Study

SEDIMENT ANALYSIS AND MANAGEMENT

Potential direct impacts to water supply and flood conveyance due to the deterioration of water quality or quantity from the existence of the proposed weir that could impact sediment load within the newly formed reservoir due to reduced velocities and entrainment potential. A sedimentation study is necessary assess the viability of project features during a future phase of this study. The impacts to water quality and conveyance to the proposed project are inconclusive due to the lack of data, and modeling efforts within the project area. No sediment samples have been provided or analyzed from the Ross Barnett Reservoir or downstream project area either on the main Pearl River channel or tributaries, for use in this study.

To determine if impacts are acceptable, additional analysis is needed. Verification would be needed to demonstrate that adding a large weir would not induce sediment loads to alter the incoming chemistry in such a way to induce failure at the existing J.H. Fewell Plant or any other proposed structure along the newly ponded area. Determination of Sediment Oxygen Demand (SOD) for Pearl River sediments that will lie under Preferred Project Lake. Impoundment will increase the depth over the sediments potentially decreasing DO in water column immediately adjacent to sediments. Deeper waters when combined with SOD could possibly result in bottom water hypoxia and anoxia.

Verification also would be needed to verify that sedimentation passed from the Ross Barnett Reservoir within a proposed ponded feature would not impact storage or conveyance of flood waters. Assessment of the tributaries for sediment load as well as the requirement of Hard Points in tributary channels to prevent incision and additional sediment into newly constructed lake would be needed.

The study described above must be completed prior to the initiation of construction phase.

WATER QUALITY

The NFI provided two distinct modeling studies, which used available data to evaluate water quality impacts the of construction of a new lake (Alternative C) on the Pearl River below Ross Barnett Reservoir. USACE Efforts were limited to review of the NFI work and recommendation for any future efforts. Modeled impacts predicted were of short duration and limited reach. A major premise of the efforts is that the waters filling the new lake are essentially those of Ross Barnett, so no significant water quality issues are expected. The studies concluded that below the proposed lake, water quality impacts in the Pearl River due to any flow alterations are muted and not substantial.

A key aspect of these studies is that the waters of the proposed lake are essentially those released from Ross Barnett and that they receive no loadings while in the proposed lake which may degrade water quality conditions. The study concluded that the three existing point sources that contribute to the project area are either not significant enough or do not directly contribute to the proposed lake waterbody, so as to not degrade the new lake water quality. However, the impact of stormwater loads upon the receiving waters of the proposed lake is poorly understood and characterized. Compounding this issue are the condition of the Jackson sewer system and the reported number of overflows and leaks. A common assumption is that sanitary sewer leaks potentially reach receiving waters via the stormwater drainage system. The degree to which the watershed of the proposed lake is susceptible to receiving sanitary sewage overflows via the stormwater collection system is unknown.

Key Findings from a review of the provided modeling results and reports are indicated in the list below:

1. This review focused on water quality information contained in Appendix D of the NFI report. Both existing data and modeling provided in support of proposed project were reviewed. In addition, information contained within other sections of the report as well as recent news articles that have potential impacts upon water quality conditions in proposed project were considered in this review.

2. The NFI report indicates that three options were originally considered for alleviating flooding issues along Pearl River in vicinity of Jackson. Option A consisted of buyouts of flood prone properties. Option B involved raising levees along Pearl while Option C consisted of channel improvements, levee improvements and construction of a weir on the Pearl south of Interstate 20. This channel, levee, and weir plan is referred to in the documentation as the “One Lake” plan and was the preferred plan after analysis by report’s authors.

3. The documentation provided contained components of two separate water quality modeling studies. One study conducted by FTN Associates used a 1D dynamic riverine water quality model, EPD-RIV1. This model was developed from CE-QUAL-RIV1 by the Environmental Protection District of Georgia Department of Natural Resources. The focus of this study was the section of the Pearl River from below Ross Barnett Reservoir to the proposed weir of Alternative C. The second modeling study was performed by Tetra Tech and used WASP for Water Quality and EFDC for hydrodynamics. The domain of this second modeling effort was the Pearl River from below Ross Barnett Reservoir to Bogalusa, LA.

4. Existing historic water quality data available at time of model development were used to support model development and application. There is very limited data in study area and no long-term monitoring stations other than some data predating construction of the Ross Barnett reservoir (1963).

5. Mississippi Department of Environmental Quality (MDEQ) performs biannual assessments of water quality conditions. At time of report generation, current (2016) and earlier, (2008, 2010, 2012, 2014) MDEQ 305(b) reports indicated that some water bodies in study area had not attained secondary contact use conditions, were not attaining aquatic life support use, or were not addressed during frequent reporting periods.

6. There are limited existing point source dischargers within the preferred plan area. One is the O.B. Curtis water treatment plant just below Ross Barnett Reservoir. Its discharge consists of backwash waters which are permitted. This discharge is just above project limits for channelization and is not expected to have detrimental impacts on overall water quality due to flow rate in river and low level of loadings. The second permitted discharger is the Rex Brown power plant that discharges to Eubanks and Town Creeks which do connect into Pearl River in the project area. This plant operates intermittingly, and its discharges are not expected to be detrimental to receiving waters. The Savannah Street Wastewater Treatment plant is the third permit and discharges into Pearl River below proposed project. Therefore, it should have no direct impact upon waters within the proposed One Lake project.

7. Report indicates city of Jackson (as of 2020) is under EPA consent decree for Sewer collection system overflows and Savannah Street WWTP overflows. This consent decree began in 2012 and was projected in report to continue until 2030. During this period Jackson is supposed to work to implement corrective action for collection system overflows and prevent Publicly Owned Treatment Work (POTW) bypasses in addition to preventing Savannah Street WWTP overflows. As of 2019 Jackson was behind the planned Consent Decree schedule. Status of this work is ongoing but completed to an unknown extent. Based on current news reports there are widespread sewer overflows. In terms of direct impact to proposed project, the elimination of sewer overflows and bypasses that directly enter waters of proposed project directly or indirectly from stormwater runoff are primary concern. Overflow locations and quantities are not presented in the report nor are locations where these flows enter the Pearl River. Depending upon the magnitude of these flows there is potential to degrade waters in proposed lake.

8. One impact of the Savannah Street Wastewater Treatment Plant upon the proposed project is that its permit requires a minimum flow in Pearl River of 227 cfs. The proposed weir has features to enable this minimum flow to be provided.

9. A review of available historical water quality data indicate that it compares favorably with current water quality standards. This implies that water quality conditions in existing system in terms of traditional water quality criteria are acceptable. This information is presented as a summary table. Individual data is not presented but is

believed to be contained in figures later in report. Water quality in existing river was not degraded below current standards during the periods that were historically sampled either in 1988-89 or August 2006. However, verification is needed to confirm that this status still applies.

10. Total Maximum Daily Loads (TMDLs) have been established for the Pearl River in the vicinity of Jackson for Total Nitrogen, Total Phosphorus, Toxaphene and Dichlorodiphenyltrichloroethane (DDT). Total Phosphorus TMDL was updated in 2015 to 70% recommended reduction for the river between Ross Barnett and Strong River. Status of efforts implemented to meet this goal are unknown.

11. Not covered in water quality section of report but of concern are conditions for former facilities in the footprint of the project. Specifically, the former Gulf States Creosoting Company site and the former Landfills. Though these sites are currently out of the normal flow path, legacy contamination from these sites is a concern that should be addressed prior to construction or inundation.

12. The EPD-RIV1 modeling covered the area from below Ross Barnett Reservoir to the proposed weir as the end of the proposed lake. This waterbody was divided into 24 segments similar to those used in the HEC-RAS modeling for water levels. Model water surface level predictions follow the NFI HEC-RAS reasonably well but are normally 1 ft or more above gage for 2014 data. It should be noted that this NFI model required recalibration by USACE. Temperature predictions were comparable to observations except for storm period when differences are blamed on tributary inputs not being accurate. Nutrient calibrations were based on 1-3 samples which may/may not have agreed with data. Calibration period was a summertime month, and, in most cases, there were little variability in nutrient levels that could not be associated to fluctuations in flow or temperature. Model Dissolved Oxygen (DO) exhibited diurnal pattern of the observation data period but didn’t really capture peaks and valleys. Peaks are likely due to photosynthesis which is difficult to capture with this model’s setup. Depth average (1D) model structure dampens DO levels due to larger portion of water column. High light extinction throughout the water column limits light penetration and model algal photosynthesis. Finally, macrophytes present in the actual system produce DO via photosynthesis which is not accounted for in the model.

13. Comparison of model conditions for existing conditions, i.e., No Action Case, and the Locally Preferred Plan, (Alternative C) indicate that diurnal temperature fluctuations decreased for preferred plan in comparison to the No Action Case. This is understandable as there are likely substantial differences in depth between the two cases. No Action would represent current flow conditions while Alternative C would have ponded water over whole of model domain. Exact depth differences are

uncertain but could be substantial. These comparisons are made using July 2014 data which contain some higher flow events.

14. Dissolved Oxygen (DO) results for July 2014 existing conditions and Alternative C comparisons indicate that DO fluctuations are muted for the Preferred Plan versus the existing conditions case in lower portion of the project. This is understandable as Alternative C would have deeper water with diminished photosynthesis over the water column. Modeled DO levels are still adequate, just not as dynamic as the No Action Case.

15. Temperature and DO results for low flow condition simulations exhibited similar behavior. Temperature results for Alternative C followed those of the existing conditions but were more muted downstream. Similar behavior was observed for DO. Modeled DO levels are adequate in Alternative C but with diminished diurnal activity and were lower than the existing conditions. Much of this behavior is likely due to comparison of physically different systems in the two cases, i.e., deeper water in Alternative C versus shallower waters in the existing conditions plan.

16. Preliminary water quality investigation assessment in the report indicates that water quality of the new lake in Alternative C will be similar to that of Ross Barnett Reservoir since it is the headwater for the new lake. This is technically correct. However, conditions in the project area are highly influenced by stormwater inflows from Jackson. Flows and loads from stormwater and associated sewerage overflows and trash are known issues. These studies do not address the hydraulic effects of a stormwater event on the project. Verification is needed to determine if stormwater flows flush the system out or only serve as nutrient, Carbonaceous biochemical oxygen demand (CBOD), and fecal coliform loads. There are varying degrees of impact on project based upon runoff quantity and duration that must be understood to ensure that project provides water quality conditions necessary to support desired uses.

17. Much of the reporting on the conclusions of the RES-1 simulations are based upon assumptions on the flows and loads that originate below the Ross Barnett Reservoir. These are in creeks and stormwater discharges. Understanding these flows and loads is critical to potential conditions in the proposed project. Much is based upon assumptions of projects ongoing at time in Jackson regarding sewer interceptor system construction and progress on Compliance Order. Though there are no combined sewers in project area, sanitary sewer overflows have potential to cross contaminate stormwater sewers thusly impacting project waters. Since approximately four years have passed it would be prudent to have a current understanding of sanitary and stormwater sewer systems and their potential for direct and indirect impacts on Alternative C on the receiving waters.

18. The WASP/EFDC modeling package spanned from below Ross Barnett to Bogalusa, LA. The purpose of this model was to demonstrate downstream impacts of Alternative C on downstream waters. Three locations downstream corresponding to USGS stations were used for Existing Condition/Alternative C comparisons. Simulations were performed for period 2001-2017 with 2009-2017 being used for calibration and 2001-2008 used for validation. Results and discussion presented indicate little to negligible impact on downstream waters. In most instances, differences between existing condition and Alternative C output are indistinguishable.

Key recommendations to better understand expected water quality conditions from the review of the provided modeling results and reports are indicated in the list below:

1. Recommend USACE preform studies to better quantify of the amount of sanitary sewer leakage potentially entering waters of the project area and determination of its impact of proposed plan water quality conditions and allowable uses. This indicates the potential loading (Nutrient, CBOD, Total Suspended Solids (TSS), Fecal Coliforms) that the waters of a new lake or other construction feature may receive. Depending upon the level of loading, additional modeling may be required to quantify the effects of these loads on receiving waters and assess potential for water quality impairment.

2. Recommend USACE complete a better assessment of tributary water quality conditions and whether they have potential to degrade a proposed plan project water quality. Focus should be on the determination of impacts associated with tributaries that *directly* feed the study area, but especially into any lake feature, if selected. Due to urban/suburban environment and known issues with sanitary sewer system, a thorough investigation is warranted as even a small tributary can be disproportionate detrimental impact.

3. Recommend USACE complete a determination of Sediment Oxygen Demand (SOD) for Pearl River sediments that will lie under Preferred Project Lake. Impoundment will increase the depth over the sediments potentially decreasing DO in water column immediately adjacent to sediments. Deeper waters when combined with SOD could possibly result in bottom water hypoxia and anoxia. The likelihood of this occurrence should be assessed.

4. Recommend that USACE develop plans to prevent known HTRW sites within Potential Project footprint from having contaminants either wash into the lake or floodway, or leach from the sediments once the project is constructed. Legacy contamination from these sites and the sediments of the current Pearl River and the proposed Alternative C or other selected plan should be evaluated and, if necessary, removed or contained prior to project development.

DOWNSTREAM GAGING

Additional stream flow and stage gaging locations are needed in the project location to better understand localized impacts.

Bridge Velocities

A rough cost estimate was added to the project cost, however further analysis on bridge impacts have been paused and is awaiting further direction by PDT leads and a MDOT-Rankin Hinds coordination letter.

SURVEY OF EXISTING LEVEES

A survey of all existing levees is needed to better understand levee assurances and the ability to protect interior areas.

COINCIDENCE FLOWS-LOCALS AND ROSS BARNETT OPERATIONS

Due to the time limitations of this effort and with consultation with USACE leads, it was determined to be reasonably conservative to assume full coincidence with a three-day lag for the current effort. This coincidence and timing pattern were observed in the case of the catastrophic 1979 flood event.

To adequately size interior drainage structures through selected alternatives if alternatives are available to continue this effort, it is recommended that a Watershed Analysis Tool (WAT) model be developed to combine meteorological inputs, HEC-HMS rainfall-runoff calculations, and HEC-ResSim reservoir operations and routing later in the project. Consideration would also be given to storm sewer or other interior drainage features.

SECTION 8
Summary Discussion

This Draft Environmental Impact Study (DEIS) presents three alternatives, prepared in accordance with NEPA and USACE ER 1105-2-100. In conjunction with the EIS, a Commander's Report will be provided to ASA-CW to decide which alternative to implement. The Commander's Report will provide an overview of the study and compare levels of flood protection of alternatives, if they are economically justified and assess the environmental acceptability and technical feasibility of the alternatives.

A USACE review and analysis was performed on the NFI Section 211 Report final array of alternatives. The NFI final array of alternatives included a nonstructural plan (Alternative A), a levee plan (Alternative B) and a channel improvement/weir/levee plan (Alternative C). Additionally, USACE developed two new alternatives to include a modified nonstructural plan (Alternative A1) and a CTO Alternative. The CTO alternative is a combination of features as described by the ASA. Alternatives A and B were removed from further consideration early in the evaluation process as they were not economically justified and lacked NFI support.

The purpose of the hydrologic and hydraulic (H&H) analysis was to update the NFI's H&H analysis to current engineering standards, address unresolved comments from the incomplete ATR, correct inaccuracies, create and calibrate a hydrology model, calibrate the updated hydraulic model, and perform a simplified risk assessment on existing and proposed features. Some key updates include but were not limited to updating the statistical analysis to include the last 40 years of data, creation of a hydrology model to determine tributary inflows, inclusion of tributaries in the hydraulic model geometry, switching the hydraulic model to unsteady flow, modifying existing levees to accurately simulate overtopping flows, correcting the geometry for Alternative C and CTO to match the proposed plans, and calibrating the model to more flood recent events. USACE also evaluated potential impacts from climate change using USACE's latest guidance.

The USACE updated H&H analysis evaluated existing conditions and proposed alternatives. For the purposes of the H&H portions of this study, Alternative A1, which is based on buyouts and floodproofing is hydraulically the same as the existing condition. Model results may be used interchangeably.

H&H modeled the proposed channel improvements and weir design elevations as prescribed in the NFI Alternative C and CTO. The USACE analysis shows that all flood reductions are due to channel improvements, and that the proposed weir does not provide flood reduction benefits. In addition, the USACE analysis demonstrates inducement just upstream of the weir, along some tributaries, and downstream of the weir. The downstream inducements are due to increased conveyance from the upstream channel improvements. The calibrated model was extended downstream for43.4 miles and inducements were further assessed at the 20% and 1% Annual Chance Exceedance Events. The 1% ACE was then extended even further downstream using a USACE calibrated Pearl River CWMS model. Significant impacts to the downstream watershed beyond river mile 200 are highly unlikely.

USACE completed a simplified risk assessment on the proposed weir and existing levees. No additional risk is expected to occur to existing features under alternative A. Further Analysis and modeling are required to assess risk for alternative CTO, depending on which features are selected. Alternative C features a proposed weir that meets significant hazard dam requirements and currently necessitates a standard 3 levels of design and construction. However, this standard would need to be continually verified during further design of the proposed weir. Alternative C proposed weir impounds water against existing levees, Jackson Fairgrounds MS and East Jackson MS, and seepage mitigation would be required. The Jackson Fairgrounds and East Jackson levees are not expected to have a significant reduction in overtopping frequencies, but this would need to be verified as detailed design of the proposed weir continues. The downstream Jackson-East Jackson Flood Control Project would undergo some inducement at higher flood events. Mitigation features have not been designed.

The NFI provided two distinct modeling studies, which used available data to evaluate water quality impacts the of construction of a new lake behind the proposed weir. USACE Efforts were limited to review of NFI work and recommendation for any future efforts. Modeled impacts predicted were of short duration and limited reach, and sampling efforts were hindered by a dry period. USACE has developed recommendation for further analysis to reduce risk and uncertainty, should alternative C or CTO with a lake be constructed.

USACE completed a climate change assessment to verify NFI assumptions. Future climate change and the impact to precipitation are not expected to impact frequency flows for the design life of this project.

Several analyses will need to be completed to better understand the full impact of the proposed features if Alternatives C or CTO are selected. These items include but are not limited to sediment analysis to determine potential sediment volume and impacts to proposed lake, water quality sampling and analysis to better understand characteristics of tributary contributions to the project area, temporary gage features to further refine calibration near key design features, analysis of overtopping assurance levels of proposed and existing features within the project area, interior drainage of existing levees to determine mitigation for loss of drainage structure operability, redesign of the proposed weir to meet USACE and State standards, further coordination and analysis of bridge impacts, updated surveys of key levee and tributary features, and determination of operation and maintenance plans for all proposed features. USACE would need to complete further analysis of the proposed weir tie in features, and seepage protection for existing levees. If tributary features are selected as part of alternative CTO, further refinement of the modeling along the tributary reaches would be necessary.

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List of Acronyms and Abbreviations

1D	One Dimensional
2D	Two Dimensional
AEP	Annual Exceedance Probability
ASA-CW	Assistant Secretary of the Army for Civil Works
ATR	Agency Technical Review
CBOD	Carbonaceous Biochemical Oxygen Demand
CDR	Climate Data Record
CFS	Cubic Feet per Second
CHAT	Climate Hydrology Assessment Tool
CTO	Combination Thereof
CWMS	Corps Water Management System
DDT	Dichlorodiphenyltrichloroethane
DEIS	Draft Environmental Impact Study
DO	Dissolved Oxygen
ECB	Engineering and Construction Bulletin
EIS	Environmental Impact Study
EM	Engineering Manual
EMA	Expected Moments Algorithm
EPA	Environmental Protection Agency
ER	Engineering Regulation
FEMA	Federal Emergency Management Agency
FRM	Flood Risk Management
GIS	Geographic Information Systems
GPM	Gallon Per Minute
HEC-HMS	Hydrologic Engineering Center- Hydrologic Modeling system
HEC-RAS	Hydraulic Engineering Center- River Analysis Software
HEC-ResSim	Hydrologic Engineering Center-Reservoir Simulation Software

HEC-SSP	Hydrologic Engineering Center Statistical Software Package
HEC-WAT	Hydrologic Engineering Center Watershed Analysis Tool
NEXRAD	Next Generation Weather Radar
HQ USACE	Headquarters United States Army Corps of Engineers
HTRW	Hazardous, Toxic, and Radioactive Waste
HUC	Hydrologic Unit Code
LPP	Locally Preferred Plan
MDEQ	Mississippi Department of Environmental Quality
MDOT	Mississippi Department of Transportation
MSL	Mean Sea Level
NAVD	North American Vertical Datum of 1988
NCEI	National Centers for Environmental Information
NED	National Economic Development
NEPA	National Environmental Policy Act
NFI	Nonfederal Interest
NFS	Nonfederal Sponsor
NGVD	National Geodetic Vertical Datum of 1929
NID	National Inventory of Dams
NLCD	National Land Cover Database
NLD	National Levee Database
NOAA	National Ocean and Atmospheric Administration
NRCS	Natural Resource Conservation Service
NWS	National Weather Service
OSE	Other Societal Effects
O&M	Operations and Maintenance
PDT	Project Delivery Team
PED	Pre-Construction Engineering and Design
PMF	**Probable Maximum Flood**
PMP	Probable Maximum Precipitation
POTW	Publicly Owned Treatment Works
PRBDD	Pearl River Basin Development District

QPE	Quantitative Precipitation Estimation
RM	River Mile
RS	River Station
SLC	Sea Level Change
SOD	Sediment Oxygen Demand
SSURGO	Soil Survey Graphic Database
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

Table 1: Stage and Flow Calibration Summary for all Gages, all Calibration Events, HEC-RAS model.

Gage	Calculated-2017	Obs 2017	Difference	Calculated Jan 2020	Observed Jan 2020	Difference	Calculated Feb 2020	Observed Feb 2020	Difference	Calculated-2022	Obs 2022	Difference	Average Difference
Pearl @ 80-stage	265.95	266.71	-0.76	264.92	264.86	0.06	270.11	270.06	0.05	268.69	268.77	-0.08	-0.18
Pearl @ 80 – flow	40465	40000	465	33,157	32200	957	72874.83	77300	-4425.17	59089	56600	2489	-128.54
Pearl @ 25 Stage*	-	-	--	-	-	--	276.83	277.5	-0.67	274.84	274.18	0.66	-0.01
Hanging Moss	279.25	282.04	-2.79	278.84	280.61	-1.77	278.37	278.82	-0.45	280.29	280.31	-0.02	-1.26
Purple	274.43	276.74	-2.31	-	-	--	278.7	279.19	-0.49	--	--	--	
White Oak	--	--	--	276.37	274.99	1.38	278.37	279.15	-0.78	276.78	277.01	-0.23	0.12
Eubanks	272.57	272.63	-0.06	271.59	272.26	-0.67	276.44	275.34	1.1	274.4	273.21	1.19	0.39
Town	276.11	276.1	0.01	274.75	274.65	0.1	270.69	270.63	0.06	274.21	274.46	-0.25	-0.02
Lynch	279.36	279.25	0.11	277.45	280.11	-2.66	273.47	276.13	-2.66	278.19	280.39	-2.2	-1.85
Cany	266.34	267.79	-1.45	266.11	268.18	-2.07	266.89	265.21	1.68	--	--	--	-0.61

*Rating not developed until after all calibration events occurred / Flow not published till late 2022.
Red is from preliminary or annual peak data.
Priority was also given to the 2020 flood extent map created by USGS. (Outline in purple)

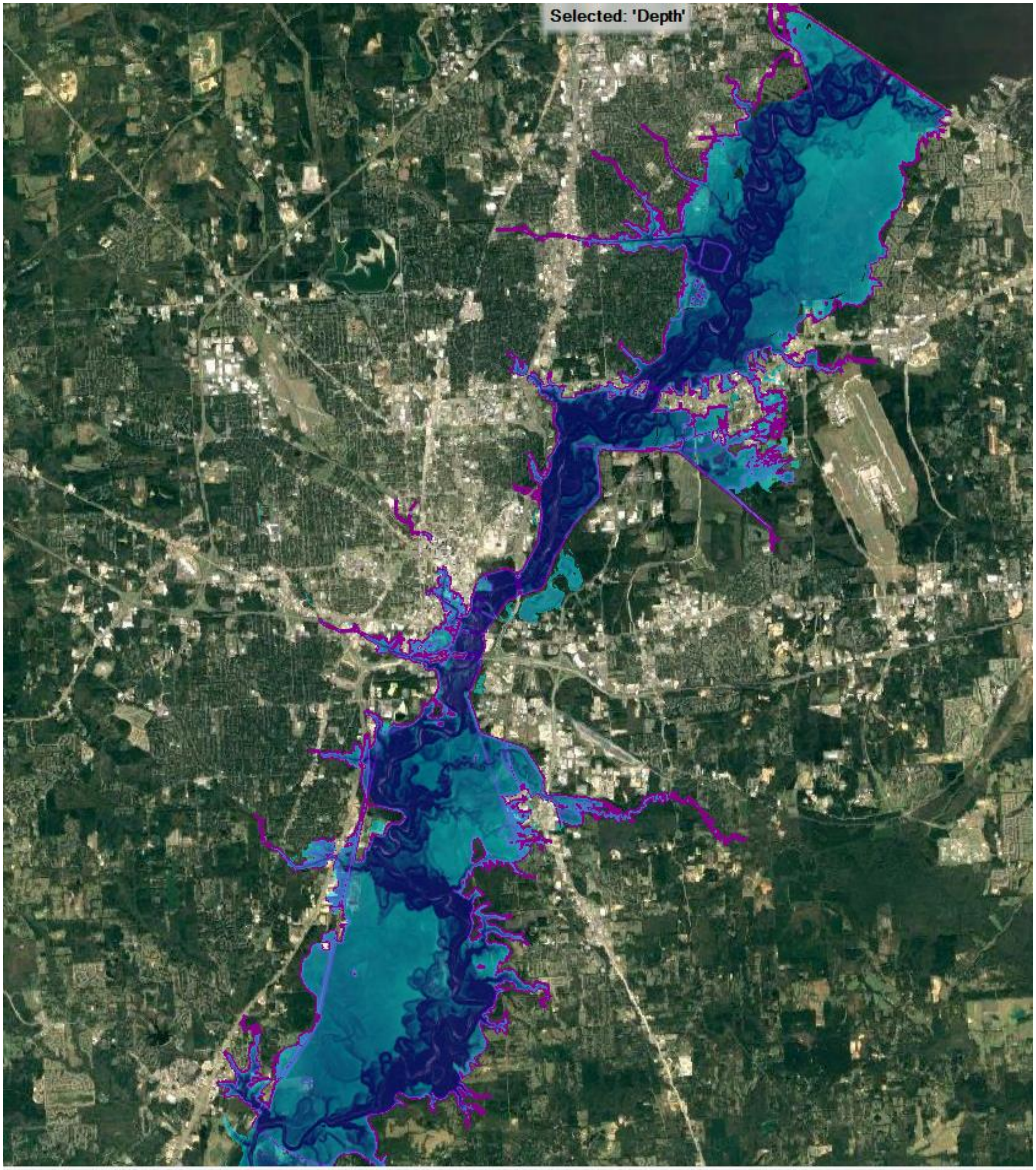


Figure 1: USGS Max inundation for Feb 2020 event vs RAS simulation

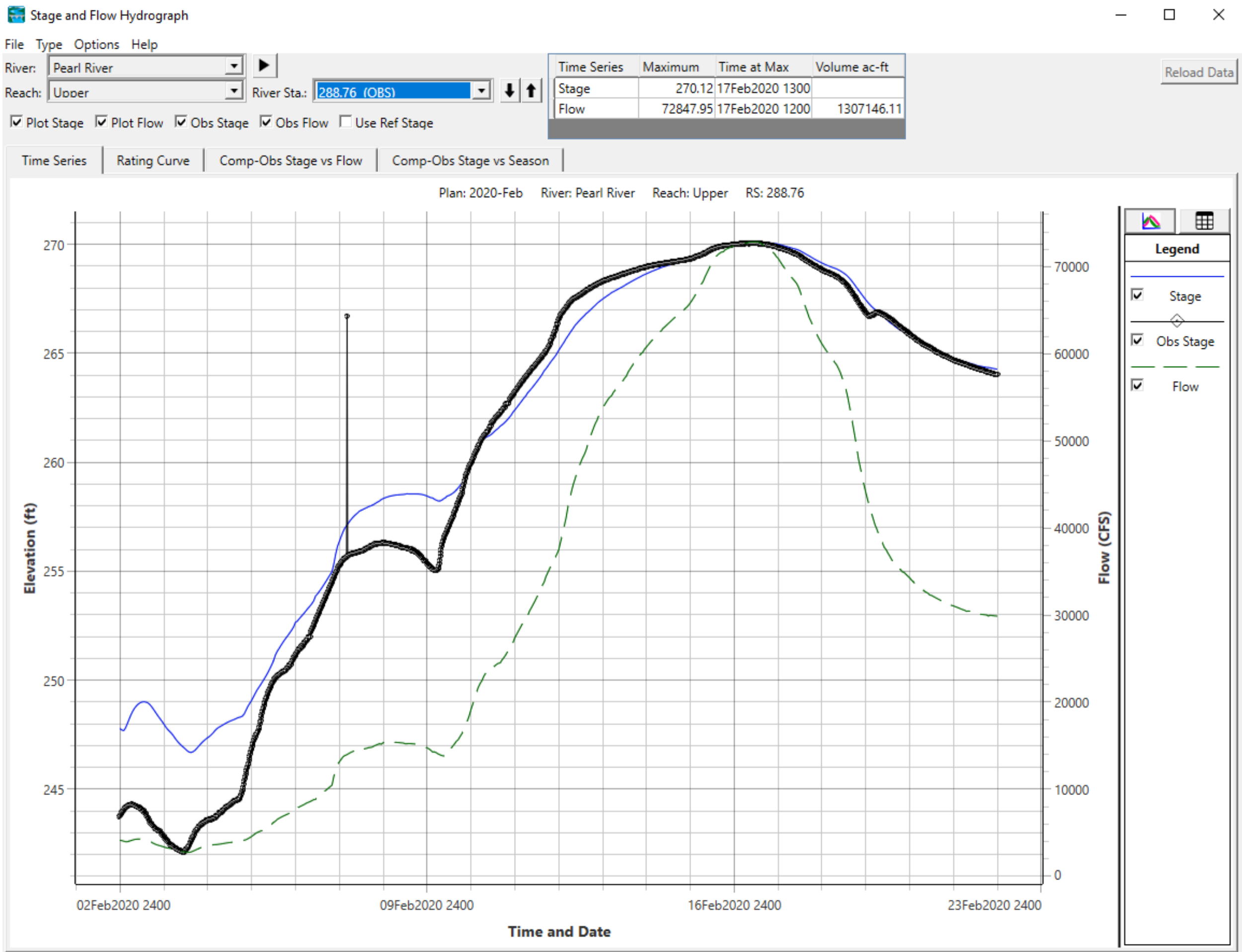


Figure 2: OBS vs Calculated Stage for Pearl River at Jackson Gage, Feb 2020, HEC-RAS model

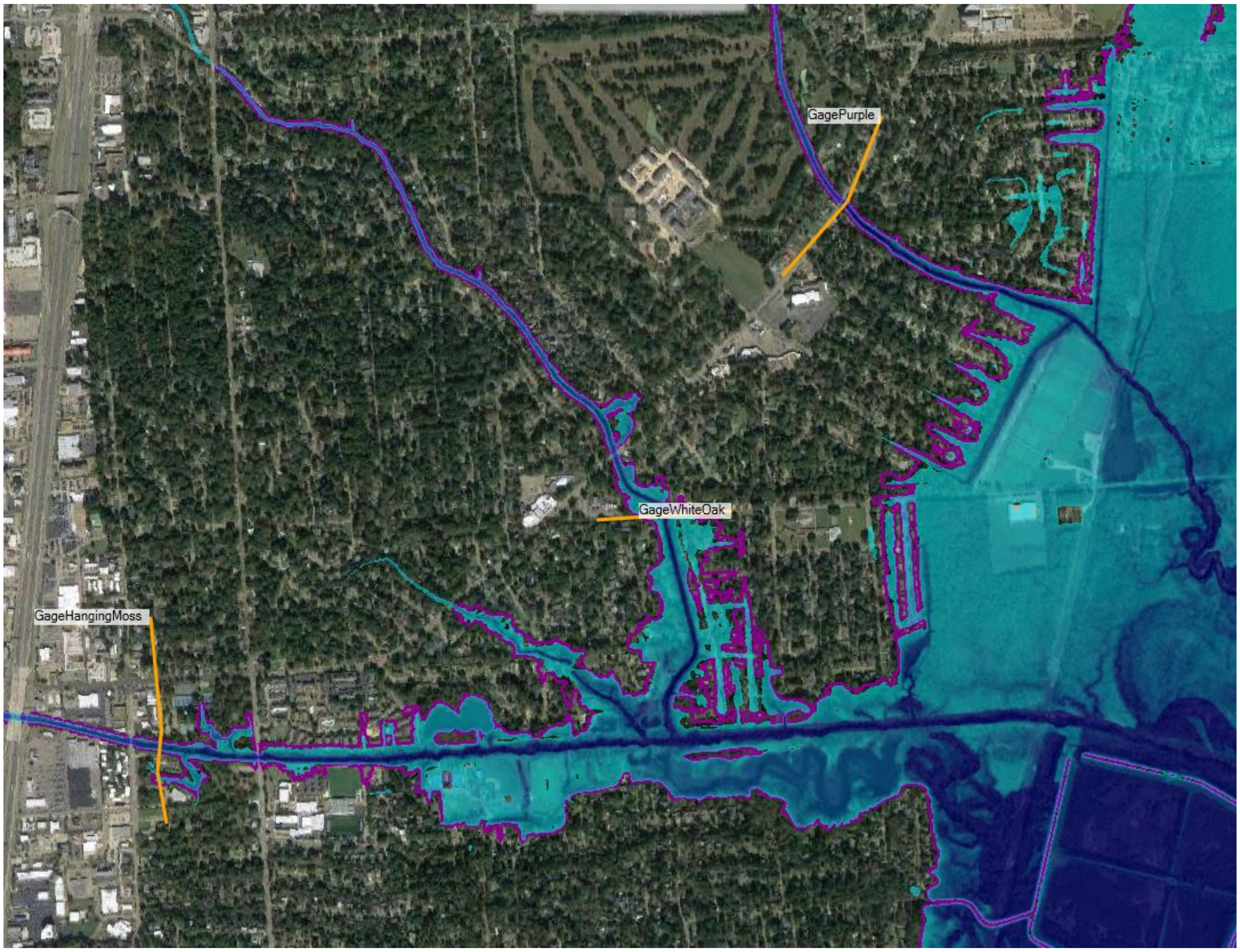


Figure 3: Flood Extent Comparison for 2020 Flood, Calculated vs USGS Flood Extent Near the Purple, White Oak, and Hanging Moss Creek Gage Locations.

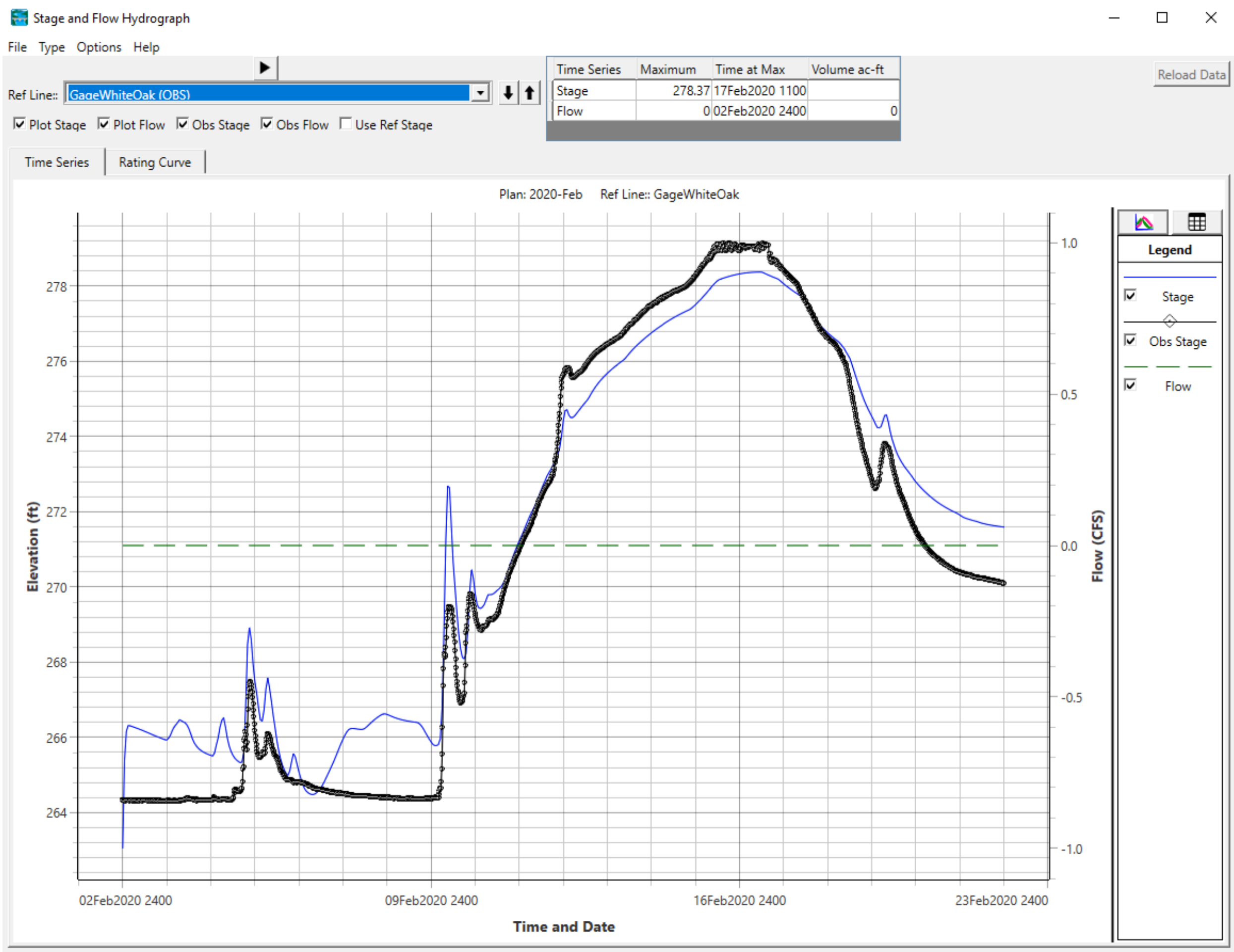


Figure 4: OBS vs Calculated Stage for White Oak Creek Gages, Feb 2020, HEC-RAS model

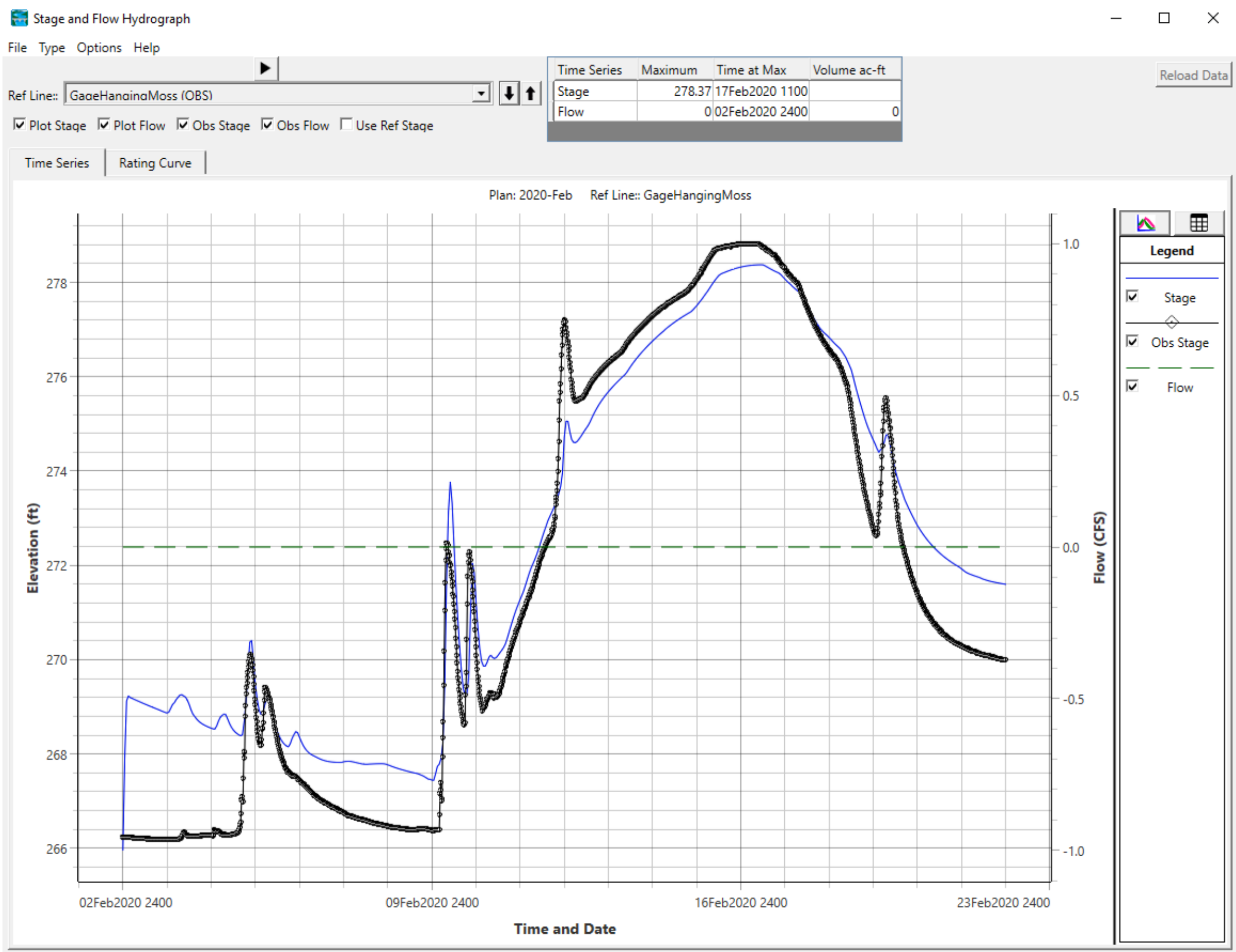


Figure 5: OBS vs Calculated Stage for Hanging Moss Creek Gage, Feb 2020, HEC-RAS model

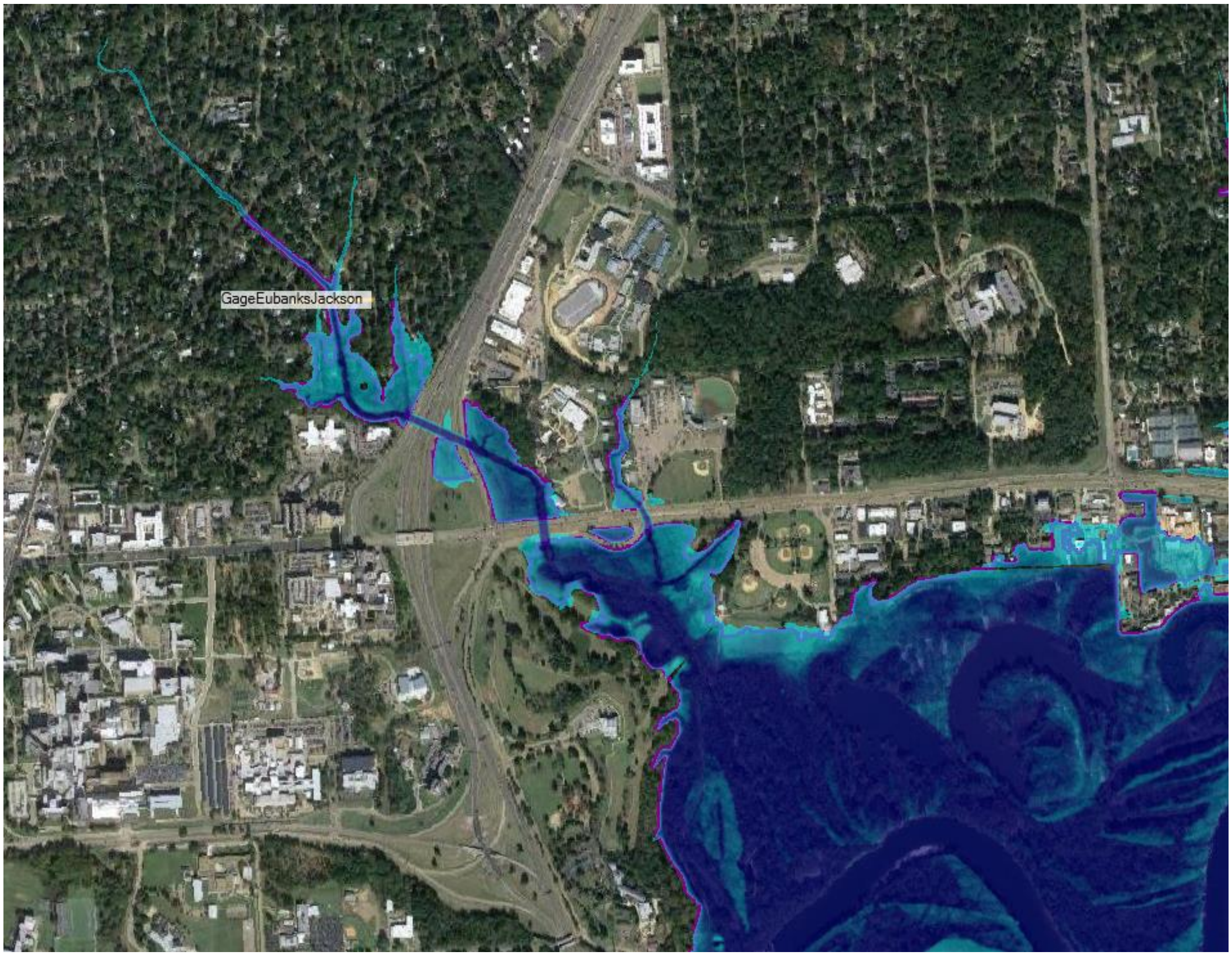


Figure 6: Flood Extent Comparison for 2020 Flood, Calculated vs USGS Flood Extent Near the Eubanks Creek at Jackson Gage Locations.

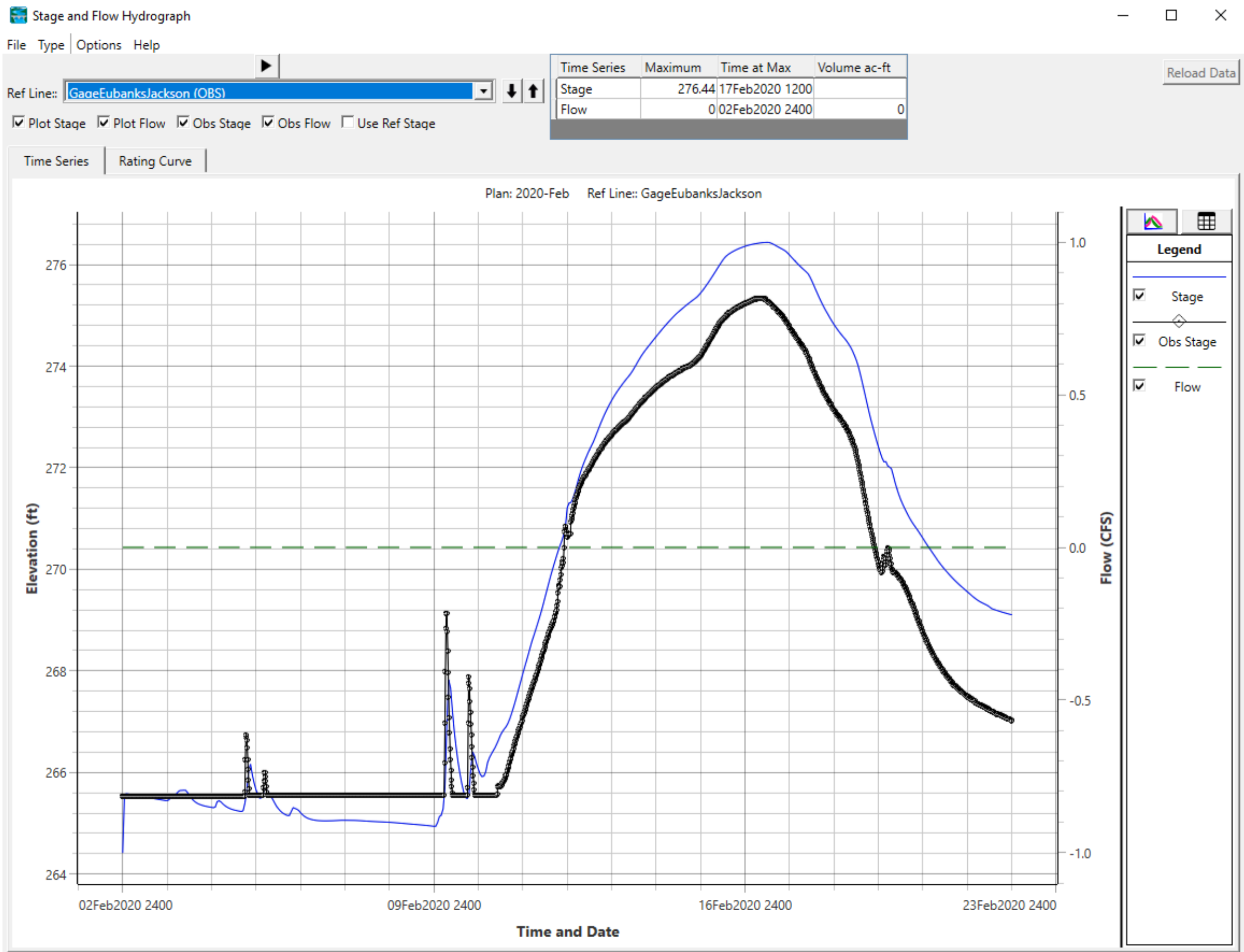


Figure 7: OBS vs Calculated Stage for Eubanks Creek at Jackson Gage, Feb 2020, HEC-RAS model

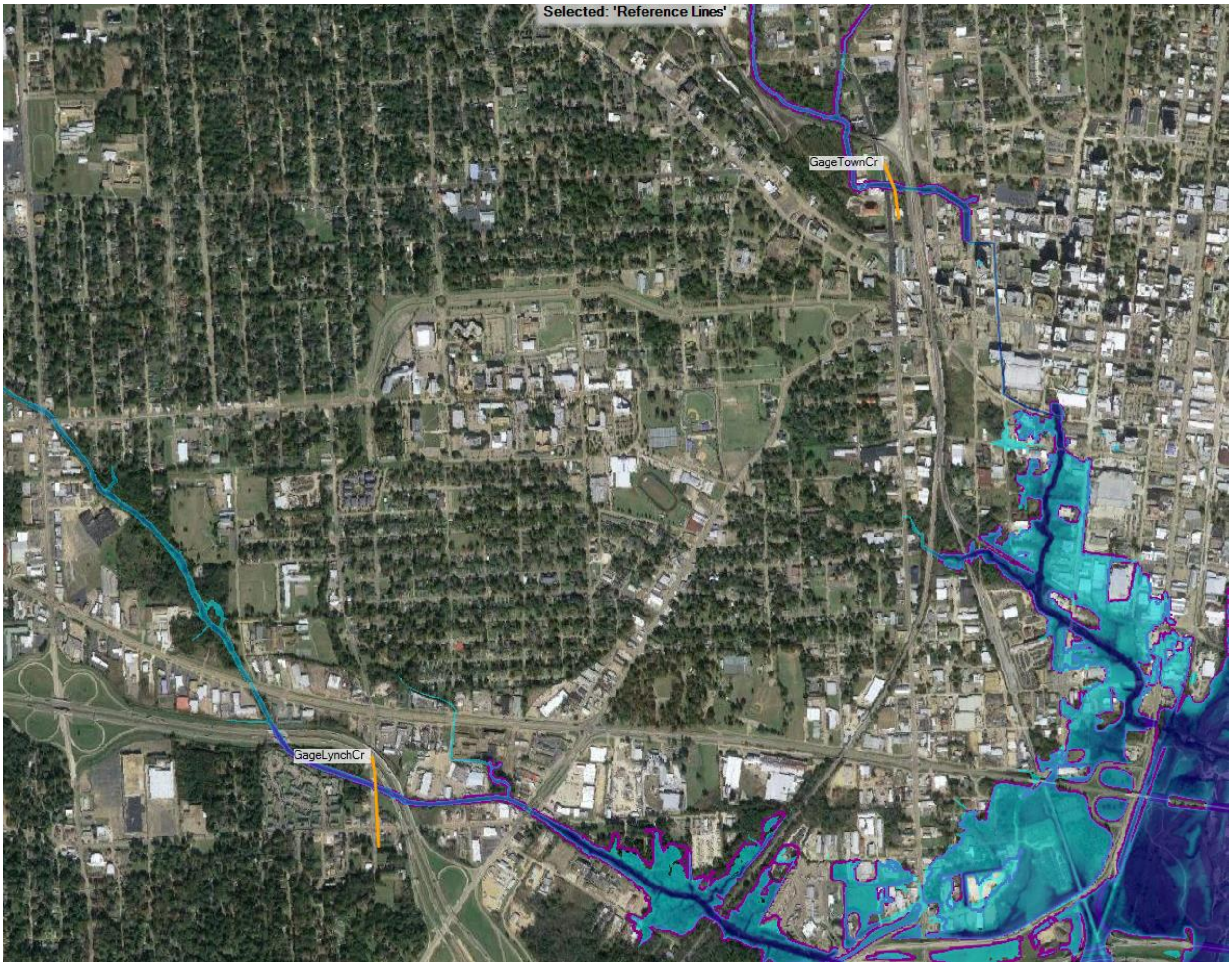


Figure 8: Flood Extent Comparison for 2020 Flood, Calculated vs USGS Flood Extent Near the Town and Lynch Creek Gage

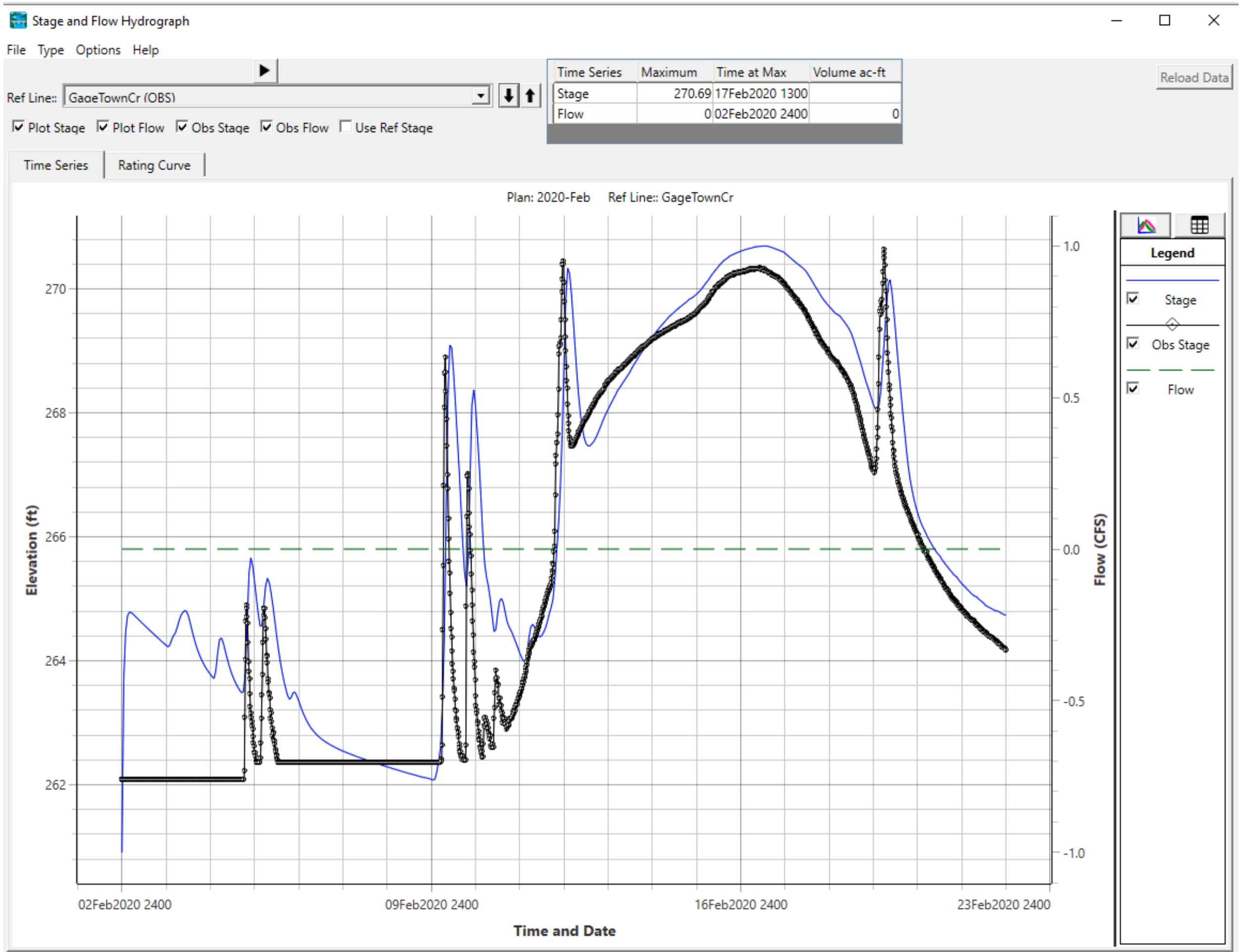


Figure 9: OBS vs Calculated Stage for Town Creek Gage, Feb 2020, HEC-RAS model

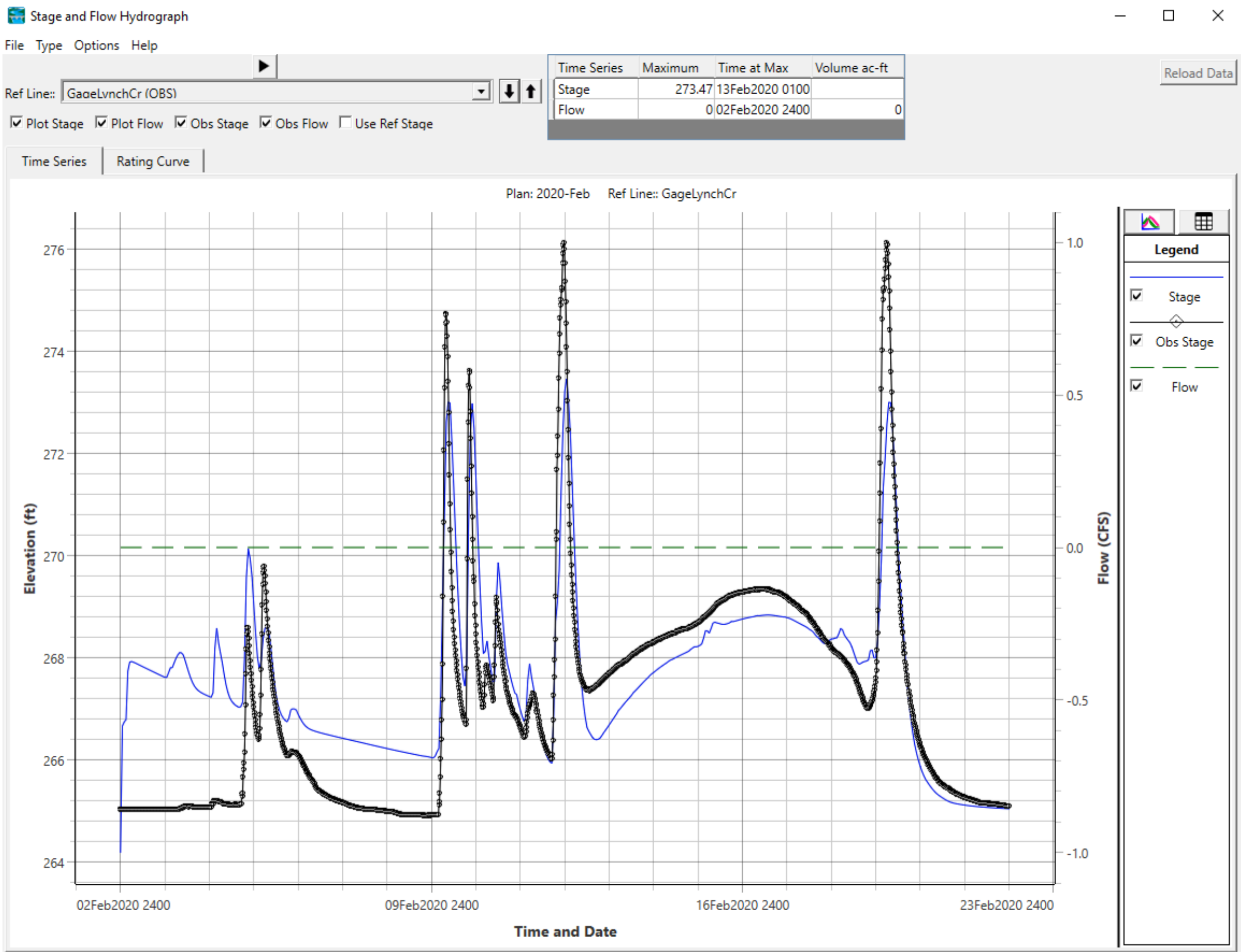


Figure 10: OBS vs Calculated Stage for Lynch Creek Gage Feb 2020, HEC-RAS model

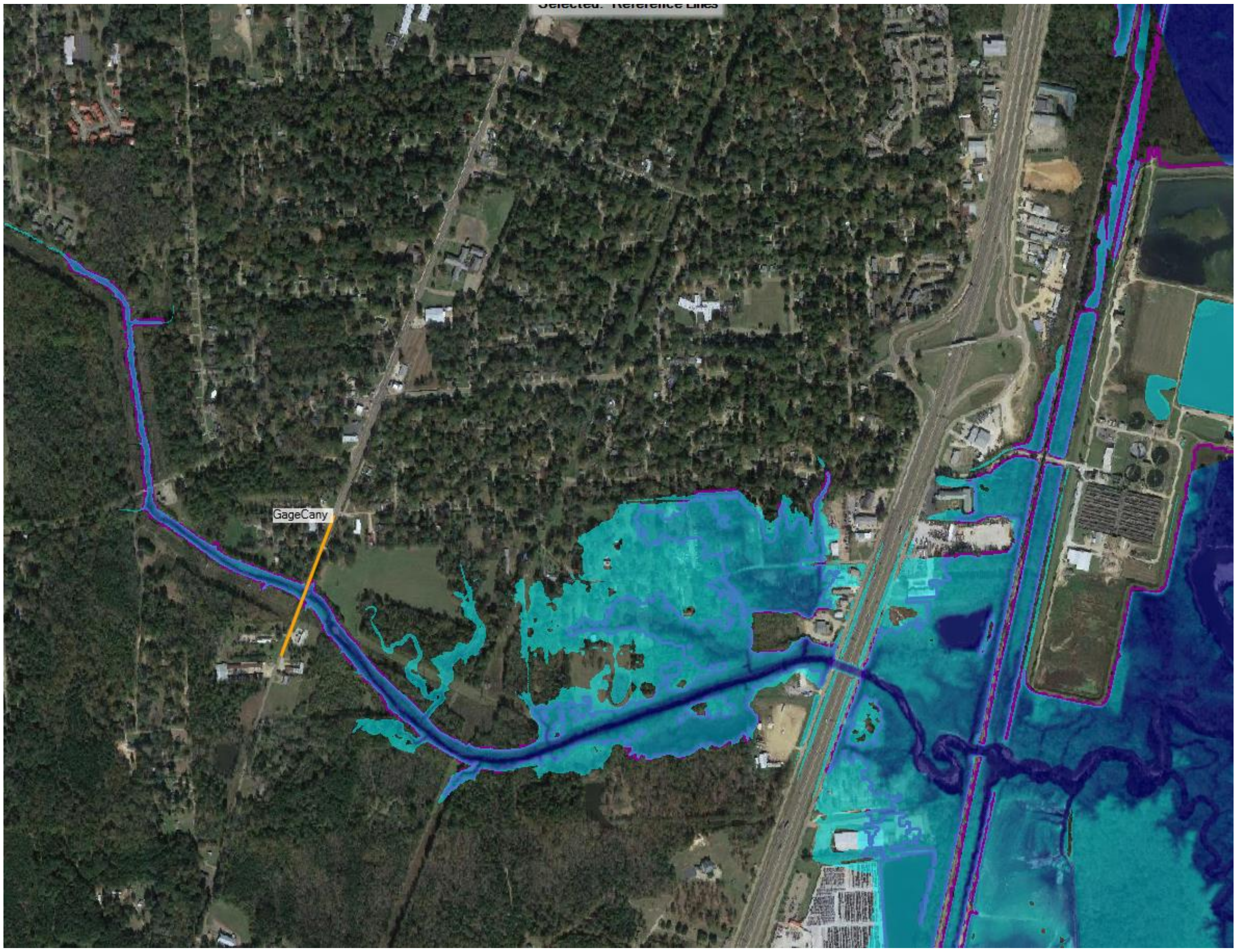


Figure 11: Flood Extent Comparison for 2020 Flood, Calculated vs USGS Flood Extent Near the Cany Creek Gage Locations.

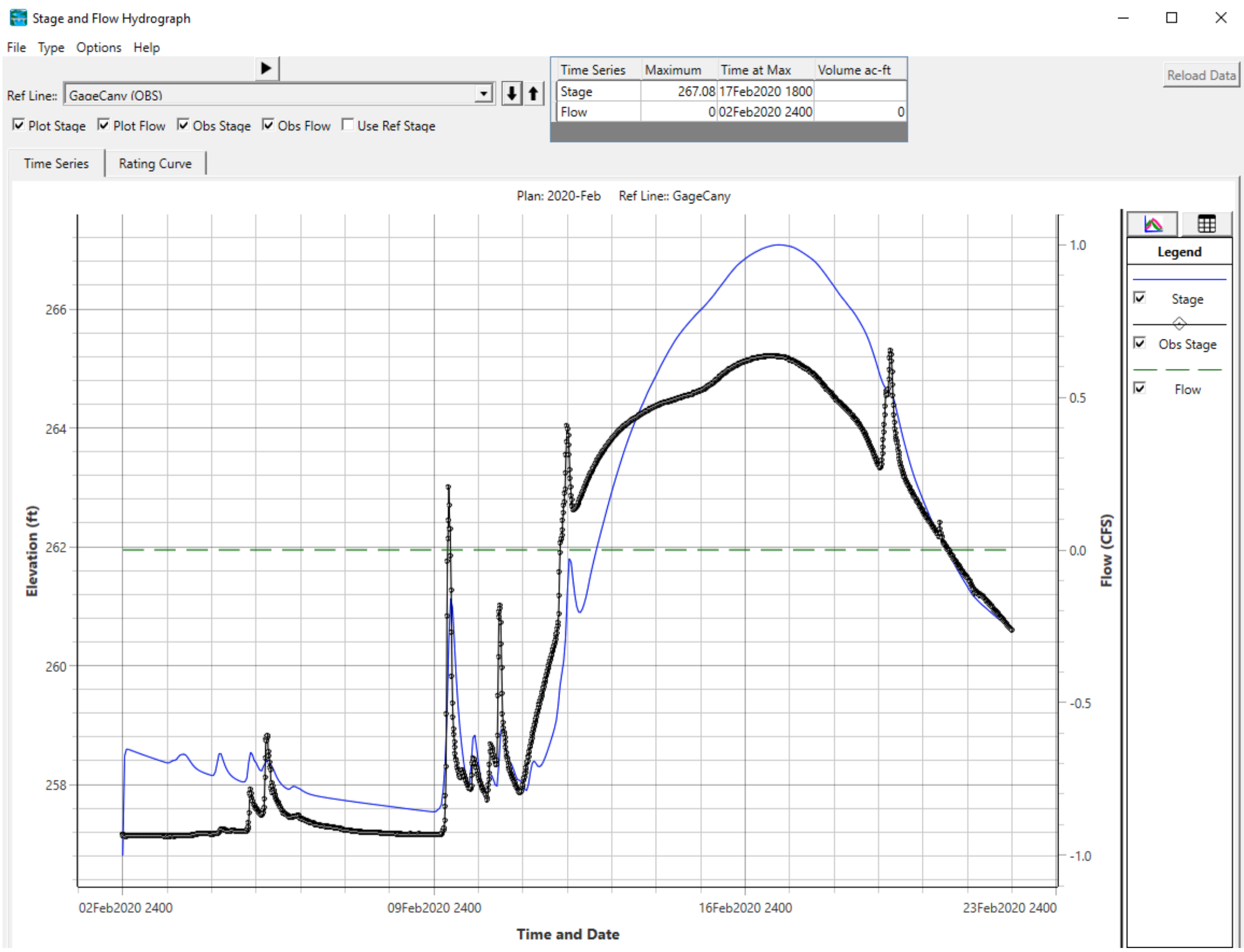


Figure 12: OBS vs Calculated Stage for Cany Creek Gage, Feb 2020, HEC-RAS model

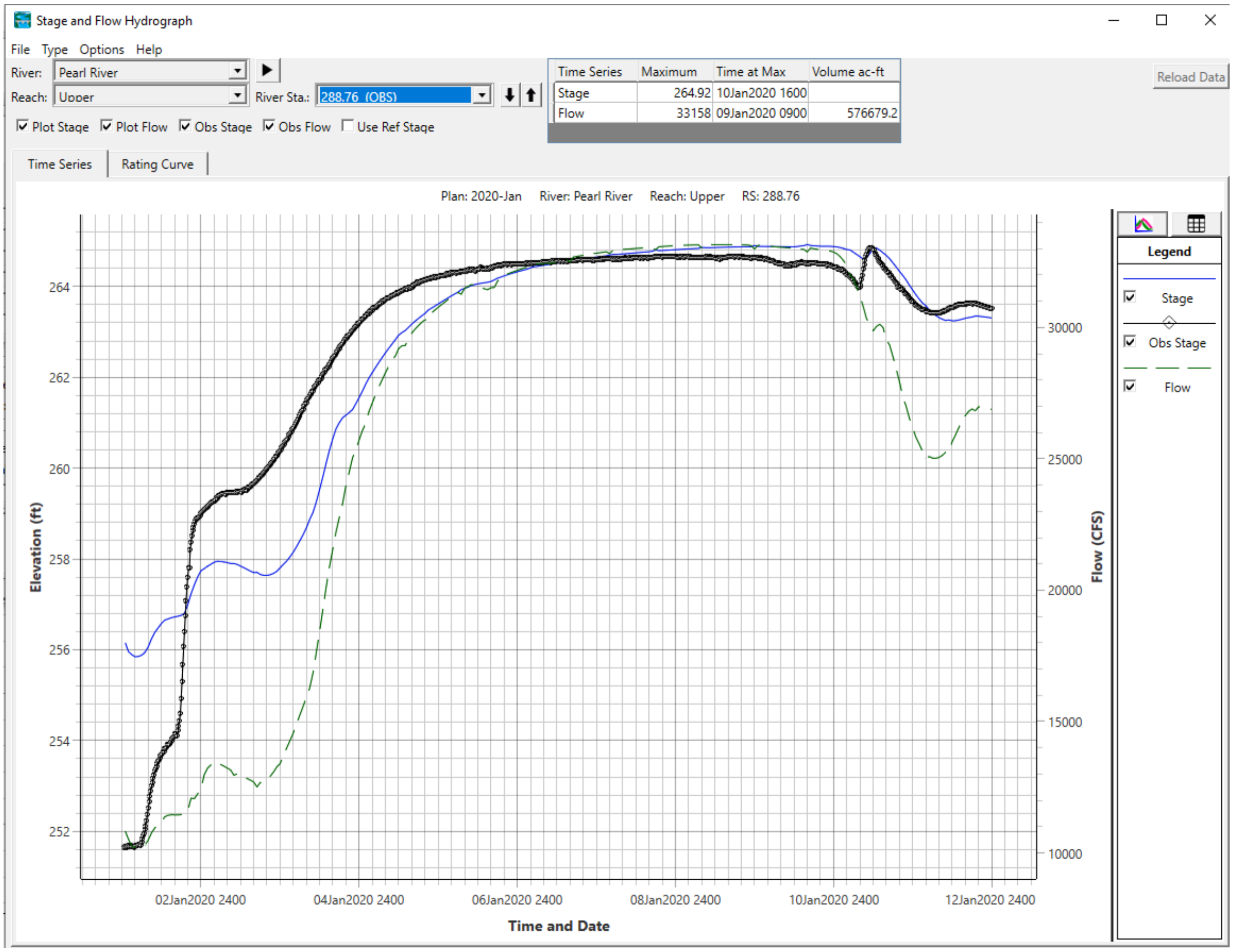


Figure 13: OBS vs Calculated Stage for Pearl River at Jackson Gage, Jan 2020, HEC-RAS model

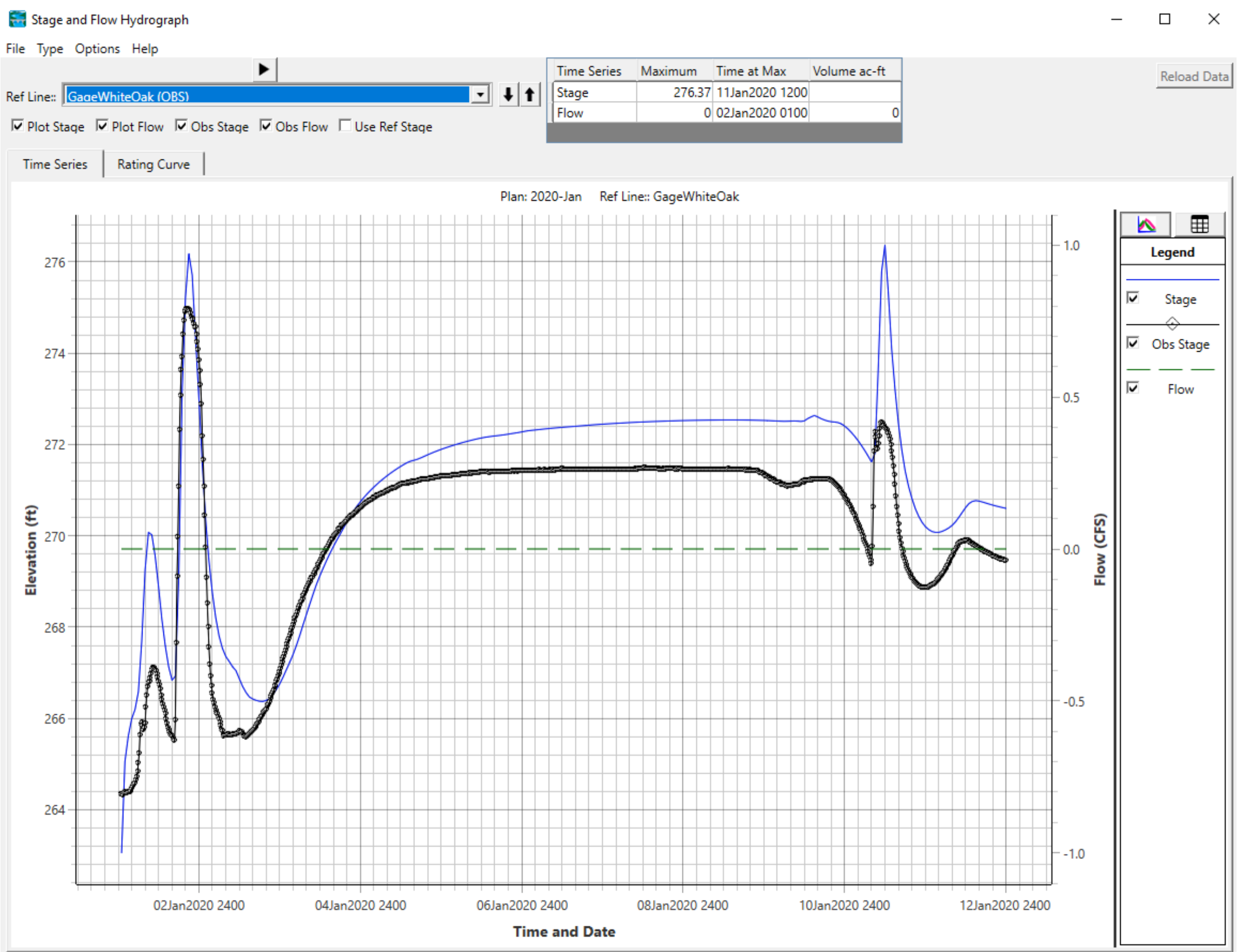


Figure 14: OBS vs Calculated Stage for White Oak Creek Gage, Jan 2020, HEC-RAS model

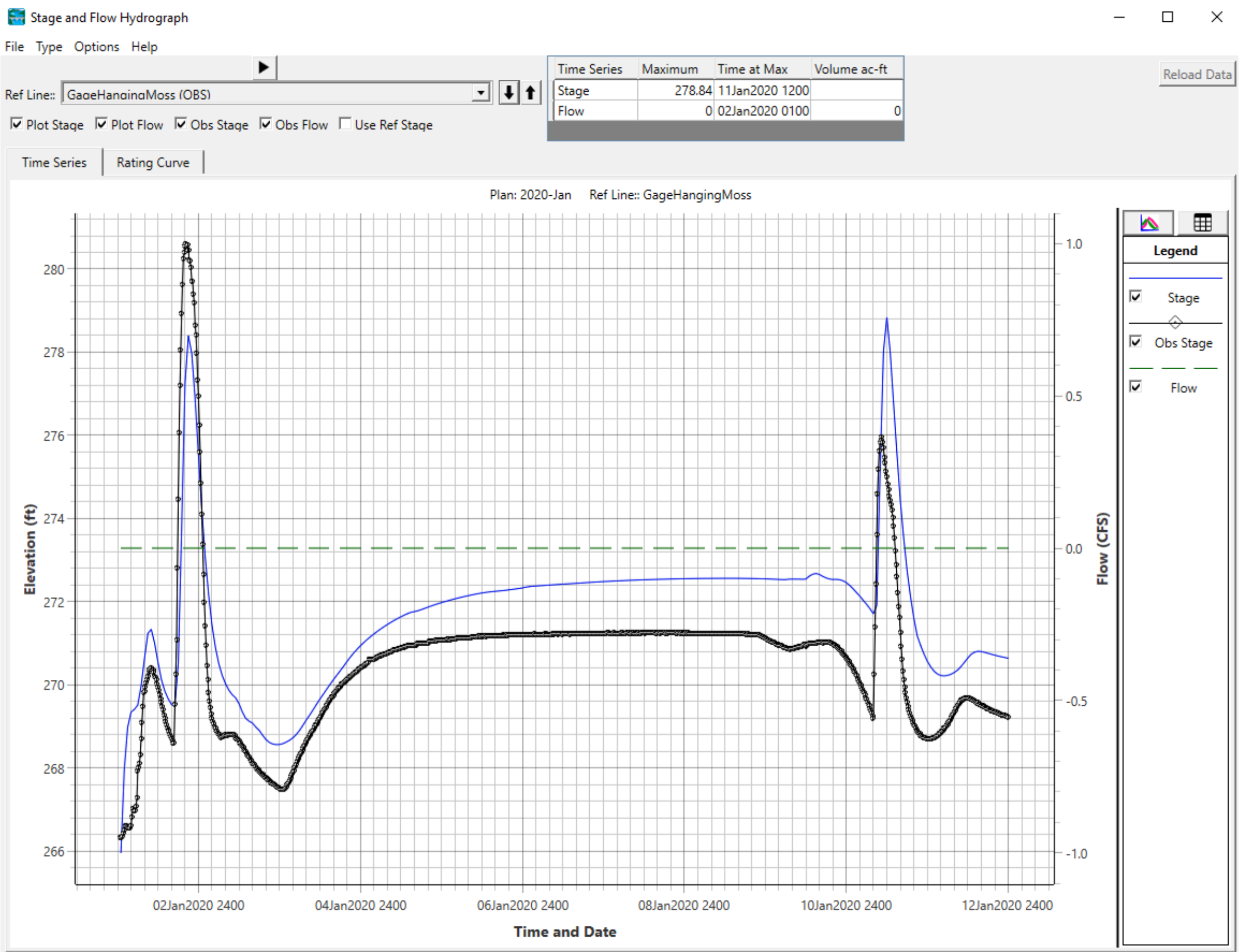


Figure 15: OBS vs Calculated Stage for Hanging Moss Gage, Jan 2020, HEC-RAS model

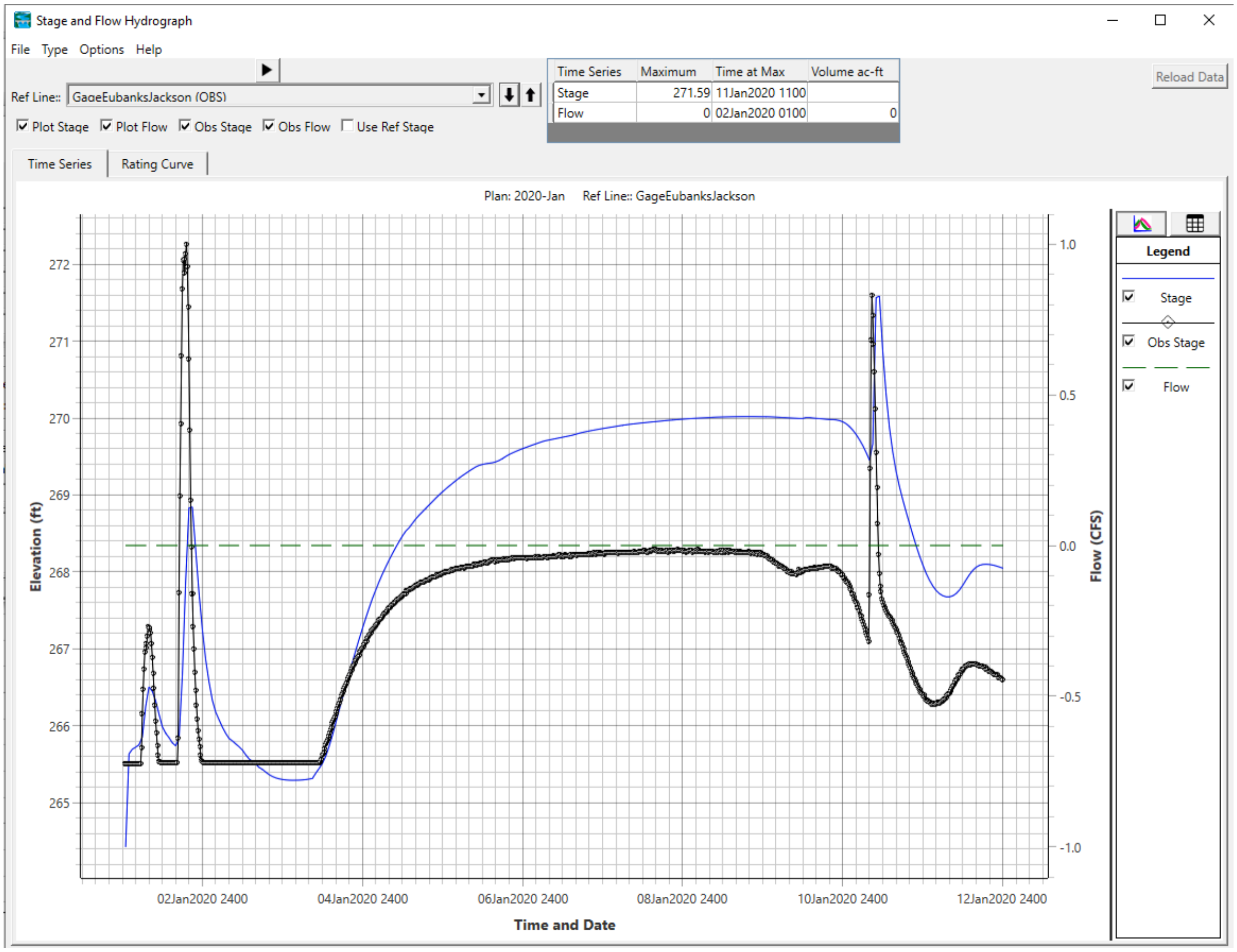


Figure 16: OBS vs Calculated Stage for Eubank Creek at Jackson Gage, Jan 2020, HEC-RAS model

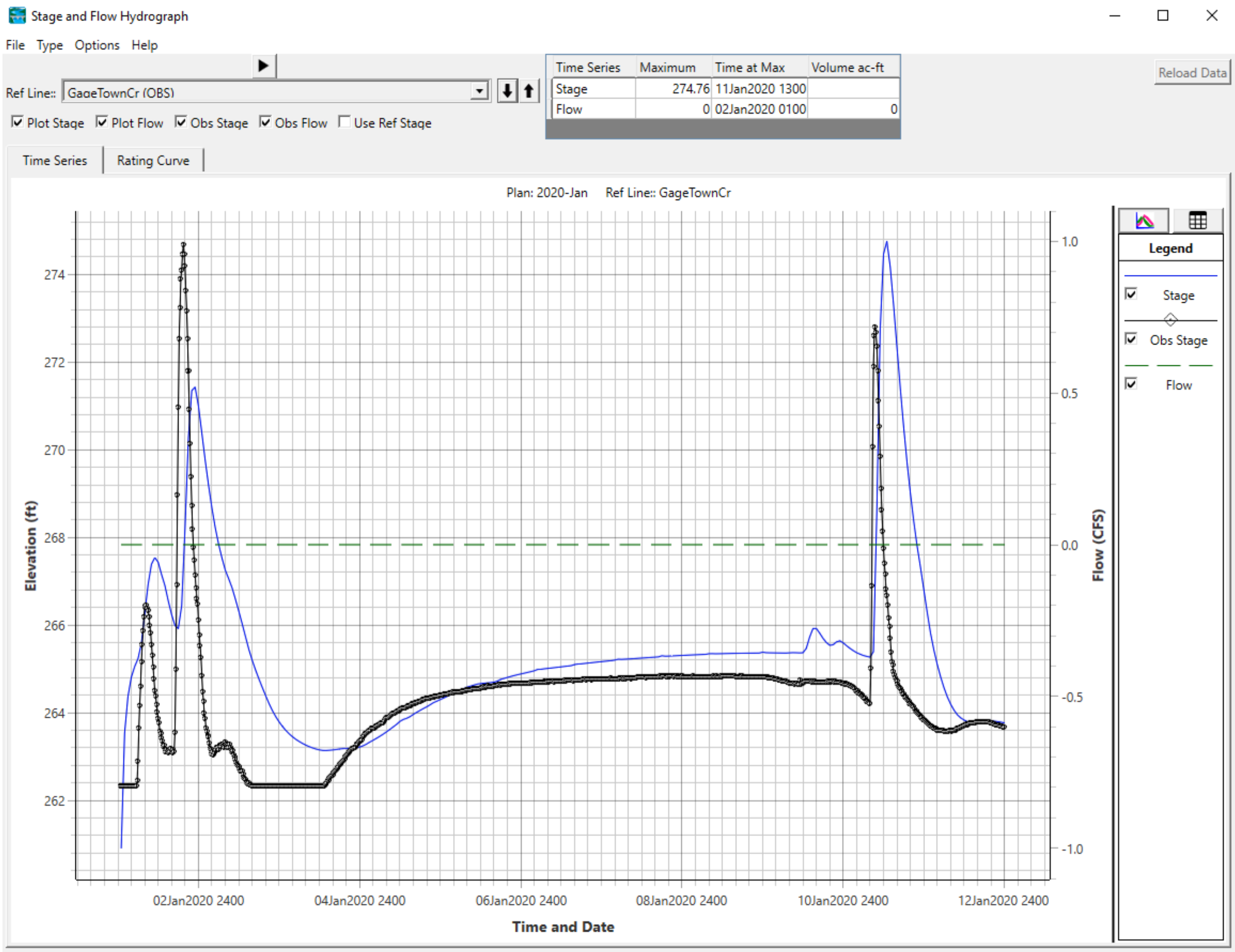


Figure 17: OBS vs Calculated Stage for Town Creek Gage, Jan 2020, HEC-RAS model

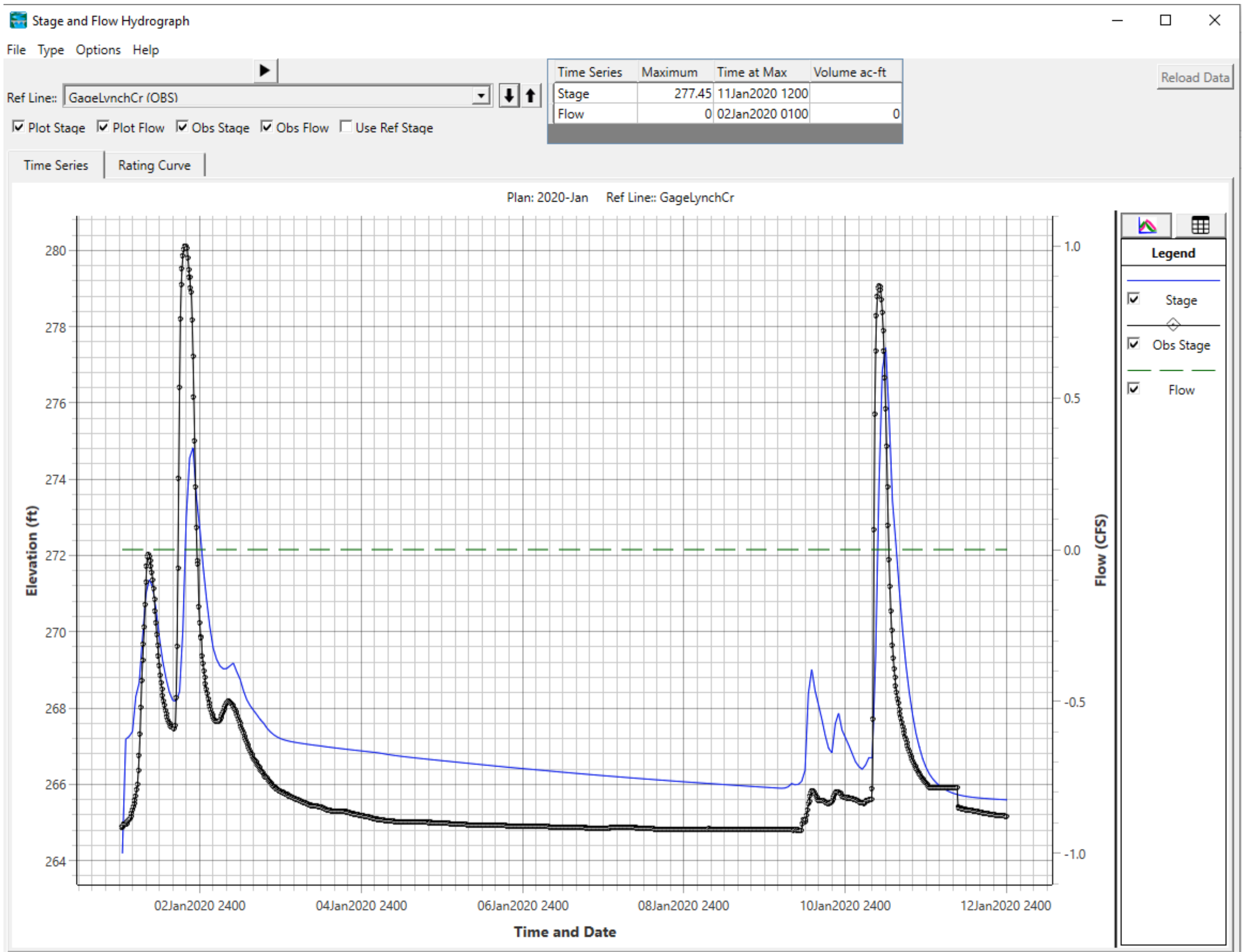


Figure 18: OBS vs Calculated Stage for Lynch Creek Gage, Jan 2020, HEC-RAS model

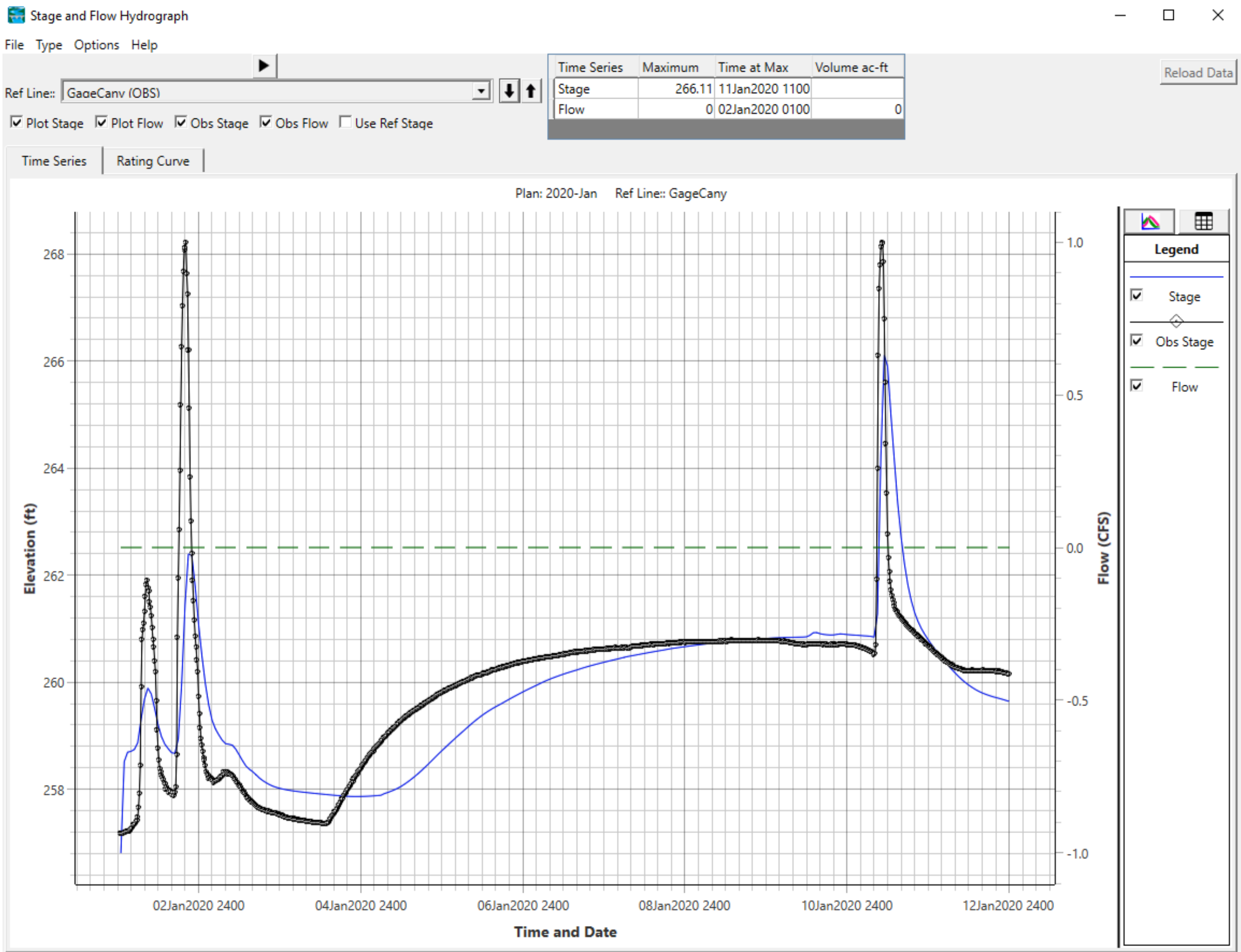


Figure 19: OBS vs Calculated Stage for Cany Creek Gage, Jan 2020, HEC-RAS model

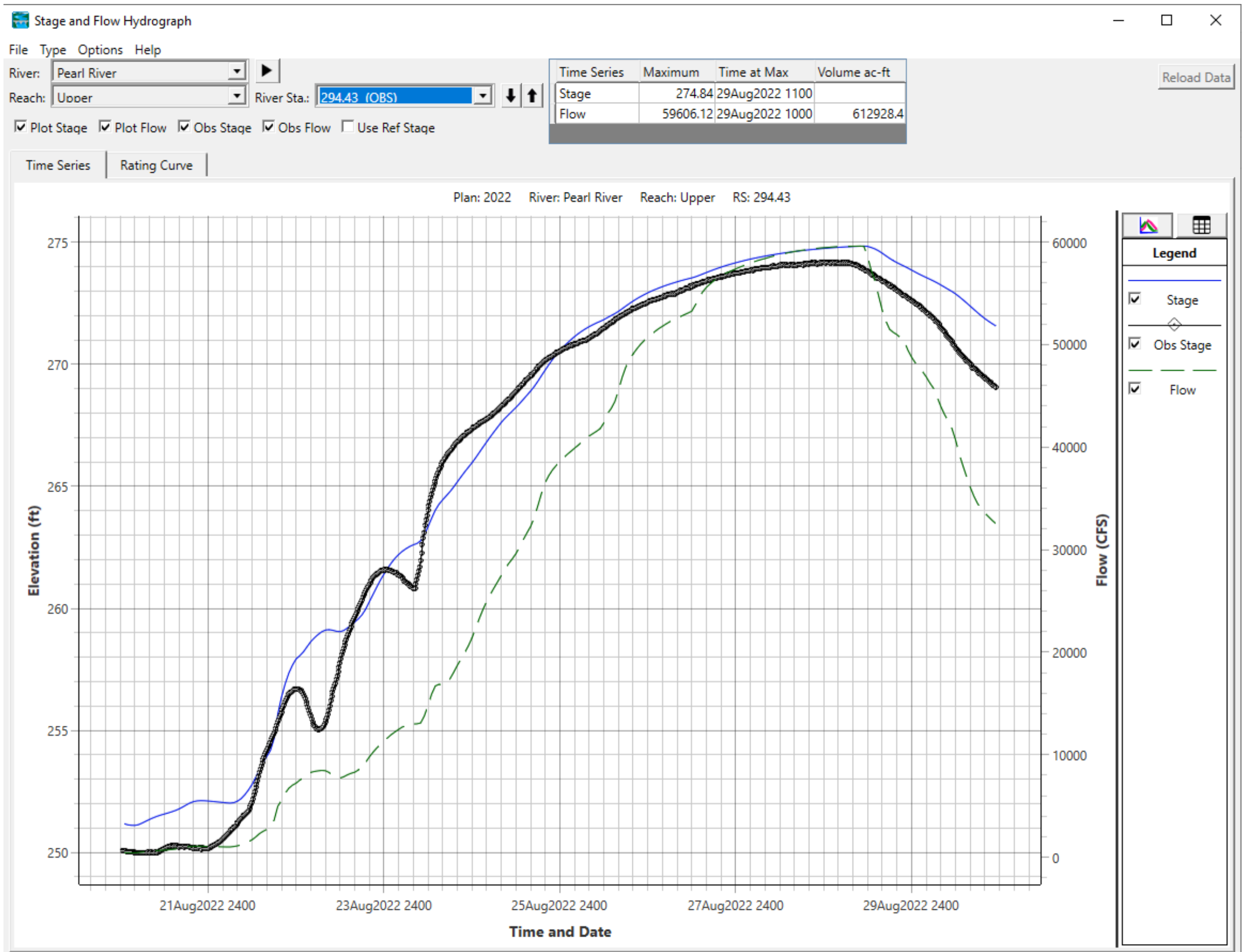


Figure 20: OBS vs Calculated Stage for Pearl River at HWY 25 Gage, Aug 2022, HEC-RAS model

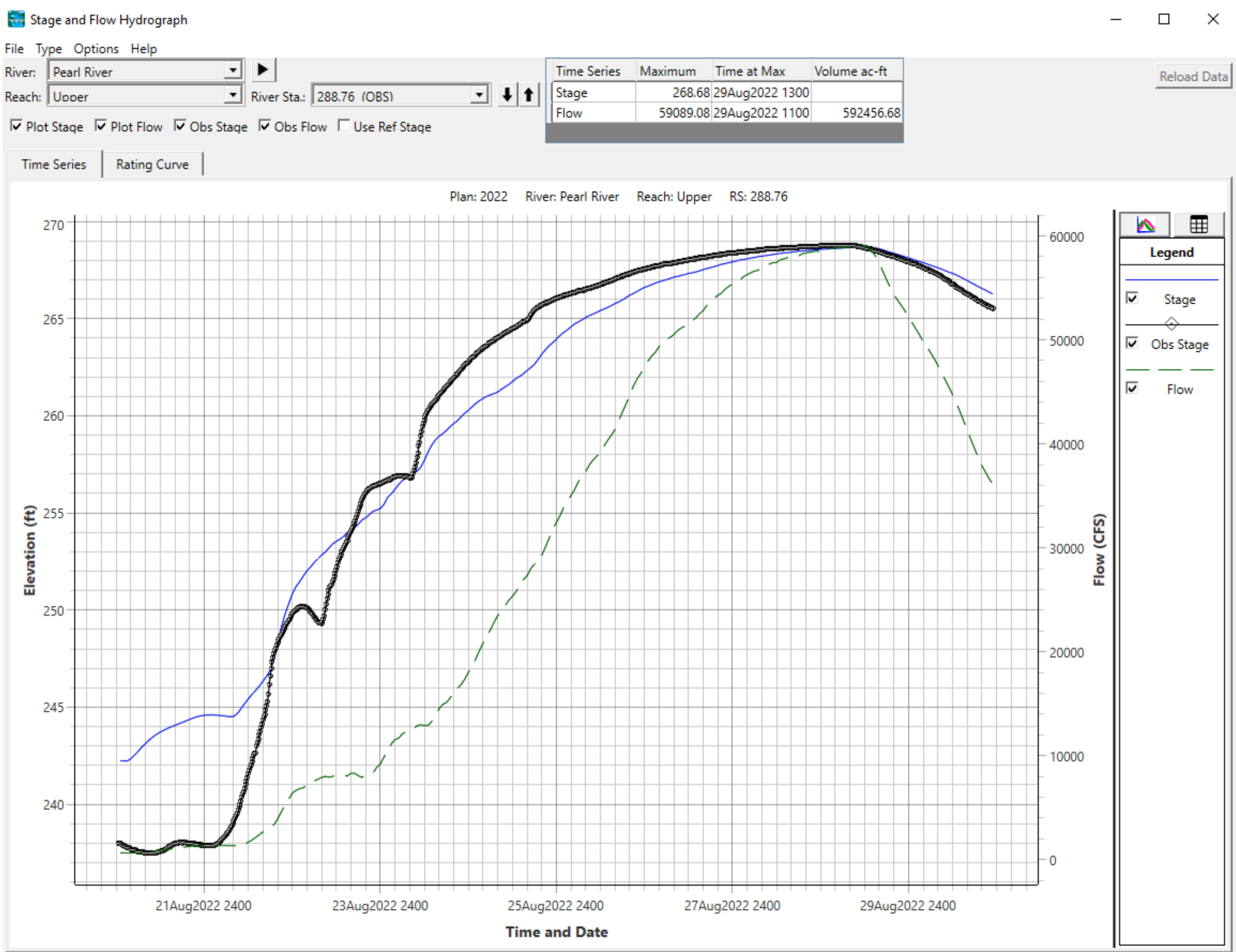


Figure 21: OBS vs Calculated Stage for Pearl River at Jackson Gage, Aug 2022, HEC-RAS model

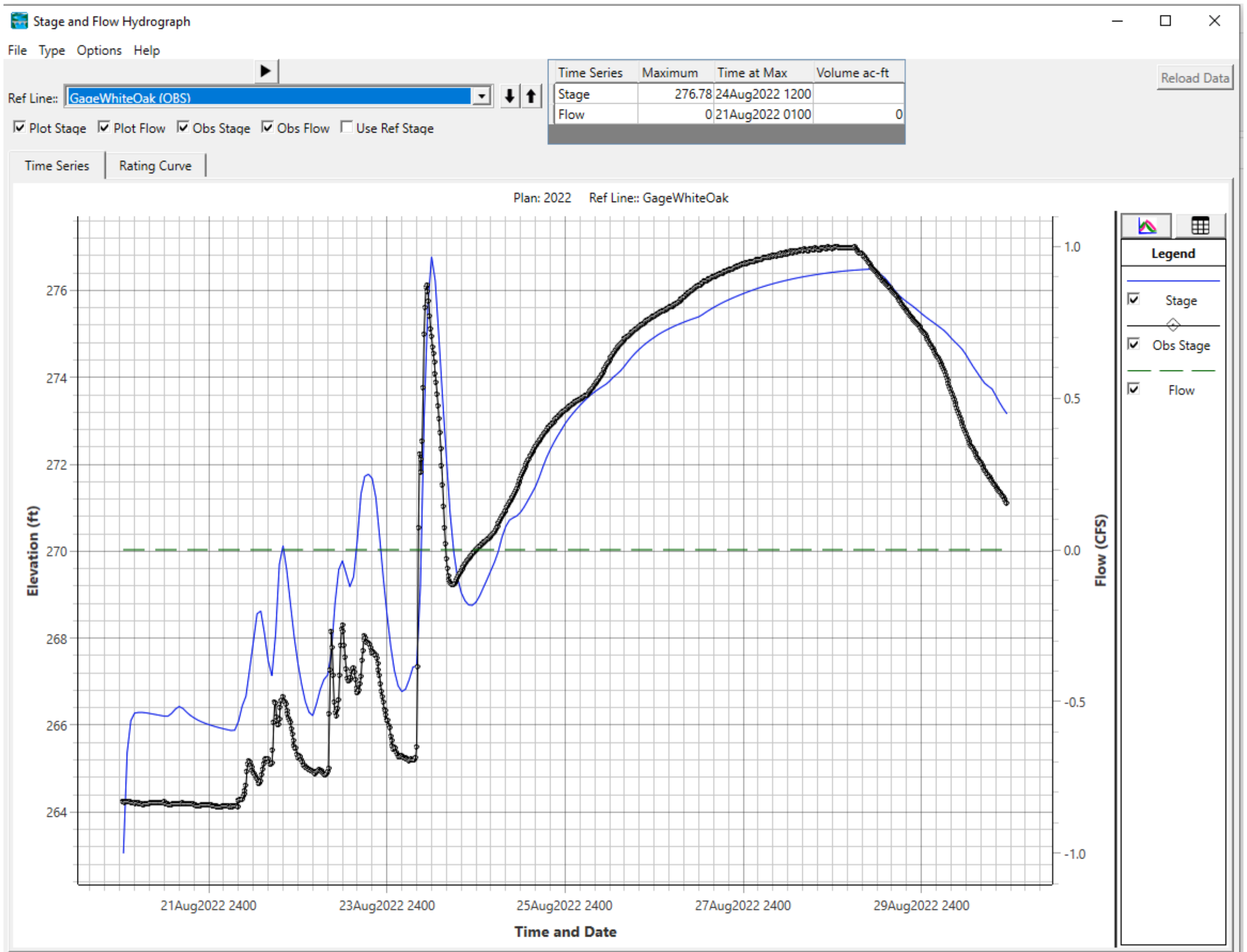


Figure 22: OBS vs Calculated Stage for White Oak Creek Gage, Aug 2022, HEC-RAS model

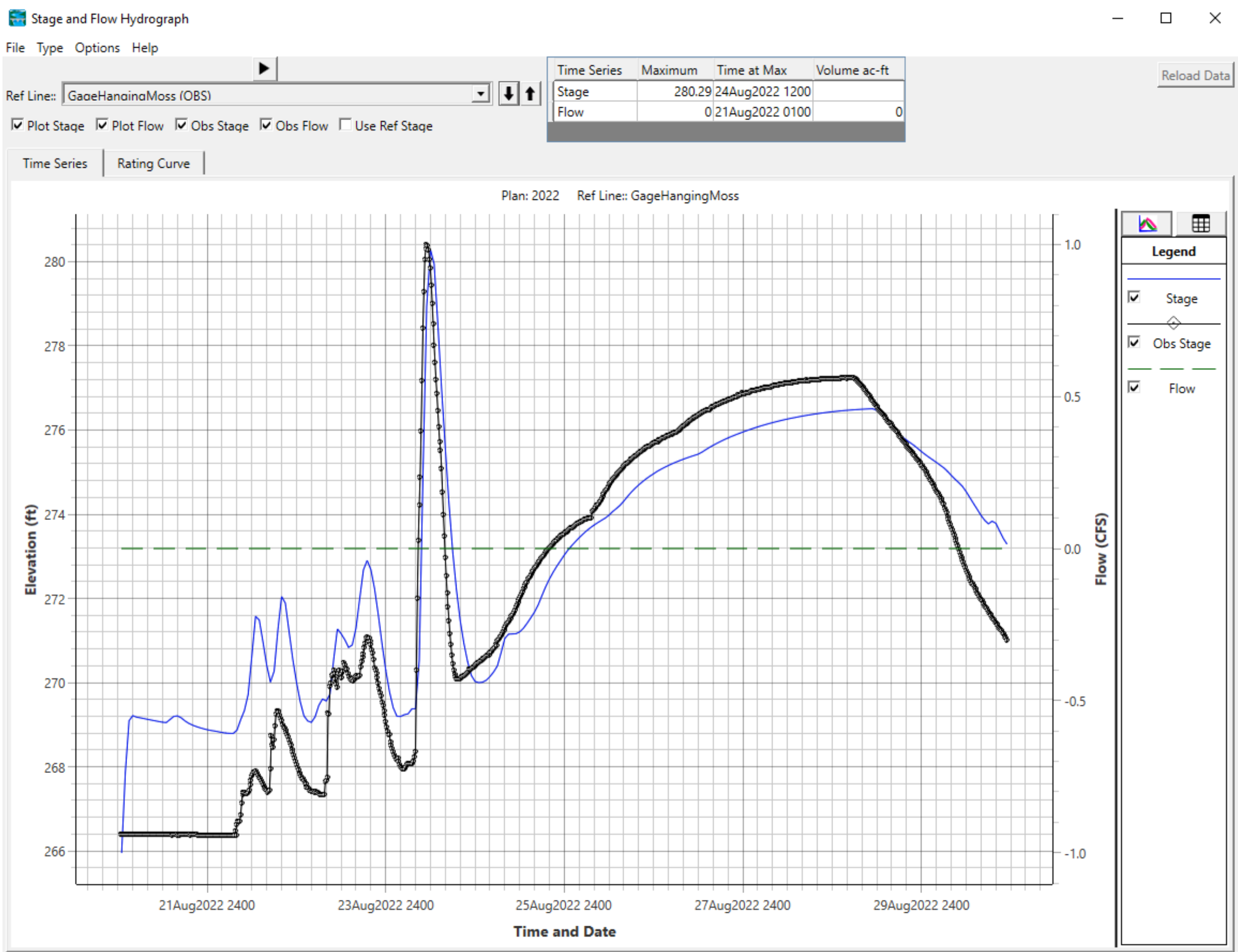


Figure 23: OBS vs Calculated Stage for Hanging Moss Gage, Aug 2022, HEC-RAS model

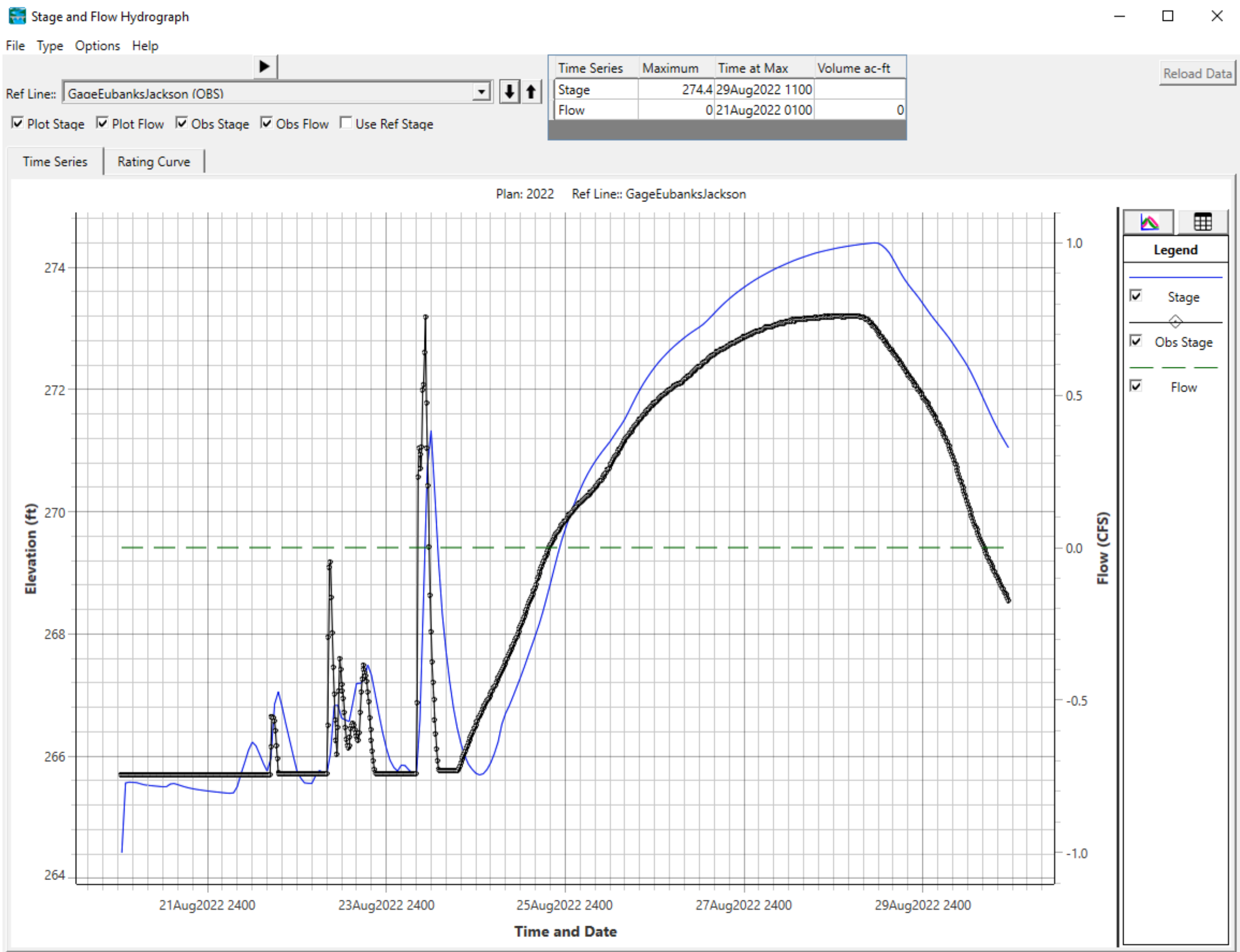


Figure 24: OBS vs Calculated Stage for Eubanks Creek at Jackson Gage, Aug 2022, HEC-RAS model

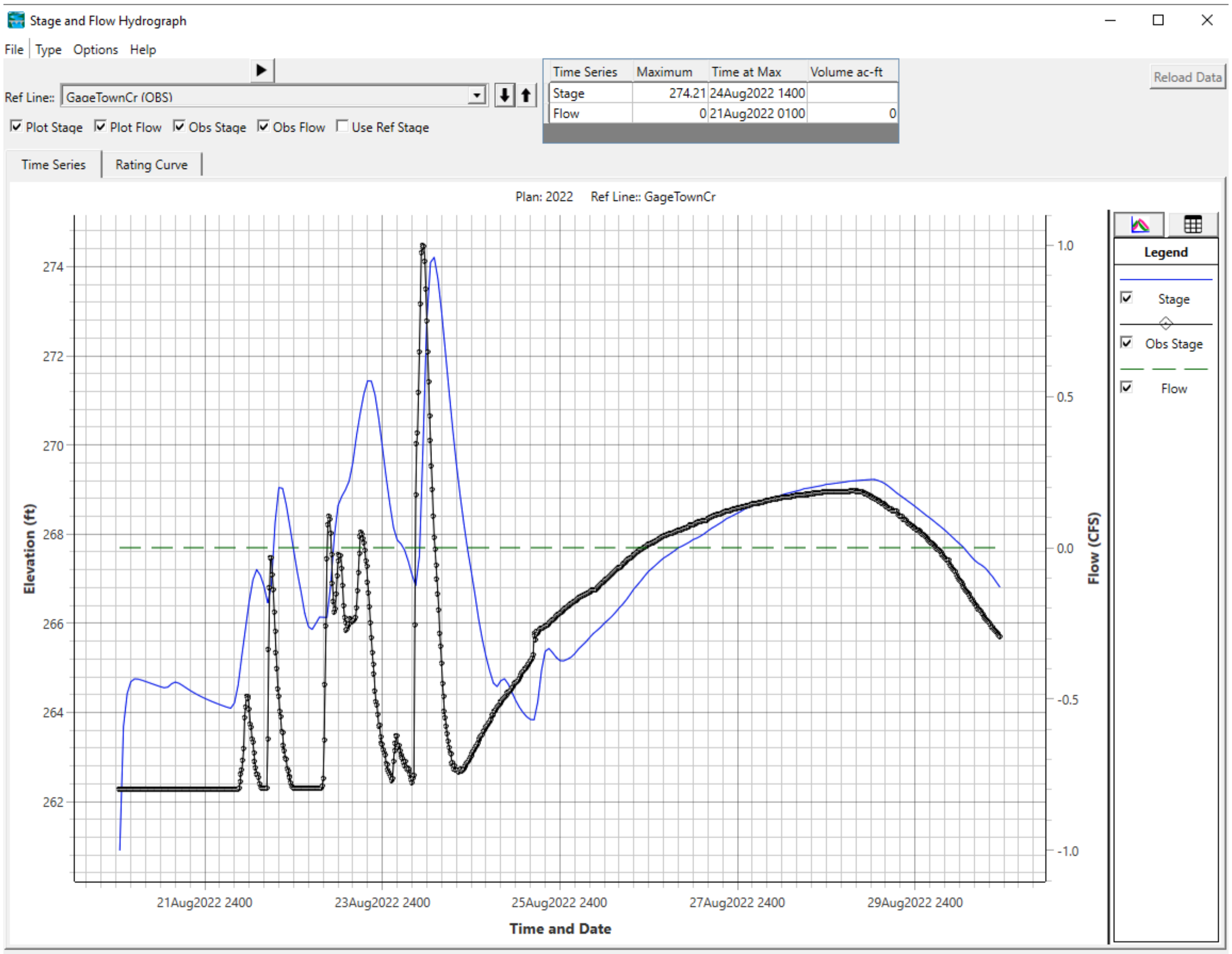


Figure 25: OBS vs Calculated Stage for Town Creek Gage, Aug 2022, HEC-RAS model

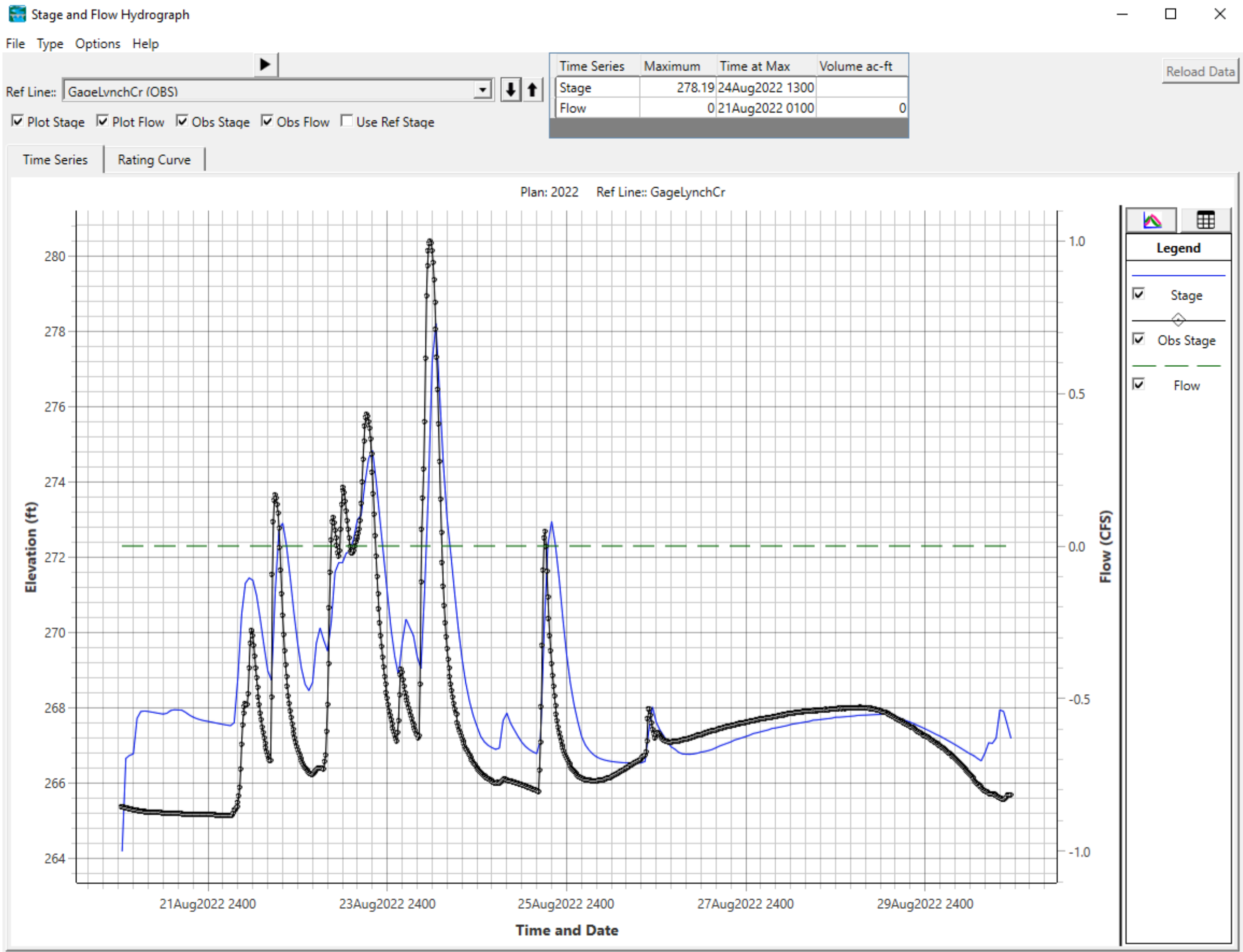
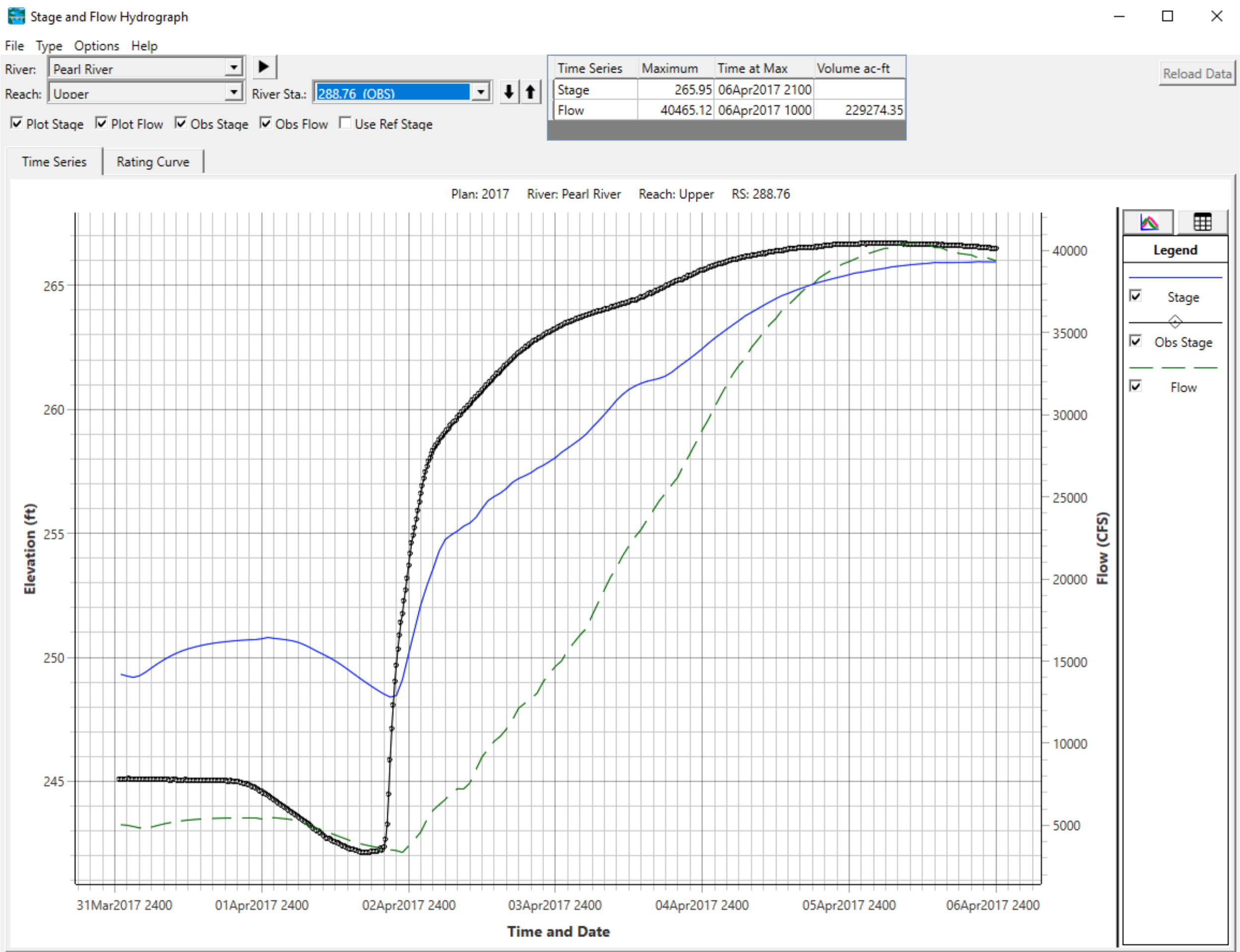


Figure 26: OBS vs Calculated Stage for Lynch Creek Gage, Aug 2022, HEC-RAS model



Time Series	Maximum	Time at Max	Volume ac-ft
Stage	265.95	06Apr2017 2100	
Flow	40465.12	06Apr2017 1000	229274.35

Figure 27: OBS vs Calculated Stage for Pearl River at Jackson Gage, Apr 2017, HEC-RAS model

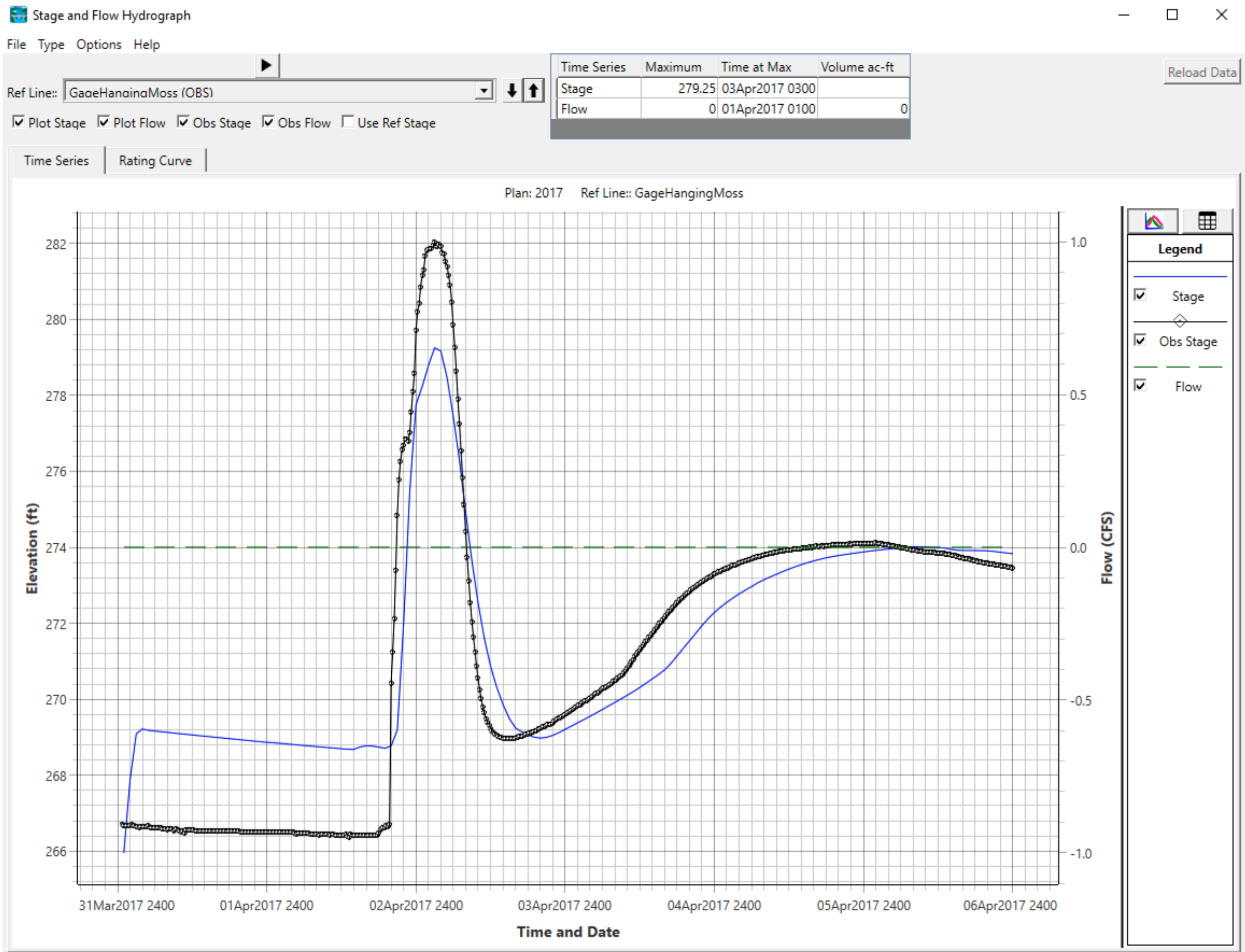


Figure 28: OBS vs Calculated Stage for Hanging Moss Creek Gage, Apr 2017, HEC-RAS model

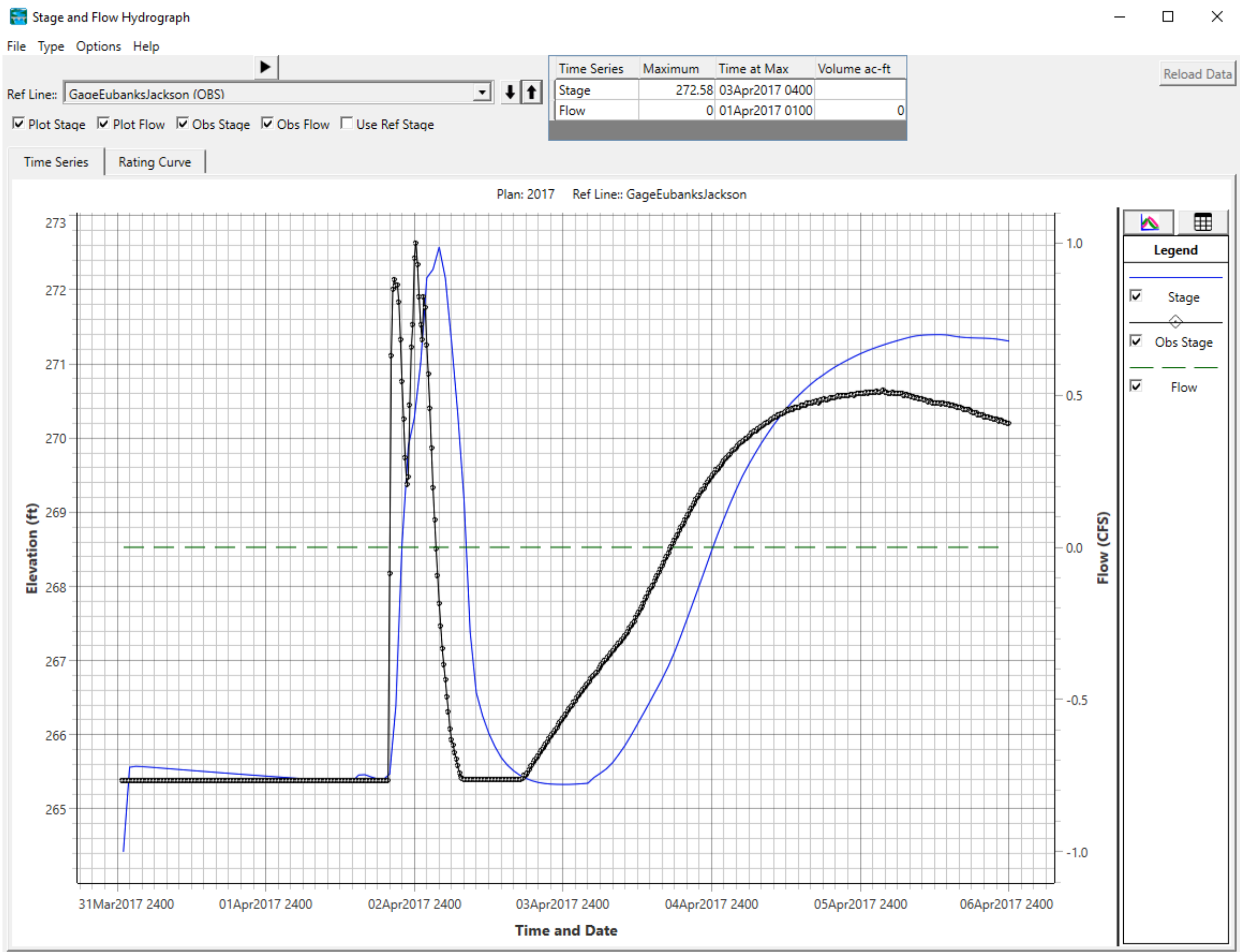


Figure 29: OBS vs Calculated Stage for Eubanks Creek Gage, Apr 2017, HEC-RAS model

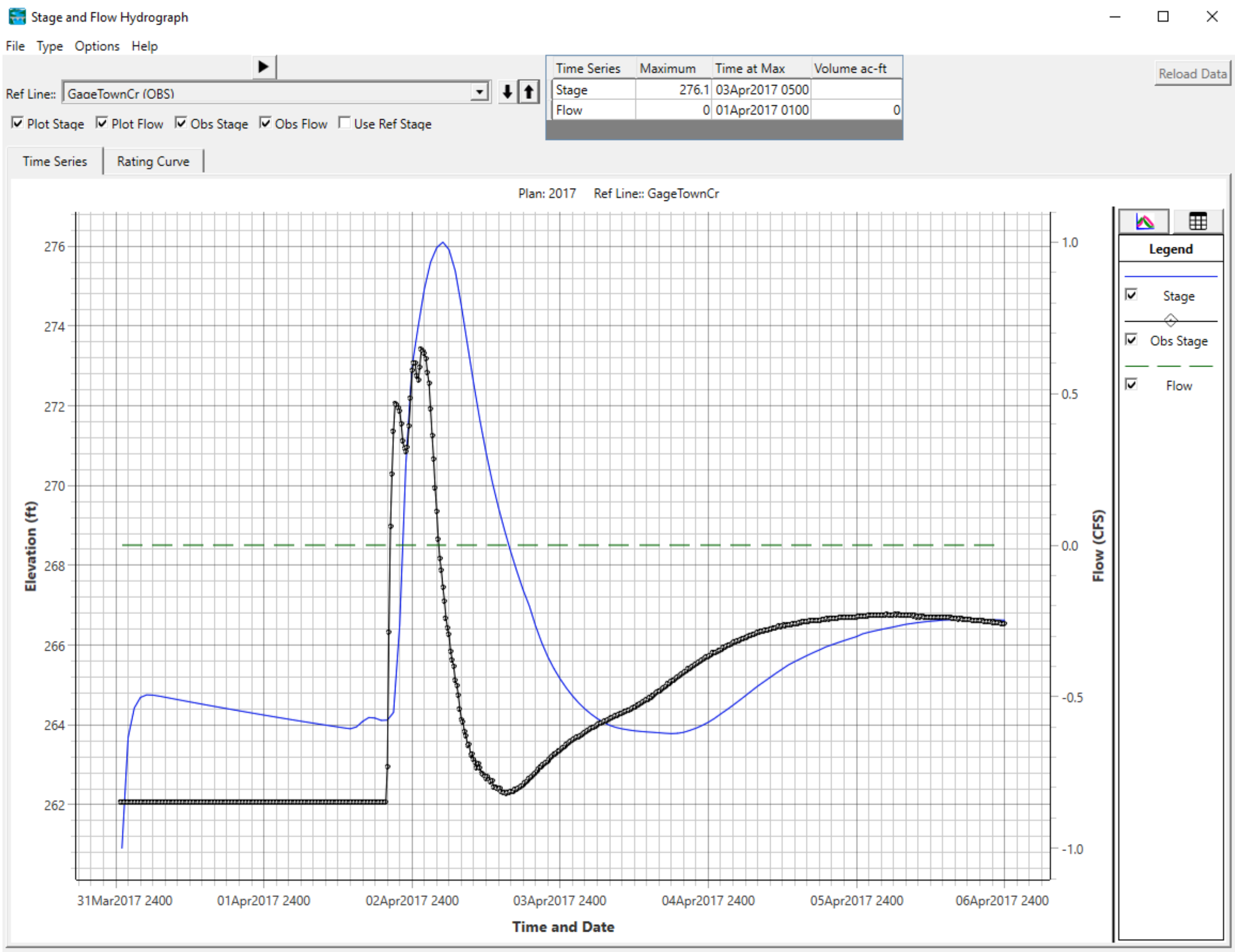


Figure 30: OBS vs Calculated Stage for Town Creek Gage, Apr 2017, HEC-RAS model

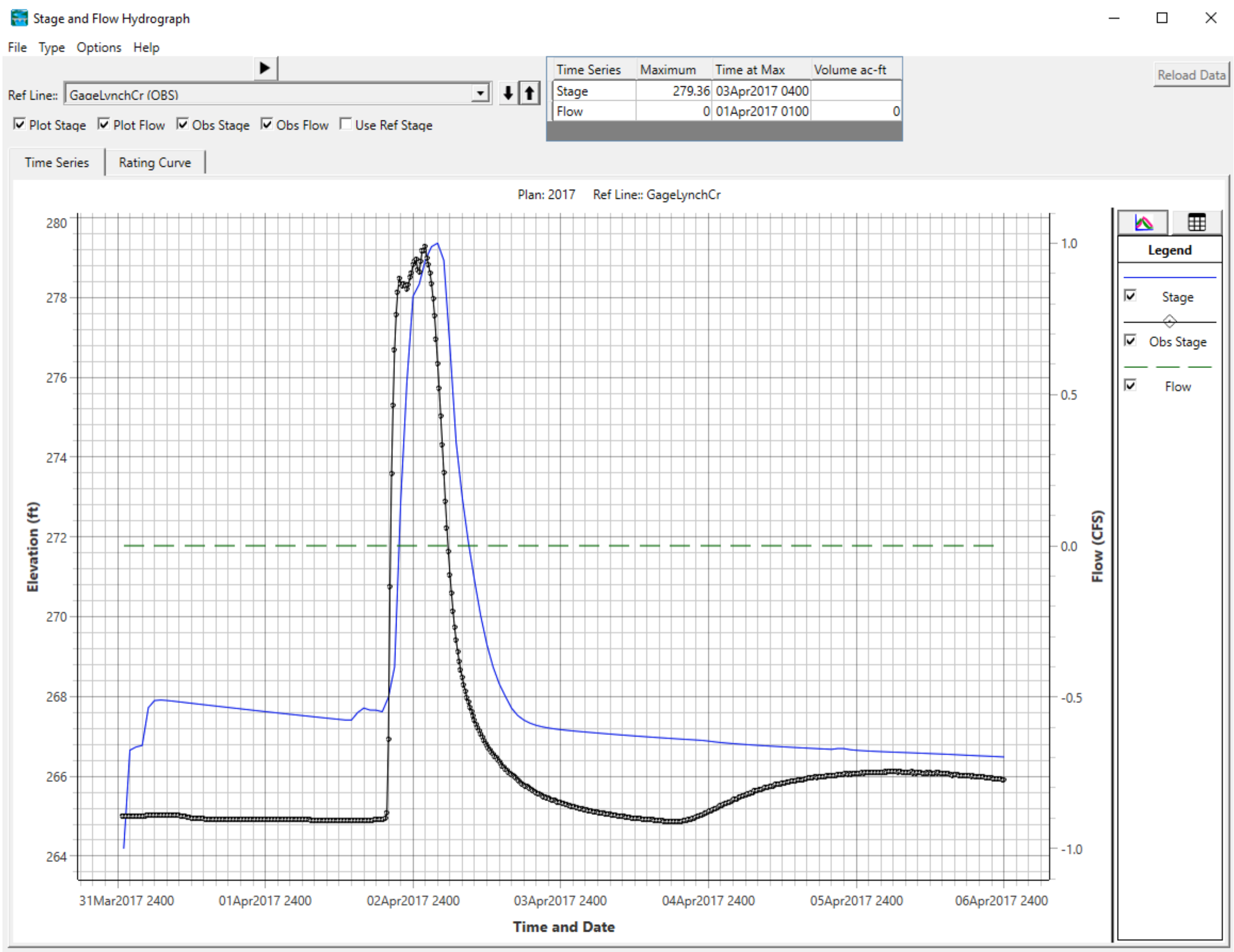


Figure 31: OBS vs Calculated Stage for Lynch Creek Gage, Apr 2017, HEC-RAS model

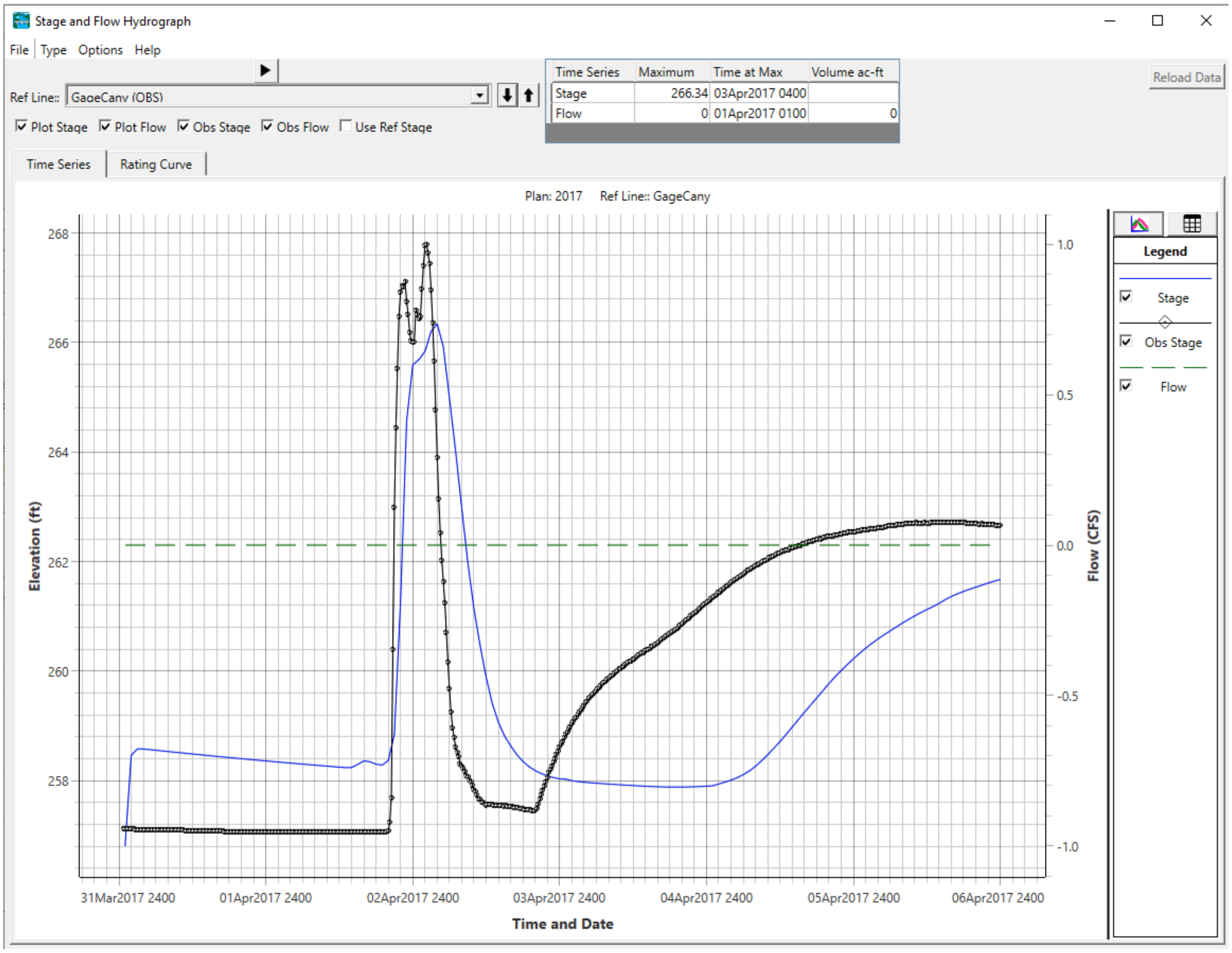


Figure 32: OBS vs Calculated Stage for Cany Creek Gage, Apr 2017, HEC-RAS model

Initial HEC-HMS Subbasin Characteristics

	Area	Longest Flowpath Length (MI)	Longest Flowpath Slope (FT/FT)	Centroidal Flowpath Length	Centroidal Flowpath Slope	10-85 Flowpath Length (MI)	10-85 FlowPath Slope (Ft/FT)	Basin Slope (FT/FT)	Basin Relief (FT)	Relief Ratio	Elongation Ratio	Drainage Density (Mi/Mi2)
Subbasin-1	1.3139	3.11024	0.00366	1.20846	0.00187	2.33268	0.00362	0.04921	60.96875	0.00371	0.41586	1.54659
S_BigCreek	26.85	13.0574	0.00334	5.96252	0.00142	9.79305	0.00191	0.05888	231.7813	0.00336	0.44778	0.93367
S_Big-WeeksMill	21.083	13.19545	0.00429	5.89871	0.00022	9.89659	0.00188	0.10573	301.5	0.00433	0.39264	1.24777
S_BrashearCr_1	12.994	8.4217	0.00425	3.40256	0.00209	6.31627	0.00271	0.05188	210	0.00472	0.48298	0.83984
S_BrushyCreek	23.908	19.01079	0.00262	9.90195	0.00164	14.25809	0.00216	0.1172	276.3125	0.00275	0.29022	1.09897
S_CaneyCreek_2	3.033	3.91179	0.0075	0.81977	0.00195	2.93384	0.00587	0.06904	158.4375	0.00767	0.50236	0.87681
S_CanyCreek_1	8.5408	6.30607	0.0043	2.99007	0.00197	4.72955	0.00338	0.06164	219.5	0.00659	0.52293	0.53328
S_CapitolBodyShop	0.23585	1.59396	0.00319	0.67947	0.00392	1.19547	0.00286	0.03175	36.46875	0.00433	0.34379	0
S_ChristwayChurch	2.859	5.24108	0.00152	2.32777	0.00034	3.93081	0.00056	0.02733	130.5625	0.00472	0.36403	0.79005
S_CityofPearl	8.4798	8.27927	0.00359	2.85194	0.00019	6.20945	0.00126	0.04469	199.1563	0.00456	0.39688	0.83494
S_DryCreek	29.601	21.94059	0.00173	10.50063	0.00068	16.45544	0.00097	0.06743	272.4375	0.00235	0.27981	1.34074
S_EubanksCr_1	1.7129	5.47976	0.00244	3.2941	0.00249	4.10982	0.00151	0.03634	75.9375	0.00262	0.2695	1.60068
S_EubanksCr_2	3.8206	4.27908	0.00437	1.66122	0.00299	3.20931	0.00312	0.05256	118.2188	0.00523	0.51543	0.75897
S_EubanksCr_3	1.2694	2.45586	0.01033	1.1214	0.00721	1.8419	0.00838	0.07908	138.0938	0.01065	0.51766	0.90647
S_EubanksCr_4	0.64261	2.09159	0.00926	1.11423	0.0027	1.56869	0.00519	0.07054	124.3438	0.01126	0.43247	0.84723
S_Fairgrounds	1.5873	3.24616	0.00655	1.23956	0.00096	2.43462	0.0055	0.06483	112.375	0.00656	0.43794	0.39646
S_FlowoodYMCA	1.5456	3.05466	0.00413	1.61263	0.00103	2.291	0.00323	0.03239	101.5	0.00629	0.45924	0.16784
S_GallatinStDump	1.2697	3.14511	0.00227	1.41862	0.0001	2.35884	0.00127	0.08749	132.875	0.008	0.40427	2.2469
S_Haley-Chestnut-Bear	37.595	12.47074	0.0041	0.44023	0.00015	9.35305	0.00153	0.07881	271.6563	0.00413	0.55479	1.12621
S_HangingMossSouth	0.16996	1.18926	0.01424	0.43054	0.00019	0.89194	0.01026	0.09606	89.5625	0.01426	0.39116	0
S_HangingMoss_1	11.24	7.91787	0.00347	3.39237	0.00189	5.9384	0.00263	0.05156	202	0.00483	0.47778	0.92978
S_HangingMoss_2	1.8912	3.40688	0.00369	1.04527	0.00168	2.55516	0.00329	0.04387	108.2188	0.00602	0.45548	1.01197
S_HangingMoss_3	2.2186	3.89087	0.00358	1.95854	0.00072	2.91815	0.00324	0.0585	117.7813	0.00573	0.43196	1.49927
S_HardyCreek	5.6221	5.56222	0.00514	2.14356	0.00359	4.17166	0.00423	0.06903	151.7813	0.00517	0.48101	1.16157
S_HogCreek_1	7.3102	5.29571	0.00488	2.24274	0.00162	3.97178	0.00302	0.06783	143.9688	0.00515	0.5761	0.81389
S_HogCreek_3	0.29562	1.98885	0.00455	1.12985	0.00359	1.49164	0.00403	0.06196	47.5625	0.00453	0.30848	4.03271
S_HogCreek_4	0.41722	1.82754	0.00238	0.45734	0.00397	1.37066	0.00245	0.05342	31.40625	0.00325	0.39881	2.17667
S_HogCreek2	4.9705	4.49595	0.00471	2.02783	0.00145	3.37196	0.00299	0.05327	135.9688	0.00573	0.55954	0.89971
S_Holcomb-Still	14.046	9.4711	0.00204	5.24987	0.00068	7.10333	0.00104	0.05961	189.375	0.00379	0.44651	1.19929
S_Howard-Steamboat-Hawkins	16.799	13.12264	0.00319	4.28593	0.00019	9.84198	0.00157	0.06846	220.1875	0.00318	0.35243	1.10787
S_JacksonHewitt	0.4858	1.40056	0.01158	0.59352	0.00216	1.05042	0.00932	0.03621	85.59375	0.01157	0.56151	0
S_LimestoneCreek	37.909	28.3259	0.00223	15.71966	0.00093	21.24443	0.00115	0.11882	333.1875	0.00223	0.24527	1.23125
S_LynchCr_1	4.5075	4.96042	0.00431	2.50226	0.00258	3.72032	0.00353	0.05235	134.4375	0.00513	0.48295	0.70004
S_LynchCr_2	4.5603	4.00703	0.0046	1.58662	0.00146	3.00527	0.00355	0.05395	117.8438	0.00557	0.60135	0.79147
S_LynchCr_3	3.6818	5.21632	0.00526	2.14033	0.00318	3.91224	0.00282	0.05724	148.8438	0.0054	0.41507	0.8527
S_MountainCreek	25.39	13.70276	0.00377	6.61497	0.0011	10.27707	0.0015	0.08703	281.2813	0.00389	0.41493	1.06103
S_NeelyCr_1	5.8296	6.94462	0.00057	3.31205	0.00035	5.20846	0.00071	0.03545	47.34375	0.00129	0.39231	0.91025
S_NeelyCr_2	2.3688	3.84478	0.00193	1.35122	0.00232	2.88359	0.00057	0.03533	51.46875	0.00254	0.45169	0.62258
S_Pearl-CanyCr	5.9005	6.39929	0.00208	1.08643	0.00014	4.79947	0.00183	0.0462	173.2188	0.00513	0.42832	1.25097
S_Pearl-RichlandCr	0.88588	3.18224	0.00175	1.83012	0.00012	2.38668	0.00218	0.07049	42.09375	0.00251	0.33374	2.79823
S_Pearl_EubanksCr	0.72277	2.11816	0.00271	0.89942	0.00155	1.58862	0.00261	0.08947	123.875	0.01108	0.45289	2.06547
S_Pearl_HangingMoss	1.5052	4.25255	0.00117	2.31354	0.00165	3.18941	0.00105	0.03307	38.34375	0.00171	0.32554	1.78399
S_Pearl_HogCreek	0.99059	3.69194	0.00113	1.25426	0.00002	2.76895	0.00071	0.07211	80.53125	0.00413	0.30419	3.50972
S_Pearl_Hwy25	0.7645	2.45971	0.00243	0.42868	0.0026	1.84478	0.00214	0.06001	97	0.00747	0.40111	1.19297
S_Pearl_HWY80	0.23581	1.07375	0.00428	0.33871	0.00016	0.80531	0.00211	0.10042	54.65625	0.00964	0.5103	4.46891
S_Pearl_I55	0.96278	3.12892	0.00243	1.18278	0.00017	2.34669	0.00132	0.08625	52.46875	0.00318	0.35385	3.22114
S_Pearl_PrarieBranch	0.58603	2.48879	0.00293	1.44337	0.00095	1.86659	0	0.07533	48.5625	0.0037	0.34708	3.67823
S_Pearl_Purple	1.6932	3.78702	0.001	2.08036	0.00004	2.84026	0.00072	0.05771	28.90625	0.00145	0.38772	1.79729
S_PrarieBranch_1	9.4389	6.71856	0.00439	3.11689	0.00278	5.03892	0.0027	0.04807	166.375	0.00469	0.51599	0.71044
S_PrarieBranch_2	0.7813	2.22308	0.00257	0.94819	0.00091	1.66731	0.00169	0.06568	44.8125	0.00382	0.44866	2.67663
S_PurpleCreek_1	6.1148	7.77066	0.00455	3.51973	0.00319	5.828	0.00286	0.0552	215.7188	0.00526	0.35908	0.96789
S_PurpleCreek_2	0.7878	2.30428	0.00483	0.94469	0.00308	1.72821	0.00409	0.04668	58.78125	0.00483	0.43463	1.78706
S_RenoCreek	23.437	13.47638	0.00371	5.69408	0.00041	10.10729	0.00215	0.09679	297.7188	0.00418	0.40536	1.2945
S_RhodesCreek	37.116	21.77627	0.00211	11.33175	0.00112	16.3322	0.00126	0.0659	275.2188	0.00239	0.31568	1.1091
S_RichlandCr_1	20.975	8.2903	0.00342	3.49653	0.00104	6.21772	0.00173	0.06985	237.2813	0.00542	0.62335	0.89858
S_RichlandCr_2	13.713	7.14127	0.00482	2.9736	0.00124	5.35595	0.00193	0.06361	218.75	0.0058	0.58512	0.90112

Subbasin Name	Area (MI2)	Subbasin Name	Area (MI2)
Subbasin-1	1.3139	S_Pearl_H	0.99059
S_BigCreel	26.85	S_Pearl_H	0.7645
S_Big-Wee	21.083	S_Pearl_H	0.23581
S_Brashea	12.994	S_Pearl_I5	0.96278
S_BrushyC	23.908	S_Pearl_Pr	0.58603
S_CaneyCr	3.033	S_Pearl_Pu	1.6932
S_CanyCre	8.5408	S_PrarieBr	9.4389
S_CapitolB	0.23585	S_PrarieBr	0.7813
S_Christwa	2.859	S_PurpleCr	6.1148
S_CityofPe	8.4798	S_PurpleCr	0.7878
S_DryCree	29.601	S_RenoCre	23.437
S_Eubanks	1.7129	S_Rhodes(	37.116
S_Eubanks	3.8206	S_Richlanc	20.975
S_Eubanks	1.2694	S_Richlanc	13.713
S_Eubanks	0.64261	S_Richlanc	14.736
S_Fairgrou	1.5873	S_Richlanc	14.932
S_Flowooc	1.5456	S_Richlanc	11.384
S_Gallatin!	1.2697	S_Richlanc	2.0173
S_Haley-Cl	37.595	S_Richlanc	4.0709
S_Hanging	0.16996	S_RiverRo	0.1444
S_Hanging	11.24	S_RockyCr	26.633
S_Hanging	1.8912	S_RossBar	6.1657
S_Hanging	2.2186	S_Savanna	0.4843
S_HardyCr	5.6221	S_SPearOr	3.4262
S_HogCree	7.3102	S_SteenCr	42.204
S_HogCree	0.29562	S_SteenCr	20.671
S_HogCree	0.41722	S_Terrapir	18.005
S_HogCree	4.9705	S_TheVaul	1.5586
S_Holcoml	14.046	S_Tougalo	4.1197
S_Howard	16.799	S_TownCr_	8.3137
S_Jacksonl	0.4858	S_TownCr_	0.33194
S_Limesto	37.909	S_TownCr_	2.0979
S_LynchCr_	4.5075	S_TrahonC	4.7718
S_LynchCr_	4.5603	S_Trahon-	12.19
S_LynchCr_	3.6818	S_TwinLak	1.1689
S_Mounta	25.39	S_TwinLak	1.4737
S_NeelyCr_	5.8296	S_UMMC	1.3031
S_NeelyCr_	2.3688	S_Vaughn(	14.36
S_Pearl-Ca	5.9005	S_Westsid	3.1609
S_Pearl-Ri	0.88588	S_WhiteO	2.6847
S_Pearl_Et	0.72277	S_WhiteO	5.6652
S_Pearl_H	1.5052		

S_RichlandCr_3	14.736	11.6944	0.00323	4.94643	0.00094	8.7708	0.00137	0.04423	209.0313	0.00339	0.3704	1.394
S_RichlandCr_4	14.932	12.32481	0.0021	5.15802	0.00075	9.24361	0.00083	0.05573	175.2813	0.00269	0.35378	1.54652
S_RichlandCr_5	11.384	9.05277	0.00301	3.82277	0.00107	6.78957	0.00204	0.0602	202.4375	0.00424	0.42056	1.05148
S_RichlandCr_6	2.0173	5.21246	0.00479	2.79397	0.00042	3.90935	0.00203	0.06975	145.4375	0.00528	0.30747	2.33556
S_RichlandCr_7	4.0709	6.98752	0.00483	2.96257	0.00163	5.24064	0.00261	0.05243	178.5	0.00484	0.32582	1.82549
S_RiverRoadN	0.1444	0.81071	0.00445	0.36854	0.00482	0.60803	0.00379	0.03061	23	0.00537	0.52898	0
S_RockyCreek	26.633	17.8439	0.00286	4.3478	0.00009	13.38293	0.00131	0.09685	292.9063	0.00311	0.32634	1.27598
S_RossBarnett	6.1657	8.23302	0.00284	2.83267	0.00007	6.17476	0.00146	0.06041	135.5625	0.00312	0.34032	1.4108
S_SavannaStWWTP	0.4843	2.50286	0.00298	2.14286	0.00198	1.87715	0.00226	0.06647	40.78125	0.00309	0.31373	1.48455
S_SPearOrchardRd	3.4262	5.07226	0.00464	2.60154	0.00295	3.80419	0.00411	0.05959	134.875	0.00504	0.41178	0.85593
S_SteenCreek_1	42.204	19.09873	0.00252	6.35846	0.00079	14.32405	0.00113	0.06268	287.5625	0.00285	0.38382	1.11899
S_SteenCreek_2	20.671	16.31618	0.00253	8.15741	0.00073	12.23713	0.00116	0.07656	272.8125	0.00317	0.31443	1.35522
S_TerrapinSkinCr	18.005	8.97929	0.00482	4.06533	0.0017	6.73446	0.00232	0.06578	234.1875	0.00494	0.53322	0.84088
S_TheVault	1.5586	3.7242	0.00449	2.22877	0.00364	2.79315	0.00377	0.04433	122	0.0062	0.37825	1.03805
S_Tougaloo	4.1197	6.76559	0.00456	3.35056	0.00308	5.0742	0.00356	0.05175	169.7813	0.00475	0.33852	1.01834
S_TownCr_1	8.3137	7.06275	0.00276	3.21025	0.00142	5.29706	0.0025	0.04396	119.7188	0.00321	0.46066	0.90753
S_TownCr_2	0.33194	1.44658	0.00909	0.65297	0.00333	1.08494	0.00817	0.06373	73.625	0.00964	0.44941	2.66997
S_TownCr_3	2.0979	4.82133	0.0053	1.81719	0.00349	3.616	0.00322	0.05493	150.3438	0.00591	0.33898	1.15211
S_TrahonCreek	4.7718	5.25456	0.00582	2.42423	0.00236	3.94092	0.00452	0.06348	173.8438	0.00627	0.46909	0.66583
S_Trahon-Big	12.19	9.59863	0.00311	3.29523	0.00199	7.19897	0.0023	0.06917	185.0938	0.00365	0.41044	1.28606
S_TwinLakeA	1.1689	2.89034	0.00609	1.619	0.00157	2.16775	0.0043	0.06496	107.125	0.00702	0.42208	0.00243
S_TwinLakeB	1.4737	2.64575	0.00925	1.211	0.0065	1.98431	0.00593	0.06849	131.4375	0.00941	0.51774	0.53811
S_UMMC	1.3031	2.68544	0.00983	1.33726	0.00815	2.01408	0.00672	0.08016	144.4063	0.01018	0.47966	0.40896
S_VaughnCreek	14.36	13.18899	0.00313	8.21007	0.00157	9.89174	0.00163	0.04983	224.5	0.00322	0.32421	1.12319
S_WestsidePark	3.1609	4.56984	0.00469	2.30699	0.00217	3.42738	0.00356	0.05812	128	0.0053	0.43899	0.79119
S_WhiteOakCr_1	2.6847	3.74979	0.0059	1.77686	0.00351	2.81234	0.00487	0.06622	151.6875	0.00766	0.49305	0.71263
S_WhiteOakCr_2	5.6652	8.83153	0.00409	3.98412	0.0021	6.62365	0.00282	0.05574	220.8438	0.00474	0.30411	1.13768

Initial Loss Parameters for the HEC-HMS

	Initial Loss (In)	Constant Rate (IN/HR)	Impervious (%)
Subbasin-1	0.5	0.7	0.447
S_BigCreek	0.5	1.87	8.59
S_Big-WeeksMill	0.5	0.68	0.671
S_BrashearCr_1	0.5	0.78	26.2
S_BrushyCreek	0.5	0.34	1.73
S_CaneyCreek_2	0.5	0.42	23.1
S_CanyCreek_1	0.5	0.79	20
S_CapitolBodyShop	0.5	0.29	45.2
S_ChristwayChurch	0.5	2.21	5.82
S_CityofPearl	0.5	2.56	31.7
S_DryCreek	0.5	1.64	1.35
S_EubanksCr_1	0.5	2.1	10.1
S_EubanksCr_2	0.5	0.23	29.8
S_EubanksCr_3	0.5	1.73	38.4

S_EubanksCr_4	0.5	2.88	22.6
S_Fairgrounds	0.5	2.1	52.7
S_FlowoodYMCA	0.5	1.39	0
S_GallatinStDump	0.5	3.01	8.92
S_Haley-Chestnut-Bear	0.5	0.88	0.866
S_HangingMossSouth	0.5	0.3	4.74
S_HangingMoss_1	0.5	0.81	10.9
S_HangingMoss_2	0.5	1.17	45.5
S_HangingMoss_3	0.5	2.21	19.4
S_HardyCreek	0.5	1.38	16.6
S_HogCreek_1	0.5	1.52	9.38
S_HogCreek_3	0.5	0.51	35.6
S_HogCreek_4	0.5	0.51	15.9
S_HogCreek2	0.5	1.32	0
S_Holcomb-Still	0.5	2.41	1.49

S_Howard-Steamboat-Hawkins	0.5	2.48	2.16
S_JacksonHewitt	0.5	1.16	0
S_LimestoneCreek	0.5	0.54	0.609
S_LynchCr_1	0.5	1.34	19.8
S_LynchCr_2	0.5	0.23	41.7
S_LynchCr_3	0.5	0.67	44.2
S_MountainCreek	0.5	2.02	0.927
S_NeelyCr_1	0.5	3.07	22.8
S_NeelyCr_2	0.5	2.78	32.9
S_Pearl-CanyCr	0.5	2.47	0
S_Pearl-RichlandCr	0.5	2.5	0.493
S_Pearl_EubanksCr	0.5	3.88	26.4
S_Pearl_HangingMoss	0.5	0.3	0.224
S_Pearl_HogCreek	0.5	3.99	0.313

S_Pearl_Hwy25	0.5	2.21	24.4
S_Pearl_HWY80	0.5	2	19.8
S_Pearl_I55	0.5	4.04	2.96
S_Pearl_PrarieBranch	0.5	4.12	0.0368
S_Pearl_Purple	0.5	2.5	0.0994
S_PrarieBranch_1	0.5	1.93	0
S_PrarieBranch_2	0.5	1.98	20.9
S_PurpleCreek_1	0.5	1.56	0
S_PurpleCreek_2	0.5	0.79	0
S_RenoCreek	0.5	0.58	0.53
S_RhodesCreek	0.5	1.63	2.09
S_RichlandCr_1	0.5	1.76	5.1
S_RichlandCr_2	0.5	1.91	7.38
S_RichlandCr_3	0.5	2.12	1.33
S_RichlandCr_4	0.5	1.5	4.8
S_RichlandCr_5	0.5	2.01	9.74
S_RichlandCr_6	0.5	3.68	0

S_RichlandCr_7	0.5	3.19	0
S_RiverRoadN	0.5	1.64	0
S_RockyCreek	0.5	0.8	0.736
S_RossBarnett	0.5	1.86	0
S_SavannaStWWTP	0.5	4.06	10.3
S_SPearOrchardRd	0.5	1.25	0
S_SteenCreek_1	0.5	2.17	4.34
S_SteenCreek_2	0.5	2.11	1.02
S_TerrapinSkinCr	0.5	2.38	19.7
S_TheVault	0.5	0.25	56.3
S_Tougaloo	0.5	0.91	22.9
S_TownCr_1	0.5	0.89	35
S_TownCr_2	0.5	0.38	53.7
S_TownCr_3	0.5	0.99	45.5
S_TrahonCreek	0.5	1.07	8.02
S_Trahon-Big	0.5	1.65	13.5
S_TwinLakeA	0.5	2.02	15.2

S_TwinLakeB	0.5	2.45	24
S_UMMC	0.5	0.3	26.4
S_VaughnCreek	0.5	1.3	3.24
S_WestsidePark	0.5	0.95	23.2
S_WhiteOakCr_1	0.5	0.47	8
S_WhiteOakCr_2	0.5	0.56	25.2

Initial Transform Values, HEC-

	Time of Concentration (HR)	Storage Coefficient (HR)
Subbasin-1	2.1	2.1
S_BigCreek	5.75	5.75
S_Big-WeeksMill	5.76	5.76
S_BrashearCr_1	4.04	4.04
S_BrushyCreek	7.35	7.35
S_CaneyCreek_2	1.86	1.86
S_CanyCreek_1	3.45	7.11
S_CapitolBodyShop	1.5	1.5
S_ChristwayChurch	3.96	3.96
S_CityofPearl	4.27	4.27
S_DryCreek	8.81	8.81
S_EubanksCr_1	3.84	3.84
S_EubanksCr_2	2.6	2.6

S_EubanksCr_3	1.69	1.69
S_EubanksCr_4	1.73	1.73
S_Fairgrounds	2.02	2.02
S_FlowoodYMCA	2.32	2.32
S_GallatinStDump	2.59	2.59
S_Haley-Chestnut-Bear	2.68	2.68
S_HangingMossSouth	0.989	3.05
S_HangingMoss_1	3.98	3.98
S_HangingMoss_2	2.1	2.1
S_HangingMoss_3	2.64	2.64
S_HardyCreek	2.9	2.9
S_HogCreek_1	3.05	3.05
S_HogCreek_3	1.77	1.77
S_HogCreek_4	1.42	1.42
S_HogCreek2	2.82	2.82
S_Holcomb-Still	5.5	5.5

S_Howard-Steamboat-Hawkins	5.37	5.37
S_Jackson Hewitt	1.16	1.16
S_LimestoneCreek	10.5	10.5
S_LynchCr_1	3.02	3.02
S_LynchCr_2	2.47	2.47
S_LynchCr_3	3.03	3.03
S_MountainCreek	6.24	6.24
S_NeelyCr_1	4.63	4.63
S_NeelyCr_2	3.06	3.06
S_Pearl-CanyCr	2.8	2.8
S_Pearl-RichlandCr	2.59	2.59
S_Pearl_EubanksCr	1.8	1.8
S_Pearl_HangingMoss	3.38	3.38
S_Pearl_HogCreek	2.86	2.86

S_Pearl_Hwy25	1.55	1.55
S_Pearl_HWY80	1.13	1.13
S_Pearl_I55	2.43	2.43
S_Pearl_PrarieBranch	5.96	1.47
S_Pearl_Purple	3.34	3.34
S_PrarieBranch_1	3.68	3.68
S_PrarieBranch_2	1.98	1.98
S_PurpleCreek_1	3.95	3.95
S_PurpleCreek_2	1.75	1.75
S_RenoCreek	5.62	5.62
S_RhodesCreek	8.65	8.65
S_RichlandCr_1	4.34	4.34
S_RichlandCr_2	3.88	3.88
S_RichlandCr_3	5.52	5.52
S_RichlandCr_4	6.13	6.13
S_RichlandCr_5	4.46	4.46
S_RichlandCr_6	3.44	3.44

S_RichlandCr_7	3.68	3.68
S_RiverRoadN	0.977	0.977
S_RockyCreek	6.07	6.07
S_RossBarnett	4.16	4.16
S_SavannaStWWTP	2.51	2.51
S_SPearOrchardRd	3.01	3.01
S_SteenCreek_1	7.11	7.11
S_SteenCreek_2	7.27	7.27
S_TerrapinSkinCr	4.45	4.45
S_TheVault	2.65	2.65
S_Tougaloo	3.61	3.61
S_TownCr_1	3.81	3.81
S_TownCr_2	1.23	1.23
S_TownCr_3	2.76	2.76
S_TrahonCreek	2.93	2.93
S_Trahon-Big	4.26	4.26
S_TwinLakeA	2.19	2.19

S_TwinLakeB	1.86	1.86
S_UMMC	1.89	1.89
S_VaughnCreek	6.5	6.5
S_WestsidePark	2.87	2.87
S_WhiteOakCr_1	2.39	2.39
S_WhiteOakCr_2	4.27	4.27

Initial Baseflow Parameters, HEC-HMS model

	Initial Type	Initial Discharge (CFS/MI2)	Initial Discharge (CFS)	Recession Constant	Threshold Type	Threshold Flow (CFS)	Ratio To Peak
Subbasin-1	Discharge	10		0.55	Ratio to Peak		0.1
S_BigCreek	Discharge	10		0.55	Ratio to Peak		0.1
S_Big-WeeksMill	Discharge	10		0.55	Ratio to Peak		0.1
S_BrashearCr_1	Discharge	10		0.55	Ratio to Peak		0.1
S_BrushyCreek	Discharge	10		0.55	Ratio to Peak		0.1
S_CaneyCreek_2	Discharge	10		0.55	Ratio to Peak		0.1
S_CanyCreek_1	Discharge	10		0.55	Ratio to Peak		0.1
S_CapitolBodyShop	Discharge	10		0.55	Ratio to Peak		0.1
S_ChristwayChurch	Discharge	10		0.55	Ratio to Peak		0.1
S_CityofPearl	Discharge	10		0.55	Ratio to Peak		0.1
S_DryCreek	Discharge	10		0.55	Ratio to Peak		0.1
S_EubanksCr_1	Discharge	10		0.55	Ratio to Peak		0.1
S_EubanksCr_2	Discharge	10		0.55	Ratio to Peak		0.1

S_EubanksCr_3	Discharge	10	0.55	Ratio to Peak	0.1
S_EubanksCr_4	Discharge	10	0.55	Ratio to Peak	0.1
S_Fairgrounds	Discharge	10	0.55	Ratio to Peak	0.1
S_FlowoodYMCA	Discharge	10	0.55	Ratio to Peak	0.1
S_GallatinStDump	Discharge	10	0.55	Ratio to Peak	0.1
S_Haley-Chestnut-Bear	Discharge	10	0.55	Ratio to Peak	0.1
S_HangingMossSouth	Discharge	10	0.55	Ratio to Peak	0.1
S_HangingMoss_1	Discharge	10	0.55	Ratio to Peak	0.1
S_HangingMoss_2	Discharge	10	0.55	Ratio to Peak	0.1
S_HangingMoss_3	Discharge	10	0.55	Ratio to Peak	0.1
S_HardyCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_HogCreek_1	Discharge	10	0.55	Ratio to Peak	0.1
S_HogCreek_3	Discharge	10	0.55	Ratio to Peak	0.1
S_HogCreek_4	Discharge	10	0.55	Ratio to Peak	0.1
S_HogCreek2	Discharge	10	0.55	Ratio to Peak	0.1
S_Holcomb-Still	Discharge	10	0.55	Ratio to Peak	0.1

S_Howard-Steamboat-Hawkins	Discharge	10	0.55	Ratio to Peak	0.1
S_JacksonHewitt	Discharge	10	0.55	Ratio to Peak	0.1
S_LimestoneCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_LynchCr_1	Discharge	10	0.55	Ratio to Peak	0.1
S_LynchCr_2	Discharge	10	0.55	Ratio to Peak	0.1
S_LynchCr_3	Discharge	10	0.55	Ratio to Peak	0.1
S_MountainCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_NeelyCr_1	Discharge	10	0.55	Ratio to Peak	0.1
S_NeelyCr_2	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl-CanyCr	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl-RichlandCr	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_EubanksCr	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_HangingMoss	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_HogCreek	Discharge	10	0.55	Ratio to Peak	0.1

S_Pearl_Hwy25	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_HWY80	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_I55	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_PrarieBranch	Discharge	10	0.55	Ratio to Peak	0.1
S_Pearl_Purple	Discharge	10	0.55	Ratio to Peak	0.1
S_PrarieBranch_1	Discharge	10	0.55	Ratio to Peak	0.1
S_PrarieBranch_2	Discharge	10	0.55	Ratio to Peak	0.1
S_PurpleCreek_1	Discharge	10	0.55	Ratio to Peak	0.1
S_PurpleCreek_2	Discharge	10	0.55	Ratio to Peak	0.1
S_RenoCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_RhodesCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_RichlandCr_1	Discharge	10	0.55	Ratio to Peak	0.1
S_RichlandCr_2	Discharge	10	0.55	Ratio to Peak	0.1
S_RichlandCr_3	Discharge	10	0.55	Ratio to Peak	0.1
S_RichlandCr_4	Discharge	10	0.55	Ratio to Peak	0.1
S_RichlandCr_5	Discharge	10	0.55	Ratio to Peak	0.1
S_RichlandCr_6	Discharge	10	0.55	Ratio to Peak	0.1

S_RichlandCr_7	Discharge	10	0.55	Ratio to Peak	0.1
S_RiverRoadN	Discharge	10	0.55	Ratio to Peak	0.1
S_RockyCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_RossBarnett	Discharge	10	0.55	Ratio to Peak	0.1
S_SavannaStWWTP	Discharge	10	0.55	Ratio to Peak	0.1
S_SPearOrchardRd	Discharge	10	0.55	Ratio to Peak	0.1
S_SteenCreek_1	Discharge	10	0.55	Ratio to Peak	0.1
S_SteenCreek_2	Discharge	10	0.55	Ratio to Peak	0.1
S_TerrapinSkinCr	Discharge	10	0.55	Ratio to Peak	0.1
S_TheVault	Discharge	10	0.55	Ratio to Peak	0.1
S_Tougaloo	Discharge	10	0.55	Ratio to Peak	0.1
S_TownCr_1	Discharge	10	0.55	Ratio to Peak	0.1
S_TownCr_2	Discharge	10	0.55	Ratio to Peak	0.1
S_TownCr_3	Discharge	10	0.55	Ratio to Peak	0.1
S_TrahonCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_Trahon-Big	Discharge	10	0.55	Ratio to Peak	0.1
S_TwinLakeA	Discharge	10	0.55	Ratio to Peak	0.1

S_TwinLakeB	Discharge	10	0.55	Ratio to Peak	0.1
S_UMMC	Discharge	10	0.55	Ratio to Peak	0.1
S_VaughnCreek	Discharge	10	0.55	Ratio to Peak	0.1
S_WestsidePark	Discharge	10	0.55	Ratio to Peak	0.1
S_WhiteOakCr_1	Discharge	10	0.55	Ratio to Peak	0.1
S_WhiteOakCr_2	Discharge	10	0.55	Ratio to Peak	0.1

Initial Reach Routing Parameters, HEC-HMS model

	Initial Type	Initial Discharge (CFS)	Length (FT)	Slope (FT/FT)	Manning's N	Space-time method	subreaches	subinterval	index method	Index Flow (CFS)	Index Celerity	Shape	Diameter	Width (FT)	Side Slope (XH:1V)	Left Manning's N	Right Manning's N	Cross Section	Elevation-Discharge	Elevation-Area	Elevation-width	Elevation-Perimeter	Invert (FT)
R_Richland1	Discharge		26912.48	0.00126	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		25	2								
R_Richland2	Discharge		5033.477	0.00019	0.05	Auto DX Auto DT			Celerity		4	Trapezoid		30	2								
R_RichlandCr_3	Discharge		14969.28	0.00055	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		30	2								
R_RichlandCr_4	Discharge		32935.53	0.0006	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		40	2								
R_TerrapinSkinCr	Discharge		22766.3	0.00091	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		25	2								
R_RichlandCr_5	Discharge		22821.96	0.00053	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		40	2								
R_RichlandCr_6	Discharge		24884.27	0.00041	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		45	2								
R_NeelyCr	Discharge		4825.814	0.0025	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		25	2								
R_RichlandCr_7	Discharge		15453.72	0.00051	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		50	2								
R_HangingMoss_1	Discharge		5074.872	0.00233	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		40	2								
R_HangingMoss_2	Discharge		5035.325	0.00191	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		45	2								
R_HangingMoss_3	Discharge		5578.954	0.00227	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		50	2								
R_WhiteOak_1	Discharge		34030.39	0.00204	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		30	2								
R_WhiteOak_2	Discharge		2617.718	0.00396	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		30	2								
R_RossBOutflows	Discharge		8304.648	0.00008	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		270	7.5								
R_PearlTrib	Discharge		16716.11	0.00159	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		30	2								
R_Pearl1	Discharge		11382.31	0.00008	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		270	7.5								
R_Pearl2	Discharge		5396.266	0.00006	0.05	Auto DX Auto DT			Celerity		1	Trapezoid		270	7.5								
R_UnnamedTrib10	Discharge		2685.408	0.00436	0.05	Auto DX Auto DT			Celerity		2	Trapezoid		5	2								
R_Pearl3	Discharge		5255.395	0.00006	0.05	Auto DX Auto DT			Celerity		1	Trapezoid		270	7.5								
R_Purple_1	Discharge		7438.2	0.00153	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		35	2								
R_Purple_2	Discharge		1830.998	0.00031	0.05	Auto DX Auto DT			Celerity		3	Trapezoid		35	2								
R_Pearl4	Discharge		3590.717	0.00002	0.05	Auto DX Auto DT			Celerity		1	Trapezoid		270	7.5								
R_HangingMoss_4	Discharge		9377.966	0.00028	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		55	2								
R_Pearl5	Discharge		1655.702	0.00001	0.05	Auto DX Auto DT			Celerity		1	Trapezoid		270	7.5								
R_UnnamedTrib1	Discharge		8744.314	0.00042	0.05	Auto DX Auto DT			Celerity		2	Trapezoid		15	2								
R_UnnamedTrib2	Discharge		3889.882	0.00157	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		20	2								
R_UnnamedTrib3	Discharge		3375.926	0.00216	0.05	Auto DX Auto DT			Celerity		5	Trapezoid		5	2								

R_UnnamedTrib4	Discharge	8644.786	0.0016	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	20	2
R_Pearl6	Discharge	2255.616	0.00007	0.05	Auto DX Auto DT	Celerity		2	Trapezoid	270	7.5
R_HangingMossSouth	Discharge	1262.818	0.00049	0.05	Auto DX Auto DT	Celerity		1	Trapezoid	8	2
R_Pearl7	Discharge	3917.179	0.00002	0.05	Auto DX Auto DT	Celerity		1	Trapezoid	270	7.5
R_HogCreek_1	Discharge	18436.12	0.00155	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	45	2
R_HogCreek2	Discharge	6294.605	0.0007	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	45	2
R_HogCreek_3	Discharge	4802.107	0.00089	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	45	2
R_HogCreek_4	Discharge	4003.19	0.00138	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	45	2
R_Pearl8	Discharge	5681.122	0.00002	0.05	Auto DX Auto DT	Celerity		1	Trapezoid	270	7.5
R_UnnamedTrib5	Discharge	2514.917	0.00328	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	10	2
R_Pearl9	Discharge	2479.91	0.00001	0.05	Auto DX Auto DT	Celerity		1	Trapezoid	270	7.5
R_UnnamedTrib6	Discharge	2347.646	0.00039	0.05	Auto DX Auto DT	Celerity		2	Trapezoid	25	2
R_Pearl10	Discharge	6404.957	0.00001	0.05	Auto DX Auto DT	Celerity		1	Trapezoid	270	7.5
R_PrarieBranch	Discharge	11047.29	0.0006	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	30	2
R_Pearl11	Discharge	4983.422	0.00145	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	270	7.5
R_Eubanks_1	Discharge	15315.7	0.00271	0.05	Auto DX Auto DT	Flow	626		Trapezoid	20	2
R_Eubanks_2	Discharge	6075.485	0.00434	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	20	2
R_Eubanks_3	Discharge	2884.675	0.00128	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	20	2
R_Pearl12	Discharge	5380.32	0.00021	0.05	Auto DX Auto DT	Celerity		4	Trapezoid	270	7.5
R_UnnamedTrib7	Discharge	2509.056	0.0006	0.05	Auto DX Auto DT	Celerity		3	Trapezoid	10	2
R_Pearl13	Discharge	11041.43	0.00016	0.05	Auto DX Auto DT	Celerity		4	Trapezoid	270	7.5
R_UnnamedTrib8	Discharge	5345.366	0.00648	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	5	2
R_Pearl14	Discharge	4840.862	0.00014	0.05	Auto DX Auto DT	Celerity		3	Trapezoid	270	7.5
R_Town_1	Discharge	3655.766	0.00471	0.05	Auto DX Auto DT	Celerity		8	Trapezoid	20	2
R_Town_2	Discharge	1030.814	0.0144	0.05	Auto DX Auto DT	Celerity		10	Trapezoid	20	2
R_Town_3	Discharge	12754.53	0.00313	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	20	2
R_Town_4	Discharge	740.256	0.00034	0.05	Auto DX Auto DT	Celerity		4	Trapezoid	20	2
R_Pearl15	Discharge	6149.986	0.00016	0.05	Auto DX Auto DT	Celerity		4	Trapezoid	270	7.5
R_Lynch_2	Discharge	12383.13	0.0032	0.05	Auto DX Auto DT	Celerity		1	Trapezoid	20	2
R_Lynch_3	Discharge	816.552	0.00107	0.05	Auto DX Auto DT	Celerity		5	Trapezoid	20	2

R_Pearl16	Discharge	8913.538	0.00011	0.05	Auto DX Auto DT	Celerity	3	Trapezoid	270	7.5
R_Pearl17	Discharge	7143.154	0.00021	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Pearl18	Discharge	3800.914	0.00014	0.05	Auto DX Auto DT	Celerity	3	Trapezoid	270	7.5
R_RichlandCr_8	Discharge	2440.786	0.00289	0.05	Auto DX Auto DT	Celerity	10	Trapezoid	50	2
R_Pearl19	Discharge	10654.78	0.00013	0.05	Auto DX Auto DT	Celerity	3	Trapezoid	270	7.5
R_Cany	Discharge	13243.93	0.00172	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	35	2
R_Pearl20	Discharge	17053.29	0.00018	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Pearl21	Discharge	39221.42	0.0002	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	270	7.5
R_Pearl22	Discharge	12019.44	0.00011	0.05	Auto DX Auto DT	Celerity	3	Trapezoid	270	7.5
R_BigCreek_1	Discharge	15782.87	0.00099	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	40	2
R_Trahon	Discharge	30282.17	0.00133	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	5	2
R_BigCreek_2	Discharge	6679.992	0.00116	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	40	2
R_Pearl23	Discharge	34538.75	0.00013	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Steen_1	Discharge	24614.78	0.00065	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	20	2
R_MountainCreek	Discharge	19756.18	0.00088	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	10	2
R_Steen_2	Discharge	42706.44	0.00073	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	30	2
R_Pearl24	Discharge	8923.622	0.00014	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Pearl25	Discharge	1924.402	0.00023	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	270	7.5
R_Pearl26	Discharge	40616.29	0.00008	0.05	Auto DX Auto DT	Celerity	3	Trapezoid	270	7.5
R_Pearl27	Discharge	37582.25	0.00011	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Pearl28	Discharge	29120.68	0.0001	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Pearl29	Discharge	43356.77	0.0001	0.05	Auto DX Auto DT	Celerity	4	Trapezoid	270	7.5
R_Pearl30	Discharge	8794.896	0.0002	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	270	7.5
R_Lynch_1	Discharge	13947.07	0.00145	0.05	Auto DX Auto DT	Celerity	5	Trapezoid	20	2

Final Calibrated HEC-HMS Subbasin Characteristics

	Area	Longest Flowpath Length (MI)	Longest Flowpath Slope (FT/FT)	Centroidal Flowpath Length	Centroidal Flowpath Slope	10-85 Flowpath Length (MI)	10-85 FlowPath Slope (Ft/FT)	Basin Slope (FT/FT)	Basin Relief (FT)	Relief Ratio	Elongation Ratio	Drainage Density (Mi/Mi2)
S_RichlandCr_1	20.975	3.11024	0.00366	1.20846	0.00187	2.33268	0.00362	0.04921	60.96875	0.00371	0.41586	1.54659
S_RichlandCr_2	13.713	13.0574	0.00334	5.96252	0.00142	9.79305	0.00191	0.05888	231.7813	0.00336	0.44778	0.93367
S_DryCreek	29.601	13.19545	0.00429	5.89871	0.00022	9.89659	0.00188	0.10573	301.5	0.00433	0.39264	1.24777
S_RichlandCr_3	14.736	8.4217	0.00425	3.40256	0.00209	6.31627	0.00271	0.05188	210	0.00472	0.48298	0.83984
S_TerrapinSkinCr	18.005	19.01079	0.00262	9.90195	0.00164	14.25809	0.00216	0.1172	276.3125	0.00275	0.29022	1.09897
S_RichlandCr_4	14.932	3.91179	0.0075	0.81977	0.00195	2.93384	0.00587	0.06904	158.4375	0.00767	0.50236	0.87681
S_RichlandCr_5	11.384	6.30607	0.0043	2.99007	0.00197	4.72955	0.00338	0.06164	219.5	0.00659	0.52293	0.53328
S_RichlandCr_6	2.0173	1.59396	0.00319	0.67947	0.00392	1.19547	0.00286	0.03175	36.46875	0.00433	0.34379	0
S_CityofPearl	8.4798	5.24108	0.00152	2.32777	0.00034	3.93081	0.00056	0.02733	130.5625	0.00472	0.36403	0.79005
S_NeelyCr_1	5.8296	8.27927	0.00359	2.85194	0.00019	6.20945	0.00126	0.04469	199.1563	0.00456	0.39688	0.83494
S_NeelyCr_2	2.3688	21.94059	0.00173	10.50063	0.00068	16.45544	0.00097	0.06743	272.4375	0.00235	0.27981	1.34074
S_RichlandCr_7	4.0709	5.47976	0.00244	3.2941	0.00249	4.10982	0.00151	0.03634	75.9375	0.00262	0.2695	1.60068
S_EubanksCr_1	1.7129	4.27908	0.00437	1.66122	0.00299	3.20931	0.00312	0.05256	118.2188	0.00523	0.51543	0.75897
S_EubanksCr_2	3.8206	2.45586	0.01033	1.1214	0.00721	1.8419	0.00838	0.07908	138.0938	0.01065	0.51766	0.90647
S_EubanksCr_3	1.2694	2.09159	0.00926	1.11423	0.0027	1.56869	0.00519	0.07054	124.3438	0.01126	0.43247	0.84723
S_HangingMoss_1	11.24	3.24616	0.00655	1.23956	0.00096	2.43462	0.0055	0.06483	112.375	0.00656	0.43794	0.39646
S_Tougaloo	4.1197	3.05466	0.00413	1.61263	0.00103	2.291	0.00323	0.03239	101.5	0.00629	0.45924	0.16784
S_HangingMoss_2	1.8912	3.14511	0.00227	1.41862	0.0001	2.35884	0.00127	0.08749	132.875	0.008	0.40427	2.2469
S_WhiteOakCr_1	2.6847	12.47074	0.0041	0.44023	0.00015	9.35305	0.00153	0.07881	271.6563	0.00413	0.55479	1.12621
S_WhiteOakCr_2	5.6652	1.18926	0.01424	0.43054	0.00019	0.89194	0.01026	0.09606	89.5625	0.01426	0.39116	0
S_BrashearCr_1	12.994	7.91787	0.00347	3.39237	0.00189	5.9384	0.00263	0.05156	202	0.00483	0.47778	0.92978
S_RossBarnett	6.1657	3.40688	0.00369	1.04527	0.00168	2.55516	0.00329	0.04387	108.2188	0.00602	0.45548	1.01197
S_SPearOrchardRd	3.4262	3.89087	0.00358	1.95854	0.00072	2.91815	0.00324	0.0585	117.7813	0.00573	0.43196	1.49927
S_RiverRoadN	0.1444	5.56222	0.00514	2.14356	0.00359	4.17166	0.00423	0.06903	151.7813	0.00517	0.48101	1.16157
S_PurpleCreek_1	6.1148	5.29571	0.00488	2.24274	0.00162	3.97178	0.00302	0.06783	143.9688	0.00515	0.5761	0.81389
S_PurpleCreek_2	0.7878	1.98885	0.00455	1.12985	0.00359	1.49164	0.00403	0.06196	47.5625	0.00453	0.30848	4.03271
S_HangingMoss_3	2.2186	1.82754	0.00238	0.45734	0.00397	1.37066	0.00245	0.05342	31.40625	0.00325	0.39881	2.17667
S_Pearl_Purple	1.6932	4.49595	0.00471	2.02783	0.00145	3.37196	0.00299	0.05327	135.9688	0.00573	0.55954	0.89971
S_JacksonHewitt	0.4858	9.4711	0.00204	5.24987	0.00068	7.10333	0.00104	0.05961	189.375	0.00379	0.44651	1.19929
S_ChristwayChurch	2.859	13.12264	0.00319	4.28593	0.00019	9.84198	0.00157	0.06846	220.1875	0.00318	0.35243	1.10787
S_FlowoodYMCA	1.5456	1.40056	0.01158	0.59352	0.00216	1.05042	0.00932	0.03621	85.59375	0.01157	0.56151	0
S_CapitolBodyShop	0.23585	28.3259	0.00223	15.71966	0.00093	21.24443	0.00115	0.11882	333.1875	0.00223	0.24527	1.23125
S_Pearl_HangingMoss	1.5052	4.96042	0.00431	2.50226	0.00258	3.72032	0.00353	0.05235	134.4375	0.00513	0.48295	0.70004

S_HangingMossSouth	0.16996	4.00703	0.0046	1.58662	0.00146	3.00527	0.00355	0.05395	117.8438	0.00557	0.60135	0.79147
S_HogCreek_1	7.3102	5.21632	0.00526	2.14033	0.00318	3.91224	0.00282	0.05724	148.8438	0.0054	0.41507	0.8527
S_HogCreek2	4.9705	13.70276	0.00377	6.61497	0.0011	10.27707	0.0015	0.08703	281.2813	0.00389	0.41493	1.06103
S_HogCreek_3	0.29562	6.94462	0.00057	3.31205	0.00035	5.20846	0.00071	0.03545	47.34375	0.00129	0.39231	0.91025
S_HogCreek_4	0.41722	3.84478	0.00193	1.35122	0.00232	2.88359	0.00057	0.03533	51.46875	0.00254	0.45169	0.62258
S_TwinLakeA	1.1689	6.39929	0.00208	1.08643	0.00014	4.79947	0.00183	0.0462	173.2188	0.00513	0.42832	1.25097
S_Pearl_HogCreek	0.99059	3.18224	0.00175	1.83012	0.00012	2.38668	0.00218	0.07049	42.09375	0.00251	0.33374	2.79823
S_TwinLakeB	1.4737	2.11816	0.00271	0.89942	0.00155	1.58862	0.00261	0.08947	123.875	0.01108	0.45289	2.06547
S_Pearl_Hwy25	0.7645	4.25255	0.00117	2.31354	0.00165	3.18941	0.00105	0.03307	38.34375	0.00171	0.32554	1.78399
S_PrarieBranch_1	9.4389	3.69194	0.00113	1.25426	0.00002	2.76895	0.00071	0.07211	80.53125	0.00413	0.30419	3.50972
S_PrarieBranch_2	0.7813	2.45971	0.00243	0.42868	0.0026	1.84478	0.00214	0.06001	97	0.00747	0.40111	1.19297
S_EubanksCr_4	0.64261	1.07375	0.00428	0.33871	0.00016	0.80531	0.00211	0.10042	54.65625	0.00964	0.5103	4.46891
S_Pearl_PrarieBranch	0.58603	3.12892	0.00243	1.18278	0.00017	2.34669	0.00132	0.08625	52.46875	0.00318	0.35385	3.22114
S_UMMC	1.3031	2.48879	0.00293	1.44337	0.00095	1.86659	0	0.07533	48.5625	0.0037	0.34708	3.67823
S_Pearl_EubanksCr	0.72277	3.78702	0.001	2.08036	0.00004	2.84026	0.00072	0.05771	28.90625	0.00145	0.38772	1.79729
S_Fairgrounds	1.5873	6.71856	0.00439	3.11689	0.00278	5.03892	0.0027	0.04807	166.375	0.00469	0.51599	0.71044
S_Pearl_I55	0.96278	2.22308	0.00257	0.94819	0.00091	1.66731	0.00169	0.06568	44.8125	0.00382	0.44866	2.67663
S_TownCr_1	8.3137	7.77066	0.00455	3.51973	0.00319	5.828	0.00286	0.0552	215.7188	0.00526	0.35908	0.96789
S_TheVault	1.5586	2.30428	0.00483	0.94469	0.00308	1.72821	0.00409	0.04668	58.78125	0.00483	0.43463	1.78706
S_TownCr_2	0.33194	13.47638	0.00371	5.69408	0.00041	10.10729	0.00215	0.09679	297.7188	0.00418	0.40536	1.2945
S_TownCr_3	2.0979	21.77627	0.00211	11.33175	0.00112	16.3322	0.00126	0.0659	275.2188	0.00239	0.31568	1.1091
S_Pearl_HWY80	0.23581	8.2903	0.00342	3.49653	0.00104	6.21772	0.00173	0.06985	237.2813	0.00542	0.62335	0.89858
S_LynchCr_1	4.5075	7.14127	0.00482	2.9736	0.00124	5.35595	0.00193	0.06361	218.75	0.0058	0.58512	0.90112
S_WestsidePark	3.1609	11.6944	0.00323	4.94643	0.00094	8.7708	0.00137	0.04423	209.0313	0.00339	0.3704	1.394
S_LynchCr_2	4.5603	12.32481	0.0021	5.15802	0.00075	9.24361	0.00083	0.05573	175.2813	0.00269	0.35378	1.54652
S_LynchCr_3	3.6818	9.05277	0.00301	3.82277	0.00107	6.78957	0.00204	0.0602	202.4375	0.00424	0.42056	1.05148
S_GallatinStDump	1.2697	5.21246	0.00479	2.79397	0.00042	3.90935	0.00203	0.06975	145.4375	0.00528	0.30747	2.33556
S_HardyCreek	5.6221	6.98752	0.00483	2.96257	0.00163	5.24064	0.00261	0.05243	178.5	0.00484	0.32582	1.82549
S_SavannaStWWTP	0.4843	0.81071	0.00445	0.36854	0.00482	0.60803	0.00379	0.03061	23	0.00537	0.52898	0
S_CanyCreek_1	8.5408	17.8439	0.00286	4.3478	0.00009	13.38293	0.00131	0.09685	292.9063	0.00311	0.32634	1.27598
S_Pearl-CanyCr	5.9005	8.23302	0.00284	2.83267	0.00007	6.17476	0.00146	0.06041	135.5625	0.00312	0.34032	1.4108
S_CaneyCreek_2	3.033	2.50286	0.00298	2.14286	0.00198	1.87715	0.00226	0.06647	40.78125	0.00309	0.31373	1.48455
S_Pearl-RichlandCr	0.88588	5.07226	0.00464	2.60154	0.00295	3.80419	0.00411	0.05959	134.875	0.00504	0.41178	0.85593
S_Howard-Steamboat-Hawkins	16.799	19.09873	0.00252	6.35846	0.00079	14.32405	0.00113	0.06268	287.5625	0.00285	0.38382	1.11899
S_BigCreek	26.85	16.31618	0.00253	8.15741	0.00073	12.23713	0.00116	0.07656	272.8125	0.00317	0.31443	1.35522
S_TrahonCreek	4.7718	8.97929	0.00482	4.06533	0.0017	6.73446	0.00232	0.06578	234.1875	0.00494	0.53322	0.84088
S_Trahon-Big	12.19	3.7242	0.00449	2.22877	0.00364	2.79315	0.00377	0.04433	122	0.0062	0.37825	1.03805
S_SteenCreek_1	42.204	6.76559	0.00456	3.35056	0.00308	5.0742	0.00356	0.05175	169.7813	0.00475	0.33852	1.01834

S_MountainCreek	25.39	7.06275	0.00276	3.21025	0.00142	5.29706	0.0025	0.04396	119.7188	0.00321	0.46066	0.90753
S_SteenCreek_2	20.671	1.44658	0.00909	0.65297	0.00333	1.08494	0.00817	0.06373	73.625	0.00964	0.44941	2.66997
S_Holcomb-Still	14.046	4.82133	0.0053	1.81719	0.00349	3.616	0.00322	0.05493	150.3438	0.00591	0.33898	1.15211
S_RhodesCreek	37.116	5.25456	0.00582	2.42423	0.00236	3.94092	0.00452	0.06348	173.8438	0.00627	0.46909	0.66583
S_VaughnCreek	14.36	9.59863	0.00311	3.29523	0.00199	7.19897	0.0023	0.06917	185.0938	0.00365	0.41044	1.28606
S_Haley-Chestnut-Bear	37.595	2.89034	0.00609	1.619	0.00157	2.16775	0.0043	0.06496	107.125	0.00702	0.42208	0.00243
S_RockyCreek	26.633	2.64575	0.00925	1.211	0.0065	1.98431	0.00593	0.06849	131.4375	0.00941	0.51774	0.53811
S_BrushyCreek	23.908	2.68544	0.00983	1.33726	0.00815	2.01408	0.00672	0.08016	144.4063	0.01018	0.47966	0.40896
S_Big-WeeksMill	21.083	13.18899	0.00313	8.21007	0.00157	9.89174	0.00163	0.04983	224.5	0.00322	0.32421	1.12319
S_LimestoneCreek	37.909	4.56984	0.00469	2.30699	0.00217	3.42738	0.00356	0.05812	128	0.0053	0.43899	0.79119
S_RenoCreek	23.437	3.74979	0.0059	1.77686	0.00351	2.81234	0.00487	0.06622	151.6875	0.00766	0.49305	0.71263
Subbasin-1	1.3139	8.83153	0.00409	3.98412	0.0021	6.62365	0.00282	0.05574	220.8438	0.00474	0.30411	1.13768

Final Calibrated HEC-HMS Loss Parameters

	Initial Loss (In)	Maximum Storage (IN)	Constant Rate (IN/HR)	Impervious (%)
Subbasin-1	0.05	2.5	0.70002	0.447
S_BigCreek	0.05	2.5	1.87002	8.59
S_Big-WeeksMill	0.05	2.5	0.67998	0.671
S_BrashearCr_1	0.05	2	0.28519	26.2
S_BrushyCreek	0.05	2.5	0.3400002	1.73
S_CaneyCreek_2	0.05	2.5	0.168	23.1
S_CanyCreek_1	0.05	2.5	0.316	20
S_CapitolBodyShop	0.05	2	0.106031	45.2
S_ChristwayChurch	0.05	2	0.808	5.82
S_CityofPearl	0.05	2.5	2.56002	23.775
S_DryCreek	0.05	2.5	0.656	1.35
S_EubanksCr_1	0.05	2.5	2.1	10.1
S_EubanksCr_2	0.05	2.5	0.2299998	29.8
S_EubanksCr_3	0.05	2.5	1.72998	38.4

S_EubanksCr_4	0.05	2.5	2.88	22.6
S_Fairgrounds	0.05	2.5	2.1	39.525
S_FlowoodYMCA	0.05	2	0.50822	0
S_GallatinStDump	0.05	2.5	1.204	8.92
S_Haley-Chestnut-Bear	0.05	2.5	0.88002	0.866
S_HangingMossSouth	0.05	2	0.10969	4.74
S_HangingMoss_1	0.05	2	0.296156	10.9
S_HangingMoss_2	0.05	2	0.427781	45.5
S_HangingMoss_3	0.05	2	0.808	19.4
S_HardyCreek	0.05	2.5	0.552	16.6
S_HogCreek_1	0.05	2	0.55574	9.38
S_HogCreek_3	0.05	2	0.186469	35.6
S_HogCreek_4	0.05	2	0.186469	15.9
S_HogCreek2	0.05	2	0.4826	0
S_Holcomb-Still	0.05	2.5	2.41002	1.49

S_Howard-Steamboat-Hawkins	0.05	2.5	2.47998	2.16
S_JacksonHewitt	0.05	2	0.42412	0
S_LimestoneCreek	0.05	2.5	0.54	0.609
S_LynchCr_1	0.05	0.75	0.2512463	19.8
S_LynchCr_2	0.05	0.75	0.04312	41.7
S_LynchCr_3	0.05	0.75	0.1256288	44.2
S_MountainCreek	0.05	2.5	2.02002	0.927
S_NeelyCr_1	0.05	2.5	3.07002	17.1
S_NeelyCr_2	0.05	0.75	0.5212463	32.9
S_Pearl-CanyCr	0.05	2.5	0.988	0
S_Pearl-RichlandCr	0.05	2.5	1	0.493
S_Pearl_EubanksCr	0.05	2.5	1.552	26.4
S_Pearl_HangingMoss	0.05	2	0.10969	0.224
S_Pearl_HogCreek	0.05	2	1.458844	0.313

S_Pearl_Hwy25	0.05	2	0.808	24.4
S_Pearl_HWY80	0.05	0.75	0.3749962	19.8
S_Pearl_I55	0.05	2.5	4.03998	2.22
S_Pearl_PrarieBranch	0.05	2.5	4.12002	0.0368
S_Pearl_Purple	0.05	2	0.9141	0.0994
S_PrarieBranch_1	0.05	2.5	1.93002	0
S_PrarieBranch_2	0.05	2.5	1.98	20.9
S_PurpleCreek_1	0.05	2	0.5704	0
S_PurpleCreek_2	0.05	2	0.28885	0
S_RenoCreek	0.05	2.5	0.5800002	0.53
S_RhodesCreek	0.05	2.5	1.63002	2.09
S_RichlandCr_1	0.05	2.5	0.704	5.1
S_RichlandCr_2	0.05	2.5	0.764	7.38
S_RichlandCr_3	0.05	2.5	0.848	1.33
S_RichlandCr_4	0.05	2.5	0.6	4.8
S_RichlandCr_5	0.05	2.5	0.804	9.74
S_RichlandCr_6	0.05	2.5	1.472	0

S_RichlandCr_7	0.05	2.5	1.276	0
S_RiverRoadN	0.05	2	0.59962	0
S_RockyCreek	0.05	2.5	0.79998	0.736
S_RossBarnett	0.05	2	0.68006	0
S_SavannaStWWTP	0.05	2.5	1.624	10.3
S_SPearOrchardRd	0.05	2	0.45703	0
S_SteenCreek_1	0.05	2.5	2.17002	4.34
S_SteenCreek_2	0.05	2.5	2.11002	1.02
S_TerrapinSkinCr	0.05	2.5	0.952	19.7
S_TheVault	0.05	2.5	0.2500002	42.225
S_Tougaloo	0.05	2.5	0.91002	22.9
S_TownCr_1	0.05	2.5	0.88998	26.25
S_TownCr_2	0.05	2.5	0.3799998	40.275
S_TownCr_3	0.05	2.5	0.99	34.125
S_TrahonCreek	0.05	2.5	1.06998	8.02
S_Trahon-Big	0.05	2.5	1.65	13.5
S_TwinLakeA	0.05	2	0.73857	15.2

S_TwinLakeB	0.05	2	0.8958	24
S_UMMC	0.05	2.5	0.3	26.4
S_VaughnCreek	0.05	2.5	1.30002	3.24
S_WestsidePark	0.05	0.75	0.1781213	23.2
S_WhiteOakCr_1	0.05	2	0.171844	8
S_WhiteOakCr_2	0.05	2	0.0341249	25.2

Final Calibrated HEC-HMS Transform Values

	Time of Concentration (HR)	Storage Coefficient (HR)
Subbasin-1	1.68	2.1
S_BigCreek	4.6	5.75
S_Big-WeeksMill	4.608	5.76
S_BrashearCr_1	3.232	2.586
S_BrushyCreek	5.88	7.35
S_CaneyCreek_2	1.3392	1.674
S_CanyCreek_1	2.484	3.105
S_CapitolBodyShop	1.2	1
S_ChristwayChurch	3.168	2.534
S_CityofPearl	3.416	6.67
S_DryCreek	6.3432	7.929
S_EubanksCr_1	3.072	3.84
S_EubanksCr_2	2.08	2.6
S_EubanksCr_3	1.352	1.69
S_EubanksCr_4	1.384	1.73
S_Fairgrounds	1.616	3.15
S_FlowoodYMCA	1.856	1.485
S_GallatinStDump	1.8648	2.331
S_Haley-Chestnut-Bear	2.144	2.68
S_HangingMossSouth	0.7912	0.633
S_HangingMoss_1	3.184	2.547
S_HangingMoss_2	1.68	1.34
S_HangingMoss_3	2.112	1.69
S_HardyCreek	2.088	2.61
S_HogCreek_1	2.44	1.95
S_HogCreek_3	1.416	1.133
S_HogCreek_4	1.136	0.909
S_HogCreek2	2.256	1.805
S_Holcomb-Still	4.4	5.5

S_Howard-Steamboat-Hawkins	4.296	5.37
S_JacksonHewitt	0.928	0.742
S_LimestoneCreek	8.4	10.5
S_LynchCr_1	2.416	1.933
S_LynchCr_2	1.976	1.581
S_LynchCr_3	2.424	1.939
S_MountainCreek	4.992	6.24
S_NeelyCr_1	3.704	7.24
S_NeelyCr_2	2.448	1.958
S_Pearl-CanyCr	2.016	2.52
S_Pearl-RichlandCr	1.8648	2.331
S_Pearl_EubanksCr	1.296	1.62
S_Pearl_HangingMoss	2.704	2.163
S_Pearl_HogCreek	2.288	1.83
S_Pearl_Hwy25	1.24	0.99
S_Pearl_HWY80	0.904	0.723
S_Pearl_I55	1.944	3.8
S_Pearl_PrarieBranch	4.768	5.96
S_Pearl_Purple	2.672	2.138
S_PrarieBranch_1	2.944	3.68
S_PrarieBranch_2	1.584	1.98
S_PurpleCreek_1	3.16	2.53
S_PurpleCreek_2	1.4	1.1
S_RenoCreek	4.496	5.62
S_RhodesCreek	6.92	8.65
S_RichlandCr_1	3.1248	3.906
S_RichlandCr_2	2.7936	3.492
S_RichlandCr_3	3.9744	4.968
S_RichlandCr_4	4.4136	5.517
S_RichlandCr_5	3.2112	4.014
S_RichlandCr_6	2.4768	3.096
S_RichlandCr_7	2.6496	3.312
S_RiverRoadN	0.7816	0.6253

S_RockyCreek	4.856	6.07
S_RossBarnett	3.328	2.662
S_SavannaStWWTP	1.8072	2.259
S_SPearOrchardRd	2.408	1.926
S_SteenCreek_1	5.688	7.11
S_SteenCreek_2	5.816	7.27
S_TerrapinSkinCr	3.204	4.005
S_TheVault	2.12	4.14
S_Tougaloo	2.888	3.61
S_TownCr_1	3.048	5.95
S_TownCr_2	0.984	1.93
S_TownCr_3	2.208	4.31
S_TrahonCreek	2.344	2.93
S_Trahon-Big	3.408	4.26
S_TwinLakeA	1.752	1.402
S_TwinLakeB	1.488	1.19
S_UMMC	1.512	1.89
S_VaughnCreek	5.2	6.5
S_WestsidePark	2.296	1.837
S_WhiteOakCr_1	1.912	1.53
S_WhiteOakCr_2	3.416	2.733

Final Calibrated HEC-HMS Baseflow Parameters

	Initial Type	Initial Discharge (CFS/MI2)	Initial Discharge (CFS)	Recession Constant	January (CFS)	February (CFS)	March (CFS)	April (CFS)	May (CFS)	June (CFS)	July (CFS)	August (CFS)	September (CFS)	October (CFS)	November (CFS)	December (CFS)
S_RichlandCr_1	Discharge Per Area	10		0.75	2097.5	2097.5	2097.5	2097.5				2097.5				2097.5
S_RichlandCr_2	Discharge Per Area	10		0.75	1371.3	1371.3	1371.3	1371.3				1371.3				1371.3
S_DryCreek	Discharge Per Area	10		0.75	2960.1	2960.1	2960.1	2960.1				2960.1				2960.1
S_RichlandCr_3	Discharge Per Area	10		0.75	1473.6	1473.6	1473.6	1473.6				1473.6				1473.6
S_TerrapinSkinCr	Discharge Per Area	10		0.75	1800.5	1800.5	1800.5	1800.5				1800.5				1800.5
S_RichlandCr_4	Discharge Per Area	10		0.75	1493.2	1493.2	1493.2	1493.2				1493.2				1493.2
S_RichlandCr_5	Discharge Per Area	10		0.75	1138.4	1138.4	1138.4	1138.4				1138.4				1138.4
S_RichlandCr_6	Discharge Per Area	10		0.75	201.73	201.73	201.73	201.73				201.73				201.73
S_CityofPearl	Discharge Per Area	10		0.75	847.98	847.98	847.98	847.98				847.98				847.98
S_NeelyCr_1	Discharge Per Area	10		0.75	582.96	582.96	582.96	582.96				582.96				582.96
S_NeelyCr_2	Discharge Per Area	10		0.75	236.88	236.88	236.88	189.5				236.88				236.88
S_RichlandCr_7	Discharge Per Area	10		0.75	407.09	407.09	407.09	407.09				407.09				407.09
S_EubanksCr_1	Discharge Per Area	10		0.75	171.29	171.29	171.29	171.29				171.29				171.29
S_EubanksCr_2	Discharge Per Area	10		0.75	382.06	382.06	382.06	382.06				382.06				382.06
S_EubanksCr_3	Discharge Per Area	10		0.75	126.94	126.94	126.94	126.94				126.94				126.94
S_HangingMoss_1	Discharge Per Area	10		0.75	1124	1124	1124	1124				1124				1124
S_Tougaloo	Discharge Per Area	10		0.75	411.97	411.97	411.97	411.97				411.97				411.97
S_HangingMoss_2	Discharge Per Area	10		0.75	189.12	189.12	189.12	189.12				189.12				189.12
S_WhiteOakCr_1	Discharge Per Area	10		0.75	268.47	268.47	268.47	268.47				268.47				268.47
S_WhiteOakCr_2	Discharge Per Area	10		0.75	566.52	566.52	566.52	566.52				566.52				566.52

S_BrashearCr_1	Discharge Per Area	10	0.75	1299.4	1299.4	1299.4	1299.4	1299.4	1299.4
S_RossBarnett	Discharge Per Area	10	0.75	616.57	616.57	616.57	616.57	616.57	616.57
S_SPearOrchardRd	Discharge Per Area	10	0.75	342.62	342.62	342.62	342.62	342.62	342.62
S_RiverRoadN	Discharge Per Area	10	0.75	14.44	14.44	14.44	14.44	14.44	14.44
S_PurpleCreek_1	Discharge Per Area	10	0.75	611.48	611.48	611.48	611.48	611.48	611.48
S_PurpleCreek_2	Discharge Per Area	10	0.75	78.78	78.78	78.78	78.78	78.78	78.78
S_HangingMoss_3	Discharge Per Area	10	0.75	221.86	221.86	221.86	221.86	221.86	221.86
S_Pearl_Purple	Discharge Per Area	10	0.75	169.32	169.32	169.32	169.32	169.32	169.32
S_JacksonHewitt	Discharge Per Area	10	0.75	48.58	48.58	48.58	48.58	48.58	48.58
S_ChristwayChurch	Discharge Per Area	10	0.75	285.9	285.9	285.9	285.9	285.9	285.9
S_FlowoodYMCA	Discharge Per Area	10	0.75	154.56	154.56	154.56	154.56	154.56	154.56
S_CapitolBodyShop	Discharge Per Area	10	0.75	23.585	23.585	23.585	23.585	23.585	23.585
S_Pearl_HangingMoss	Discharge Per Area	10	0.75	150.52	150.52	150.52	150.52	150.52	150.52
S_HangingMossSouth	Discharge Per Area	10	0.75	16.996	16.996	16.996	16.996	16.996	16.996
S_HogCreek_1	Discharge Per Area	10	0.75	731.02	731.02	731.02	731.02	731.02	731.02
S_HogCreek2	Discharge Per Area	10	0.75	497.05	497.05	497.05	497.05	497.05	497.05
S_HogCreek_3	Discharge Per Area	10	0.75	29.562	29.562	29.562	29.562	29.562	29.562
S_HogCreek_4	Discharge Per Area	10	0.75	41.722	41.722	41.722	41.722	41.722	41.722
S_TwinLakeA	Discharge Per Area	10	0.75	116.89	116.89	116.89	116.89	116.89	116.89
S_Pearl_HogCreek	Discharge Per Area	10	0.75	99.059	99.059	99.059	99.059	99.059	99.059
S_TwinLakeB	Discharge Per Area	10	0.75	147.37	147.37	147.37	147.37	147.37	147.37

S_Pearl_Hwy25	Discharge Per Area	10	0.75	76.45	76.45	76.45	76.45	76.45	76.45
S_PrarieBranch_1	Discharge Per Area	10	0.75	943.89	943.89	943.89	943.89	943.89	943.89
S_PrarieBranch_2	Discharge Per Area	10	0.75	78.13	78.13	78.13	78.13	78.13	78.13
S_EubanksCr_4	Discharge Per Area	10	0.75	64.261	64.261	64.261	64.261	64.261	64.261
S_Pearl_PrarieBranch	Discharge Per Area	10	0.75	58.603	58.603	58.603	58.603	58.603	58.603
S_UMMC	Discharge Per Area	10	0.75	130.31	130.31	130.31	130.31	130.31	130.31
S_Pearl_EubanksCr	Discharge Per Area	10	0.75	72.277	72.277	72.277	72.277	72.277	72.277
S_Fairgrounds	Discharge Per Area	10	0.75	158.73	158.73	158.73	158.73	158.73	158.73
S_Pearl_I55	Discharge Per Area	10	0.75	96.278	96.278	96.278	96.278	96.278	96.278
S_TownCr_1	Discharge Per Area	10	0.75	831.37	831.37	831.37	831.37	831.37	831.37
S_TheVault	Discharge Per Area	10	0.75	155.86	155.86	155.86	155.86	155.86	155.86
S_TownCr_2	Discharge Per Area	10	0.75	33.194	33.194	33.194	33.194	33.194	33.194
S_TownCr_3	Discharge Per Area	10	0.75	209.79	209.79	209.79	209.79	209.79	209.79
S_Pearl_HWY80	Discharge Per Area	10	0.75	23.581	23.581	23.581	18.865	23.581	23.581
S_LynchCr_1	Discharge Per Area	10	0.75	450.75	450.75	450.75	360.6	450.75	450.75
S_WestsidePark	Discharge Per Area	10	0.75	316.09	316.09	316.09	252.87	316.09	316.09
S_LynchCr_2	Discharge Per Area	10	0.75	456.03	456.03	456.03	364.82	456.03	456.03
S_LynchCr_3	Discharge Per Area	10	0.75	368.18	368.18	368.18	294.54	368.18	368.18
S_GallatinStDump	Discharge Per Area	10	0.75	126.97	126.97	126.97	126.97	126.97	126.97
S_HardyCreek	Discharge Per Area	10	0.75	562.21	562.21	562.21	562.21	562.21	562.21
S_SavannaStWWTP	Discharge Per Area	10	0.75	48.43	48.43	48.43	48.43	48.43	48.43

S_CanyCreek_1	Discharge Per Area	10	0.75	854.08	854.08	854.08	854.08	854.08	854.08
S_Pearl-CanyCr	Discharge Per Area	10	0.75	590.05	590.05	590.05	590.05	590.05	590.05
S_CaneyCreek_2	Discharge Per Area	10	0.75	303.3	303.3	303.3	303.3	303.3	303.3
S_Pearl-RichlandCr	Discharge Per Area	10	0.75	88.588	88.588	88.588	88.588	88.588	88.588
S_Howard-Steamboat-Hawkins	Discharge Per Area	10	0.75	1679.9	1679.9	1679.9	1679.9	1679.9	1679.9
S_BigCreek	Discharge Per Area	10	0.75	2685	2685	2685	2685	2685	2685
S_TrahonCreek	Discharge Per Area	10	0.75	477.18	477.18	477.18	477.18	477.18	477.18
S_Trahon-Big	Discharge Per Area	10	0.75	1219	1219	1219	1219	1219	1219
S_SteenCreek_1	Discharge Per Area	10	0.75	4220.4	4220.4	4220.4	4220.4	4220.4	4220.4
S_MountainCreek	Discharge Per Area	10	0.75	2539	2539	2539	2539	2539	2539
S_SteenCreek_2	Discharge Per Area	10	0.75	2067.1	2067.1	2067.1	2067.1	2067.1	2067.1
S_Holcomb-Still	Discharge Per Area	10	0.75	1404.6	1404.6	1404.6	1404.6	1404.6	1404.6
S_RhodesCreek	Discharge Per Area	10	0.75	3711.6	3711.6	3711.6	3711.6	3711.6	3711.6
S_VaughnCreek	Discharge Per Area	10	0.75	1436	1436	1436	1436	1436	1436
S_Haley-Chestnut-Bear	Discharge Per Area	10	0.75	3759.5	3759.5	3759.5	3759.5	3759.5	3759.5
S_RockyCreek	Discharge Per Area	10	0.75	2663.3	2663.3	2663.3	2663.3	2663.3	2663.3
S_BrushyCreek	Discharge Per Area	10	0.75	2390.8	2390.8	2390.8	2390.8	2390.8	2390.8
S_Big-WeeksMill	Discharge Per Area	10	0.75	2108.3	2108.3	2108.3	2108.3	2108.3	2108.3
S_LimestoneCreek	Discharge Per Area	10	0.75	3790.9	3790.9	3790.9	3790.9	3790.9	3790.9
S_RenoCreek	Discharge Per Area	10	0.75	2343.7	2343.7	2343.7	2343.7	2343.7	2343.7

Subbasin-1	Discharge Per Area	10	0.75	131.39	131.39	131.39	131.39	131.39	131.39

Final Calibrated HEC-HMS Reach Routing Parameters

	Initial Type	Initial Discharge (CFS)	Length (FT)	Slope (FT/FT)	Manning's N	Space-time method	subreaches	subinterval	index method	Index Flow (CFS)	Index Celerity	Shape	Diameter	Width (FT)	Side Slope (XH:1V)	Left Manning's N	Right Manning's N	Cross Section	Elevation-Discharge	Elevation-Area	Elevation-width	Elevation-Perimeter	Invert (FT)
R_Richland1	Discharge		26912.48	0.00126	0.05	Auto DX A			Celerity		5	Trapezoid		25	2								
R_Richland2	Discharge		5033.477	0.00019	0.05	Auto DX A			Celerity		4	Trapezoid		30	2								
R_RichlandCr_3	Discharge		14969.28	0.00055	0.05	Auto DX A			Celerity		5	Trapezoid		30	2								
R_RichlandCr_4	Discharge		32935.53	0.0006	0.05	Auto DX A			Celerity		5	Trapezoid		40	2								
R_TerrapinSkinCr	Discharge		22766.3	0.00091	0.05	Auto DX A			Celerity		5	Trapezoid		25	2								
R_RichlandCr_5	Discharge		22821.96	0.00053	0.05	Auto DX A			Celerity		5	Trapezoid		40	2								
R_RichlandCr_6	Discharge		24884.27	0.00041	0.05	Auto DX A			Celerity		5	Trapezoid		45	2								
R_RichlandCr_7	Discharge		15453.72	0.00051	0.05	Auto DX A			Celerity		5	Trapezoid		50	2								
R_NeelyCr	Discharge		4825.814	0.0025	0.05	Auto DX A			Celerity		5	Trapezoid		25	2								
R_Eubanks_1	Discharge		15315.7	0.00271	0.05	Auto DX A			Flow	5		Trapezoid		20	2								
R_Eubanks_2	Discharge		6075.485	0.00434	0.05	Auto DX A			Celerity		5	Trapezoid		20	2								
R_HangingMoss_1	Discharge		5074.872	0.00233	0.05	Auto DX A			Celerity		5	Trapezoid		40	2								
R_HangingMoss_2	Discharge		5035.325	0.00191	0.05	Auto DX A			Celerity		5	Trapezoid		45	2								
R_HangingMoss_3	Discharge		5578.954	0.00227	0.05	Auto DX A			Celerity		5	Trapezoid		50	2								
R_WhiteOak_1	Discharge		34030.39	0.00204	0.05	Auto DX A			Flow	5		Trapezoid		30	2								
R_WhiteOak_2	Discharge		2617.718	0.00396	0.05	Auto DX A			Celerity		5	Trapezoid		30	2								
R_RossBOutflows	Discharge		8304.648	0.00008	0.05	Auto DX A			Celerity		5	Trapezoid		270	7.5								
R_PearlTrib	Discharge		16716.11	0.00159	0.05	Auto DX A			Celerity		5	Trapezoid		30	2								
R_Pearl1	Discharge		11382.31	0.00008	0.05	Auto DX A			Celerity		5	Trapezoid		270	7.5								
R_Pearl2	Discharge		5396.266	0.00006	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_UnnamedTrib10	Discharge		2685.408	0.00436	0.05	Auto DX A			Celerity		2	Trapezoid		5	2								
R_Pearl3	Discharge		5255.395	0.00006	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_Purple_1	Discharge		7438.2	0.00153	0.05	Auto DX A			Celerity		5	Trapezoid		35	2								
R_Purple_2	Discharge		1830.998	0.00031	0.05	Auto DX A			Celerity		3	Trapezoid		35	2								
R_Pearl4	Discharge		3590.717	0.00002	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_HangingMoss_4	Discharge		9377.966	0.00028	0.05	Auto DX A			Celerity		5	Trapezoid		55	2								
R_Pearl5	Discharge		1655.702	0.00001	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_UnnamedTrib1	Discharge		8744.314	0.00042	0.05	Auto DX A			Celerity		2	Trapezoid		15	2								
R_UnnamedTrib2	Discharge		3889.882	0.00157	0.05	Auto DX A			Celerity		5	Trapezoid		20	2								
R_UnnamedTrib3	Discharge		3375.926	0.00216	0.05	Auto DX A			Celerity		5	Trapezoid		5	2								
R_UnnamedTrib4	Discharge		8644.786	0.0016	0.05	Auto DX A			Celerity		5	Trapezoid		20	2								
R_Pearl6	Discharge		2255.616	0.00007	0.05	Auto DX A			Celerity		2	Trapezoid		270	7.5								
R_HangingMossSouth	Discharge		1262.818	0.00049	0.05	Auto DX A			Celerity		1	Trapezoid		8	2								
R_Pearl7	Discharge		3917.179	0.00002	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_HogCreek_1	Discharge		18436.12	0.00155	0.05	Auto DX A			Celerity		5	Trapezoid		45	2								
R_HogCreek2	Discharge		6294.605	0.0007	0.05	Auto DX A			Celerity		5	Trapezoid		45	2								
R_HogCreek_3	Discharge		4802.107	0.00089	0.05	Auto DX A			Celerity		5	Trapezoid		45	2								
R_HogCreek_4	Discharge		4003.19	0.00138	0.05	Auto DX A			Celerity		5	Trapezoid		45	2								
R_Pearl8	Discharge		5681.122	0.00002	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_UnnamedTrib5	Discharge		2514.917	0.00328	0.05	Auto DX A			Flow	5		Trapezoid		10	2								
R_Pearl9	Discharge		2479.91	0.00001	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_UnnamedTrib6	Discharge		2347.646	0.00039	0.05	Auto DX A			Celerity		2	Trapezoid		25	2								
R_Pearl10	Discharge		6404.957	0.00001	0.05	Auto DX A			Celerity		1	Trapezoid		270	7.5								
R_PrarieBranch	Discharge		11047.29	0.0006	0.05	Auto DX A			Celerity		5	Trapezoid		30	2								
R_Pearl11	Discharge		4983.422	0.00145	0.05	Auto DX A			Celerity		5	Trapezoid		270	7.5								
R_Eubanks_3	Discharge		2884.675	0.00128	0.05	Auto DX A			Celerity		5	Trapezoid		20	2								
R_Pearl12	Discharge		5380.32	0.00021	0.05	Auto DX A			Celerity		4	Trapezoid		270	7.5								
R_UnnamedTrib7	Discharge		2509.056	0.0006	0.05	Auto DX A			Celerity		3	Trapezoid		10	2								
R_Pearl13	Discharge		11041.43	0.00016	0.05	Auto DX A			Celerity		4	Trapezoid		270	7.5								
R_UnnamedTrib8	Discharge		5345.366	0.00648	0.05	Auto DX A			Celerity		5	Trapezoid		5	2								
R_Pearl14	Discharge		4840.862	0.00014	0.05	Auto DX A			Celerity		3	Trapezoid		270	7.5								
R_Town_1	Discharge		3655.766	0.00471	0.05	Auto DX A			Celerity		8	Trapezoid		20	2								
R_Town_2	Discharge		1030.814	0.0144	0.05	Auto DX A			Celerity		10	Trapezoid		20	2								
R_Town_3	Discharge		12754.53	0.00313	0.05	Auto DX A			Celerity		5	Trapezoid		20	2								
R_Town_4	Discharge		740.256	0.00034	0.05	Auto DX A			Celerity		4	Trapezoid		20	2								
R_Pearl15	Discharge		6149.986	0.00016	0.05	Auto DX A			Celerity		4	Trapezoid		270	7.5								
R_Lynch_1	Discharge		12800	0.00145	0.045	Auto DX A			Celerity		5	Trapezoid		20	2								
R_Lynch_2	Discharge		12383.13	0.0032	0.05	Auto DX A			Celerity		1	Trapezoid		20	2								
R_Lynch_3	Discharge		816.552	0.00107	0.05	Auto DX A			Celerity		5	Trapezoid		20	2								
R_Pearl16	Discharge		8913.538	0.00011	0.05	Auto DX A			Celerity		3	Trapezoid		270	7.5								

R_Pearl17	Discharge	7143.154	0.00021	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Pearl18	Discharge	3800.914	0.00014	0.05	Auto DX A	Celerity	3	Trapezoid	270	7.5
R_RichlandCr_8	Discharge	2440.786	0.00289	0.05	Auto DX A	Celerity	10	Trapezoid	50	2
R_Pearl19	Discharge	10654.78	0.00013	0.05	Auto DX A	Celerity	3	Trapezoid	270	7.5
R_Cany	Discharge	13243.93	0.00172	0.05	Auto DX A	Celerity	5	Trapezoid	35	2
R_Pearl20	Discharge	17053.29	0.00018	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Pearl21	Discharge	39221.42	0.0002	0.05	Auto DX A	Celerity	5	Trapezoid	270	7.5
R_Pearl22	Discharge	12019.44	0.00011	0.05	Auto DX A	Celerity	3	Trapezoid	270	7.5
R_BigCreek_1	Discharge	15782.87	0.00099	0.05	Auto DX A	Celerity	5	Trapezoid	40	2
R_Trahon	Discharge	30282.17	0.00133	0.05	Auto DX A	Celerity	5	Trapezoid	5	2
R_BigCreek_2	Discharge	6679.992	0.00116	0.05	Auto DX A	Celerity	5	Trapezoid	40	2
R_Pearl23	Discharge	34538.75	0.00013	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Steen_1	Discharge	24614.78	0.00065	0.05	Auto DX A	Celerity	4	Trapezoid	20	2
R_MountainCreek	Discharge	19756.18	0.00088	0.05	Auto DX A	Celerity	5	Trapezoid	10	2
R_Steen_2	Discharge	42706.44	0.00073	0.05	Auto DX A	Celerity	5	Trapezoid	30	2
R_Pearl24	Discharge	8923.622	0.00014	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Pearl25	Discharge	1924.402	0.00023	0.05	Auto DX A	Celerity	5	Trapezoid	270	7.5
R_Pearl26	Discharge	40616.29	0.00008	0.05	Auto DX A	Celerity	3	Trapezoid	270	7.5
R_Pearl27	Discharge	37582.25	0.00011	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Pearl28	Discharge	29120.68	0.0001	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Pearl29	Discharge	43356.77	0.0001	0.05	Auto DX A	Celerity	4	Trapezoid	270	7.5
R_Pearl30	Discharge	8794.896	0.0002	0.05	Auto DX A	Celerity	5	Trapezoid	270	7.5

Final Calibrated HEC-HMS Model Manning's N Values (Land Roughness Parameter) for Existing Conditions

	River Station	Frctn (n/K)	n #1	n #2	n #3	n #4	n #5	n #6	n #7
1	303.58	n	0.2	0.07	0.048	0.07	0.2		
2	303.22	n	0.2	0.07	0.045	0.07	0.2		
3	303.17	n	0.2	0.07	0.045	0.07	0.2		
4	303.03	n	0.2	0.07	0.042	0.07	0.2		
5	303.01	Lat Struct							
6	302.93	n	0.2	0.07	0.042	0.07	0.18		
7	302.8	n	0.2	0.07	0.042	0.07	0.18		
8	302.68	n	0.18	0.07	0.042	0.07	0.18		
9	302.5	n	0.18	0.07	0.07	0.042	0.07	0.18	
10	302.05	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18
11	301.86	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18
12	301.73	n	0.18	0.07	0.07	0.042	0.07	0.18	
13	301.54	n	0.18	0.07	0.042	0.07	0.18		
14	301	Lat Struct							
15	300.74	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18
16	300.47	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18
17	300.12	n	0.18	0.07	0.042	0.07	0.18		
18	299.62	n	0.18	0.07	0.042	0.07	0.18	0.07	0.18
19	299.45	Lat Struct							
20	299.02	n	0.18	0.07	0.042	0.07	0.18		
21	298.81	n	0.18	0.07	0.042	0.07	0.18		
22	298.47	n	0.18	0.07	0.042	0.07	0.18		
23	298.06	n	0.18	0.07	0.07	0.042	0.07	0.18	
24	297.87	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18
25	297.73	n	0.18	0.07	0.042	0.07	0.18		
26	297.66	n	0.18	0.07	0.042	0.07	0.18		
27	297.47	n	0.18	0.07	0.042	0.07	0.18		
28	297.22	n	0.18	0.07	0.042	0.07	0.18		
29	296.83	n	0.18	0.07	0.042	0.07	0.18		
30	296.36	n	0.18	0.07	0.042	0.07	0.18	0.07	0.18
31	296.1	n	0.18	0.07	0.042	0.07	0.18	0.07	0.18
32	295.63	n	0.18	0.07	0.04	0.07	0.18		

33	295.37	n	0.18	0.07	0.04	0.07	0.18		
34	295.14	n	0.18	0.07	0.04	0.07	0.18		
35	294.93	n	0.18	0.07	0.04	0.07	0.18		
36	294.66	n	0.18	0.07	0.04	0.07	0.18		
37	294.54	n	0.18	0.07	0.04	0.07	0.18		
38	294.5	Bridge							
39	294.43	n	0.18	0.065	0.04	0.065	0.18		
40	294.15	n	0.16	0.065	0.04	0.065	0.16		
41	293.87	n	0.16	0.065	0.04	0.065	0.16		
42	293.57	n	0.16	0.065	0.04	0.065	0.16	0.065	0.18
43	293.4	Lat Struct							
44	292.83	n	0.16	0.065	0.04	0.065	0.16		
45	292.62	n	0.16	0.065	0.04	0.065	0.16		
46	292.52	n	0.16	0.065	0.04	0.065	0.16		
47	292.43	n	0.16	0.065	0.04	0.065	0.16		
48	292.39	Bridge							
49	292.38	n	0.12	0.04	0.12				
50	292.37	Lat Struct							
51	292.35	n	0.16	0.065	0.04	0.065	0.16		
52	292.15	n	0.16	0.065	0.04	0.065	0.16		
53	291.95	n	0.16	0.04	0.16				
54	291.9	Lat Struct							
55	291.62	n	0.16	0.04	0.16				
56	291.55	Lat Struct							
57	291.4	n	0.16	0.04	0.16				
58	291.05	Inl Struct							
59	290.96	n	0.16	0.04	0.16				
60	290.61	n	0.16	0.04	0.16				
61	290.36	n	0.16	0.04	0.16				
62	290.13	n	0.16	0.04	0.16				
63	290.1	Bridge							
64	290.06	n	0.16	0.04	0.18				
65	289.91	n	0.16	0.04	0.18				
66	289.73	n	0.16	0.04	0.12				
67	289.6	n	0.16	0.04	0.12				

68	289.58	Lat Struct						
69	289.37	n	0.16	0.042	0.16			
70	289.35	Bridge						
71	289.32	n	0.1	0.0425	0.16			
72	289.28	n	0.1	0.042	0.16			
73	289.25	n	0.1	0.042	0.16			
74	289.18	n	0.1	0.042	0.16			
75	289.16	Bridge						
76	289.14	n	0.2	0.0425	0.16			
77	289.1	Lat Struct						
78	288.94	n	0.08	0.042	0.065			
79	288.81	n	0.065	0.042	0.065			
80	288.8	Bridge						
81	288.76	n	0.065	0.0425	0.065			
82	288.63	n	0.065	0.042	0.055			
83	288.49	n	0.065	0.042	0.075			
84	288.4	Bridge						
85	288.32	n	0.065	0.0425	0.065			
86	288.19	n	0.065	0.042	0.065			
87	288.04	n	0.065	0.042	0.065			
88	288.035	Bridge						
89	288.03	n	0.065	0.0425	0.065	0.15	0.055	0.18
90	287.89	n	0.065	0.042	0.065	0.15	0.055	
91	287.75	n	0.065	0.042	0.065	0.15		
92	287.61	n	0.065	0.042	0.065	0.15		
93	287.45	n	0.065	0.042	0.065	0.15		
94	287.18	n	0.13	0.042	0.15	0.055		
95	286.94	n	0.15	0.042	0.15	0.055		
96	286.9	n	0.15	0.042	0.15	0.055		
97	286.85	n	0.15	0.042	0.15	0.055		
98	286.33	n	0.15	0.042	0.15	0.075		
99	286.31	n	0.15	0.042	0.15	0.075		
100	286.09	n	0.15	0.042	0.15	0.075		
101	286.05	Lat Struct						
102	286.01	n	0.15	0.042	0.15	0.075		

103	285.9	Lat Struct			
104	285.81	n	0.15	0.042	0.15
105	285.8	n	0.15	0.042	0.15
106	285.65	n	0.15	0.042	0.15
107	285.44	n	0.15	0.042	0.15
108	285.31	n	0.15	0.042	0.15
109	285.06	n	0.15	0.042	0.15
110	284.21	n	0.15	0.042	0.15
111	283.41	n	0.15	0.042	0.15
112	282.56	n	0.15	0.042	0.15
113	282.15	n	0.15	0.042	0.15
114	281.87	n	0.15	0.042	0.15
115	281.53	n	0.15	0.042	0.15
116	281.12	n	0.15	0.042	0.15
117	280.79	n	0.15	0.042	0.15
118	280.52	n	0.15	0.042	0.15
119	280.18	n	0.15	0.042	0.15
120	279.79	n	0.15	0.042	0.15
121	279.42	n	0.15	0.042	0.15
122	278.98	n	0.15	0.042	0.15
123	278.68	n	0.15	0.042	0.15
124	278.33	n	0.15	0.042	0.15
125	278.01	n	0.15	0.042	0.15
126	277.53	n	0.15	0.042	0.15
127	277.25	n	0.15	0.042	0.15
128	276.9	n	0.15	0.042	0.15
129	276.55	n	0.15	0.042	0.15
130	275.9	n	0.15	0.042	0.15
131	275.17	n	0.15	0.042	0.15
132	274.78	n	0.15	0.042	0.15
133	274.46	n	0.15	0.042	0.15
134	274.1	n	0.15	0.042	0.15
135	273.8	n	0.15	0.042	0.15
136	273.44	n	0.15	0.042	0.15
137	273.05	n	0.15	0.042	0.15

138	272.78	n	0.15	0.042	0.15
139	272.44	n	0.15	0.042	0.15
140	272.06	n	0.15	0.042	0.15
141	271.46	n	0.15	0.042	0.15
142	271.11	n	0.15	0.042	0.15
143	270.77	n	0.15	0.042	0.15
144	270.45	n	0.15	0.042	0.15
145	270	n	0.15	0.042	0.15
146	268.62	n	0.15	0.042	0.15
147	267.01	n	0.15	0.042	0.15

Final Calibrated Ineffective Areas for Existing Conditions

	RS	Left	Right	Elev	Left	Right	Elev	Left	Right	Elev	Left	Right	Elev	Left	Right	Elev	Left	Right	Elev	Left	Right	Elev	Left	Right	Elev
1	303.58	1731	3967.52	274.3	5530.02	6862.75	272.54	7797.18	10033.7	271.31	12530.64	14491.42	278.69	15747.55	16896.45	280.63									
2	303.22	2475.49	3443.63	279.57	3994.78	6579.63	273.21	8798.96	12454.31	270.9	13272.06	14460.78	276.18	15110.29	15870.1	282.09									
3	303.17	2254.9	3313.73	282.29	3431.37	4186.27	278.44	4382.35	4980.39	275.05	5862.75	6333.33	272.41	8501.31	12449.09	271.15	13019.61	13813.73	274.52	14382.35	14705.88	276.26			
4	303.03	3107.84	7176.47	280.33	8167.1	12114.88	266.46	12147.06	12529.41	270.38	13078.43	14029.41	275.2												
5	302.93	4795.34	7317.4	278.44	7549.02	7797.79	272.56	8315.93	13616.19	271.54															
6	302.8	5318.63	7300.25	278.22	7480.39	8063.73	273.62	8553.52	12903.39	268.46															
7	302.68	5772.06	6029.41	278.29	6897.06	7705.88	274.97	8569.19	11984.33	272.23															
8	302.5	5781.86	8175.25	277.91	8992.17	12099.22	271.23																		
9	302.05	5730.39	9041.67	277.69	9221.81	9719.36	273.32	9796.57	10148.28	266.16	11167.1	12026.11	269.23												
10	301.86	5335.78	5884.8	278.22	7180.15	9178.92	276.63	10344.65	12336.81	269.77															
11	301.73	2136.03	5009.8	277.61	5738.97	9299.02	278.22	10563.97	12647.52	270.15															
12	301.54	797.79	5910.54	278.19	6305.15	9444.85	277.89	10302.7	13316.62	267.34															
13	300.74	674.02	7996.32	278.44	9007.35	11090.69	275.88	11504.29	12193.63	270.15	12300.86	12775.74	267.74	13403.8	14583.33	265.78									
14	300.47	686.27	8651.96	278.59	9411.76	11299.02	273.17	12438.73	12732.84	268.34	13051.47	13590.69	264.57	13823.53	14203.43	269.1									
15	300.12	1210.17	8164.83	277.31	8318.01	10248.16	268.39	10370.71	12254.9	269.77	13005.51	13710.17	264.87												
16	299.62		11780.02	264.72	12622.55		268.44																		
17	299.02		10582	266.68																					
18	298.81		9550	267.29																					
19	298.47		9090	263.37	9800		262.11																		
20	298.06		10200	268.04	11100		269.75																		
21	297.87		9479	266.08	10200		266.83																		
22	297.73		8590	263.3	9290		264.89																		
23	297.66		8095.35	269.95																					
24	297.47		7300	269.55	8100		277.38																		
25	297.22	1540.18	5330.7	267.59	5902.5	6732.54	277.85																		
26	296.83	10.54	3752.31	274.27	4047.43	5839.26	269.65	6640.32	7051.38	259.5	7051.38	7588.93	266.93												
27	296.36	488.8	1586.3	273.53	2305.67	3061.92	270.89	3956.52	4989.46	267.55	5026.35	6234.52	270.54												
28	296.1	55.34	569.17	267.64	727.27	1446.64	265.5	2213.44	3185.77	263.12	3249.01	5320.16	269.33												
29	295.63	86.96	1881.42	266.41	2031.62	3130.43	266.41	3486.17	3818.18	265.8	4237.15	4837.94	267.91	4964.43	5707.51	275.6									
30	295.37	230.57	691.7	271.23	1162.06	1577.08	270.78	1955.2	2637.68	265.5	2683.79	3098.81	265.2	3790.51	4011.86	268.89	4067.19	5441.37	267.16	5459.82	6372.86	272.21			
31	295.14	1162.06	2996.05	269.9	3446.64	3636.36	267.79	3667.98	5264.82	266.43															
32	294.93	498.02	924.9	264.62	948.62	1083	264.62	1462.45	1711.46	263.72	1861.66	2802.37	267.19												
33	294.66	65.54	390.14	261.86	992.51	2019.35	260.78																		
34	294.54	131.09	365.17	258.52	780.27	1201.62	262.91	1741.57	2331.46	273.47															
35	294.43	1816.48	2539.33	276.78																					
36	294.15	4.37	83.02	282.09	380.15	1109.86	258.59	1586.14	2831.46	259.346															
37	293.87	8.74	201	265.03	1022.47	2272.16	267.44	2997.5	4360.8	265.93	4421.97	5898.88	267.54												
38	293.57	0	800	272.31	828.96	2696.63	262.96	3136.08	4654.18	262.81	4734.08	7171.04	266.88	7360.8	7550.56	281.06									
39	292.83	30.77	4692.31	271.26	4923.08	5892.31	261.91	6400	7984.62	260.25															
40	292.62	246.15	5600	269.95	5646.15	6123.08	262.96	7030.77	7523.08	261.16	7600	8292.31	265.53												
41	292.52	960	6547.69	264.42																					
42	292.43		6301.54	268.84	6880		257.09																		
43	292.38		5107.69	270.5	6104.62		258.34																		
44	292.35		2218.14	265.38	2674.63		258.89																		
45	292.15		2441.79	260.98	3158.7		265.73																		
46	291.95		2724.26	261.73	3389.71		258.97																		
47	291.62		2459.56	266.38	3599.26		250.18																		
48	291.4		1647.06	260.23	2131.74		254.2																		
49	290.96		495.1	257.01	1193.63		251.86																		
50	290.61		692.4	255.69	1039.22		254.75																		
51	290.36		582.11	258.44	1738.66		259.2																		
52	290.13		716.91	260.4	1508.58		264.23																		
53	290.06		488.66	269.89	1181.07		259.46																		
54	289.91		626.53	254.69	1292.89		256.51																		
55	289.73		954.04	256.53	1950.37		255.33																		
56	289.6	79.35	589.77	254.1	737.75	980.09	254.36	1654.41	3345.31	256.78															
57	289.37	25.15	1441.92	267.24	1500.6	2229.94	258.57																		
58	289.32	244.31	718.56	261.01	768.86	1544.91	260.52	1595.21	1817.96	258.76	1861.08	2141.32	255.77												
59	289.28	218.75	612.13	260.73	711.4	1413.6	259.7	1501.84	1698.53	257.36	1735.29	1961.4	254.65												
60	289.25		1750	258.94																					
61	289.18	117.37	461.08	270.98	586.83	1211.38	265.62	1261.68	1567.66	261.66															
62	289.14	75.45	926.35	260.3	976.65	1173.65	258.12	1202.99	1366.47	257.36	2282.48	2412.68	274.97												
63	288.94	200.06	773.59	257.0754	1194.85	1306.68	252.24	1776.96	1988.36	255.25	2219.67	2328.43	273.34												
64	288.81	35.78	260.05	260.35	716.91	1051.47	255.59	1132.35	1294.12	256.03	1422.75	1534.13	264.65	1645.56	2064.67	265.611	2078.74	2173.71	271.02						
65	288.76	0	290.44	256.76	889.71	1139.71	257.89	1420.4	2032.31	269.3173															
66	288.63	120.1	501.84	254.451	960.78	2294.73	257.61	2342.22	2418.81	267.63															
67	288.49	51.68	356.2	252.334	969.56	1205.47	255.413	1424.02	1955.88	273.88	2118.87	2303.31	274.1	2335.48	3086.09	273.27									
68	288.32	63.75	458.35	260.91	837.19	1416.22	260.606	2389.65	2960.07	270.279	3282.04	3357.49	270.5												
69	288.19	132.58	651.59	256.735	1342.52	1544.12	248.99	1733.02	2140.53	259.601	2458.63	2908.98	267.378	2950.9	3096.72	271.773	3466.47	3600.6	271.95						
70	288.04	19.61	441.18	271.53	500	1274.51	251.03	1480.39	1901.96	270.63	2544.12	2941.18	250.05	3093.14	3691.18	267.7676	3723.13	4046.68	270.9462	4246.32	4427.08	271.53			
71	288.03	485.29	818.63	251.26	1093.7	1427.02	256.2967	1514.71	1985.29	269.5744	2524.51	2926.47	251.1854	3122.11	3484.84	270.105	3490.2	3647.06	270.18	3691.18	4509.8	271.98			
72	287.89	53.92	269.61	265.97	485.29	1406.86	255.8138	1784.31	2039.22	257.53	2848.04	3877.45	257.96	4241.2	4339.25	271.5359									

73	287.75	31.45	382.39	267.56	490.2	1073.53	252.89	2171.57	2470.59	253.94																		
74	287.61	18.54	191.35	267.543	314.77	1296.36	259.0035	1849.26	2018.38	256.38	2176.31	2404.24	265.4271															
75	287.45	18.38	136.03	266.96	279.16	1400.48	253.808	2150.74	3198.53	269.7																		
76	287.18	81.5	184.44	266.96	244.08	673.01	258.8859	1226.8	1389.81	261.5484	2153.11	2543.43	262.7993	2723.65	3135.42	272.2309	3718.63	4254.78	260.697									
77	286.94	54.49	946.72	261.9141	1908.69	2084.57	261.7506	2127.45	3234.07	257.6915	3452.8	3611.54	268.041	3748.86	5280.14	263.223												
78	286.9	433.65	5073.34	263.9592	5786.76	6750	252.8673	7838.08	8830.71	260.1223																		
79	286.85	435.76	6131.83	262.5903	6862.75	7900.74	254.07	9333.33	9950.98	252.2568																		
80	286.33	318.61	4950.97	264.8612	5215.69	8667.81	263.1951	8779.41	9937.5	252.109	10455.88	11183.82	253.17															
81	286.31	212.72	9342.67	263.3496	9375	10340.07	252.1136	10998.77	11335.78	253.47																		
82	286.09	442.51	10077.84	263.6229	11351.1	12913.6	253.5638	14351.8	15485.33	262.6204	15640.32	18826.59	272.6673															
83	286.01	245.08	1892.12	266.0221	2244.41	7871.9	263.0736	7951.23	9784.53	257.5508	12107.84	13156.86	249.6495	13941.18	14931.37	270												
84	285.81	980.39	3558.82	269.37	3772.93	7351.38	263.2679	7656.81	9009.82	257.6131	10715.69	10931.35	263.4141	12147.06	13774.51	248.8686	14205.88	14431.37	253.47	14490.2	15078.43	264.62						
85	285.8	1058.82	2901.96	268.3624	3656.86	7362.75	262.2946	7637.25	9088.24	256.32	10803.92	11049.02	262.47	12294.12	12901.96	245.5948	13019.61	13784.31	250.08	14107.84	14490.2	255.53	14539.22	14980.39	264.67			
86	285.65	931.37	3460.78	267.26	3627.45	7254.9	261.98	7627.45	12490.2	257.8384	12941.18	14254.9	249.62	14313.73	14745.1	259.5	14813.73	15264.71	263.19	15333.33	15656.86	272.99						
87	285.44	401.96	1000	268.2427	1127.45	1303.92	267.56	2088.24	6127.45	263.338	6696.08	7656.86	261.68	7931.37	9019.61	253.54	10245.1	10529.41	261.61	10911.76	12960.78	254.52	13480.39	14235.29	256.33	14303.92	14980.39	265.6822
88	285.31	68.63	794.12	269.2942	892.16	3117.65	266.8113	4931.37	7754.9	261.1565	8294.12	12725.49	254.295	13352.94	13764.71	245.4005	13843.14	14196.08	247.7364	14441.18	14735.29	260.4						
89	285.06	117.65	3490.2	266.3583	5225.49	8960.78	260.1797	9127.45	13303.92	253.8427	13960.78	14666.67	251.13															
90	284.21	94.36	1329.66	268.9972	2101.72	5850.49	265.306	6802.7	8852.94	263.72	9933.82	10122.55	262.81	10302.7	11555.15	254.5234	12095.59	12473.04	249.7716									
91	283.41	2736.06	5608.53	264.3467	6882.35	8754.9	263.56	9401.96	10294.12	261.88	10480.39	12519.61	254.1431	12980.39	14647.06	252.6464												
92	282.56	318.63	3149.51	269.4518	3993.08	6860.73	262.5096	7475.49	8235.29	263.27	10330.88	10735.29	261.61	10845.59	13345.59	256.7123	13406.86	14007.35	253.77	14808.62	17271.92	252.0322						
93	282.15	582.11	7735.91	267.51	7873.77	8517.16	258.03	8731.62	10968.14	261.93	11029.41	11305.15	257.29	11841.3	12683.82	253.29	13863.36	15196.08	248.0726	15839.46	16329.66	258.34	16804.54	18903.19	261.6649			
94	281.87	6121.32	8841.91	268.3704	9283.09	10992.65	255.7053	11158.09	12279.41	244.6231	13694.85	14595.59	254.3	16066.18	19044.12	260.1023	20202.21	21047.79	269.42									
95	281.53	6280.64	8716.3	267.4844	9650.74	11473.65	245.0266	12545.96	13342.52	247.1311	13495.71	22089.46	261.605															
96	281.12	7169.12	8700.98	266.8859	8992.03	10263.48	245.4744	11268.54	11820.01	242.9462	12132.35	19745.71	260.5543	20220.59	22012.87	265.9829												
97	280.79	5713.85	6648.28	267.66	7000.57	9129.89	263.094	10477.94	10952.82	252.36	11060.05	12454.04	255.18	12607.23	22686.89	261.51												
98	280.52	5821.08	6326.59	269.3	6737.95	9510.64	260.2528	10738.36	11090.69	248.64	11228.55	12683.82	252.11	12944.24	22886.03	260.25												
99	280.18	5300.25	6142.77	269.6025	7705.27	9359.68	257.9945	9600.97	9884.53	253.47	9911.15	11106	247.2819	12086.4	12316.18	246.98	12484.68	13587.62	255.2764	13694.85	23820.46	259.3467						
100	279.79	8180.15	9117.65	264.32	10036.76	10753.68	261.46	11286.76	11893.38	254.37	12169.12	12867.65	242.46	13400.74	13694.85	253.77	14779.41	16966.91	255.73	17077.21	25459.56	259.65						
101	279.42	3431.37	5438.11	259.2246	6694.24	7291.67	261.68	7582.72	9405.64	244.7972	11305.15	12377.45	256.0518	12530.64	12714.46	253.77	12837.01	13327.21	254.65	13572.3	22671.57	259.5729						
102	278.98	2405.02	2987.13	266.9633	6893.38	7674.63	244.4472	8792.89	10952.82	255.7018	12637.87	13449.75	249.2	13909.31	14522.06	254.47	14828.43	21599.27	259.5729									
103	278.68	4120.71	5055.15	267.89	6112.13	6357.23	260.85	7230.39	12071.08	249.25	12852.33	13174.02	255.93	13327.21	19577.21	258.22	19745.71	20021.45	263.49									
104	278.33	8700.98	9267.77	258.04	10125.61	11259.19	249.42	11672.79	14093.14	255.05	14261.64	15042.89	252.06	15333.95	15900.74	254.7	16636.03	22870.71	259.099									
105	278.01	2267.16	3725.49	247.4859	4926.47	6715.69	241.1528	7095.59	8210.78	251.56	8602.94	9191.18	248.09	9473.04	9975.49	254.87	10465.69	16960.79	258.194	17058.82	17205.88	261.36						
106	277.53	1974.26	2371.32	249.45	2680.15	3794.12	245.98	4488.97	5227.94	247.19	6363.97	6805.15	245.38	7930.15	8514.71	250.05	8669.12	15132.35	258.04									
107	277.25	1235.29	4036.76	245.8261	6341.91	7566.18	245.3739	7731.62	13908.09	256.8327																		
108	276.9	529.41	941.18	264.37	1235.29	3333.33	239.802	3941.18	4931.37	247.19	5821.27	7076.18	246.4292	7221.81	13280.64	257.7372	13382.35	13931.37	265.1226									
109	276.55	1211.91	2106.52	259.449	2855.39	5183.82	240.4487	6580.88	7107.84	245.73	7230.39	9460.78	246.9651	9656.86	15906.86	258.74												
110	275.9	833.33	1049.02	269.12	1509.8	2490.2	253.8173	3284.31	3862.75	242.56	4823.53	7205.88	244.8492	7382.35	13382.35	258.04	13558.82	13960.78	267.36									
111	275.17	1055.15	1801.47	258.22	1938.73	2221.81	247.3116	2702.21	3731.62	243.27	4477.94	4666.67	250.65	5155.64	5498.77	248.19	5962.01	10886.03	256.9832									
112	274.78	1725.49	2803.92	264.5442	3166.67	3333.33	248.37	3460.78	3843.14	237.8158	4588.24	6607.84	247.6616	6656.86	11490.2	256.8091												
113	274.46	2007.35	2384.8	237.09	2873.77	3002.45	243.72	3071.08	4186.27	251.7131	4297.79	4855.39	251.56	5859.07	10062.5	256.98	10294.12	10474.26	259.85	10534.31	11246.32	262.5673						
114	274.1	2377.45	3259.8	268.94	3394.81	5355.62	261.0284	5428.92	5588.24	257.16	5625	7990.2	252.9379	8284.31	8811.27	247.49	8884.8	9387.25	258.39	9950.98	10526.96	245.2	10955.88	16286.76	256.2796	16617.65	17389.71	260.68
115	273.8	2050.25	3431.37	256.46	3697.3	4057.6	259.27	4829.66	5464.46	248.19	6107.84	7952.21	254.35	8466.91	8767.16	256.11	8844.38	10731.64	258.0349	10817.4	11889.71	261.73						
116	273.44	1213.24	2713.24	257.16	2941.18	3676.47	252.76	4735.29	5713.24	252.59	6014.71	6639.71	253.47	8977.94	9102.94	260.5	9183.82	10330.88	262.26									
117	273.05	952.21	1355.39	254.12	2144.61	3036.76	249.75	4203.43	5936.27	252.31	6416.67	9033.09	256.23	9333.33	10011.03	260.3												
118	272.78	1225.49	2460.78	250.95	2872.55	3862.75	251.86	3950.98	4166.67	258.79	5313.73	6588.24	253.07	6754.9	7480.39	252.46	7558.82	7882.35	255.93	9401.96	10588.24	256.68	10764.71	11352.94	259.85			
119	272.44	1533.11	2580.85	256.3774	3055.15	3948.53	252.61	4080.88	4764.71	249.6	4775.74	5371.32	252.91	6197.7	7796.97	255.9251	8988.97	9341.91	248.39	10897.06	11580.88	256.08	12044.12	12738.97	261.06	12981.62	13731.62	262.71
120	272.06	1608.53	4315.92	255.5814	4392.88	5353.69	250.1256	5438.06	5900.54	260.15	6029.41	6392.16	259.1	6858.53	7193.95	260.15	7272.33	7997.82	254.345	8656.86	8852.94	243.97	9294.12	12343.14	264.55			

Final Calibrated HEC-HMS Model Manning's N Values (Land Roughness Parameter) for Alternative C

	River Station	Frctn (n/K)	n #1	n #2	n #3	n #4	n #5	n #6	n #7	n #8
1	303.58	n	0.2	0.07	0.048	0.07	0.2			
2	303.22	n	0.2	0.07	0.045	0.07	0.2			
3	303.17	n	0.2	0.07	0.045	0.07	0.2			
4	303.03	n	0.2	0.07	0.042	0.07	0.2			
5	303.01	Lat Struct								
6	302.93	n	0.2	0.07	0.042	0.07	0.18			
7	302.8	n	0.2	0.07	0.042	0.07	0.18			
8	302.68	n	0.18	0.07	0.042	0.07	0.18			
9	302.5	n	0.18	0.07	0.07	0.042	0.07	0.18		
10	302.05	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18	
11	301.86	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18	
12	301.73	n	0.18	0.07	0.07	0.042	0.07	0.18		
13	301.54	n	0.18	0.07	0.042	0.07	0.18			
14	301	Lat Struct								
15	300.74	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18	
16	300.47	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18	
17	300.12	n	0.18	0.07	0.042	0.07	0.18			
18	299.62	n	0.18	0.07	0.042	0.07	0.18	0.07	0.18	
19	299.45	Lat Struct								
20	299.02	n	0.18	0.07	0.042	0.07	0.18			
21	298.81	n	0.18	0.07	0.042	0.07	0.18			
22	298.47	n	0.18	0.07	0.042	0.07	0.18			
23	298.06	n	0.18	0.07	0.07	0.042	0.07	0.18		
24	297.87	n	0.18	0.07	0.18	0.07	0.042	0.07	0.18	
25	297.73	n	0.18	0.07	0.042	0.07	0.18			
26	297.66	n	0.18	0.07	0.042	0.07	0.18			
27	297.47	n	0.18	0.07	0.042	0.07	0.18			
28	297.22	n	0.18	0.07	0.042	0.07	0.18			
29	296.83	n	0.18	0.07	0.042	0.07	0.18			
30	296.36	n	0.18	0.07	0.042	0.07	0.18	0.07	0.18	
31	296.1	n	0.18	0.07	0.042	0.07	0.18	0.07	0.18	
32	295.63	n	0.18	0.07	0.04	0.07	0.18			

33	295.37	n	0.18	0.07	0.04	0.07	0.18			
34	295.14	n	0.18	0.05	0.07	0.04	0.07	0.05	0.18	
35	294.93	n	0.05	0.07	0.04	0.05	0.18			
36	294.66	n	0.18	0.05	0.07	0.04	0.05	0.18	0.05	0.18
37	294.54	n	0.18	0.05	0.04	0.05	0.18	0.05	0.18	
38	294.5	Bridge								
39	294.43	n	0.18	0.05	0.04	0.05	0.18			
40	294.15	n	0.16	0.05	0.04	0.05	0.16			
41	293.87	n	0.16	0.05	0.16	0.05	0.04	0.05	0.16	
42	293.57	n	0.16	0.05	0.04	0.05	0.18			
43	293.4	Lat Struct								
44	292.83	n	0.16	0.05	0.16	0.05	0.065	0.04	0.065	0.16
45	292.62	n	0.16	0.05	0.16	0.05	0.065	0.04	0.05	0.16
46	292.52	n	0.16	0.05	0.16	0.05	0.065	0.04	0.065	0.16
47	292.43	n	0.16	0.05	0.16	0.05	0.065	0.04	0.065	0.16
48	292.39	Bridge								
49	292.38	n	0.65	0.04	0.12					
50	292.37	Lat Struct								
51	292.35	n	0.5	0.16	0.05	0.04	0.065	0.16		
52	292.15	n	0.05	0.065	0.04	0.065	0.16			
53	291.95	n	0.05	0.04	0.16					
54	291.9	Lat Struct								
55	291.62	n	0.05	0.16	0.05	0.04	0.05	0.16		
56	291.55	Lat Struct								
57	291.4	n	0.05	0.04	0.05	0.16				
58	291.05	Inl Struct								
59	290.96	n	0.05	0.04	0.05	0.16				
60	290.61	n	0.05	0.04	0.05	0.16				
61	290.36	n	0.05	0.04	0.05	0.16				
62	290.13	n	0.05	0.04	0.05	0.16				
63	290.1	Bridge								
64	290.06	n	0.16	0.05	0.04	0.05	0.18			
65	289.91	n	0.05	0.04	0.05	0.16				
66	289.73	n	0.05	0.04	0.05	0.12				
67	289.6	n	0.05	0.04	0.12					

68	289.58	Lat Struct								
69	289.37	n	0.16	0.05	0.042	0.16				
70	289.35	Bridge								
71	289.32	n	0.1	0.05	0.1	0.05	0.1	0.05	0.0425	0.16
72	289.28	n	0.1	0.05	0.1	0.05	0.042	0.16		
73	289.25	n	0.1	0.05	0.1	0.05	0.042	0.16		
74	289.18	n	0.1	0.05	0.1	0.05	0.042	0.16		
75	289.16	Bridge								
76	289.14	n	0.05	0.2	0.05	0.0425	0.16			
77	289.1	Lat Struct								
78	288.94	n	0.05	0.042	0.05	0.065				
79	288.81	n	0.065	0.05	0.042	0.05	0.065			
80	288.8	Bridge								
81	288.76	n	0.05	0.0425	0.05	0.065				
82	288.63	n	0.05	0.042	0.05	0.055				
83	288.49	n	0.05	0.042	0.075					
84	288.4	Bridge								
85	288.32	n	0.05	0.0425	0.05	0.065				
86	288.19	n	0.05	0.042	0.05	0.065				
87	288.04	n	0.065	0.05	0.042	0.065				
88	288.035	Bridge								
89	288.03	n	0.065	0.05	0.0425	0.05	0.065	0.15	0.055	0.18
90	287.89	n	0.065	0.05	0.042	0.05	0.15	0.055		
91	287.75	n	0.05	0.042	0.05	0.15				
92	287.61	n	0.05	0.042	0.05	0.065	0.15			
93	287.45	n	0.065	0.05	0.042	0.05	0.065	0.15		
94	287.18	n	0.13	0.05	0.042	0.05	0.15	0.055		
95	286.94	n	0.15	0.042	0.05	0.15	0.055			
96	286.9	n	0.15	0.042	0.05	0.15	0.055			
97	286.85	n	0.15	0.042	0.05	0.15	0.055			
98	286.33	n	0.15	0.05	0.042	0.042	0.15	0.075		
99	286.32	Inl Struct								
100	286.31	n	0.15	0.045	0.15	0.075				
101	286.09	n	0.15	0.042	0.15	0.075				
102	286.05	Lat Struct								

103	286.01	n	0.15	0.042	0.15	0.075
104	285.9	Lat Struct				
105	285.81	n	0.15	0.042	0.15	
106	285.8	n	0.15	0.042	0.15	
107	285.65	n	0.15	0.042	0.15	
108	285.44	n	0.15	0.042	0.15	
109	285.31	n	0.15	0.042	0.15	
110	285.06	n	0.15	0.042	0.15	
111	284.21	n	0.15	0.042	0.15	
112	283.41	n	0.15	0.042	0.15	
113	282.56	n	0.15	0.042	0.15	
114	282.15	n	0.15	0.042	0.15	
115	281.87	n	0.15	0.042	0.15	
116	281.53	n	0.15	0.042	0.15	
117	281.12	n	0.15	0.042	0.15	
118	280.79	n	0.15	0.042	0.15	
119	280.52	n	0.15	0.042	0.15	
120	280.18	n	0.15	0.042	0.15	
121	279.79	n	0.15	0.042	0.15	
122	279.42	n	0.15	0.042	0.15	
123	278.98	n	0.15	0.042	0.15	
124	278.68	n	0.15	0.042	0.15	
125	278.33	n	0.15	0.042	0.15	
126	278.01	n	0.15	0.042	0.15	
127	277.53	n	0.15	0.042	0.15	
128	277.25	n	0.15	0.042	0.15	
129	276.9	n	0.15	0.042	0.15	
130	276.55	n	0.15	0.042	0.15	
131	275.9	n	0.15	0.042	0.15	
132	275.17	n	0.15	0.042	0.15	
133	274.78	n	0.15	0.042	0.15	
134	274.46	n	0.15	0.042	0.15	
135	274.15	Lat Struct				
136	274.1	n	0.15	0.042	0.15	
137	274.09	Lat Struct				

138	273.8	n	0.15	0.042	0.15		
139	273.44	n	0.15	0.042	0.15		
140	273.05	n	0.15	0.042	0.15		
141	272.78	n	0.15	0.042	0.15		
142	272.44	n	0.15	0.042	0.15		
143	272.3	Lat Struct					
144	272.2	n	0.15	0.042	0.15	0.042	0.15
145	272.18	Lat Struct					
146	272.06	n	0.15	0.042	0.15		
147	271.46	n	0.15	0.042	0.15		
148	271.4	Lat Struct					
149	271.11	n	0.15	0.042	0.15		
150	270.77	n	0.15	0.042	0.15		
151	270.45	n	0.15	0.042	0.15		
152	270	n	0.15	0.042	0.15		
153	268.62	n	0.15	0.042	0.15		
154	267.01	n	0.15	0.042	0.15		

Summary Results a Selected Cross Sections for Various Scenarios for HEC-Ras Model

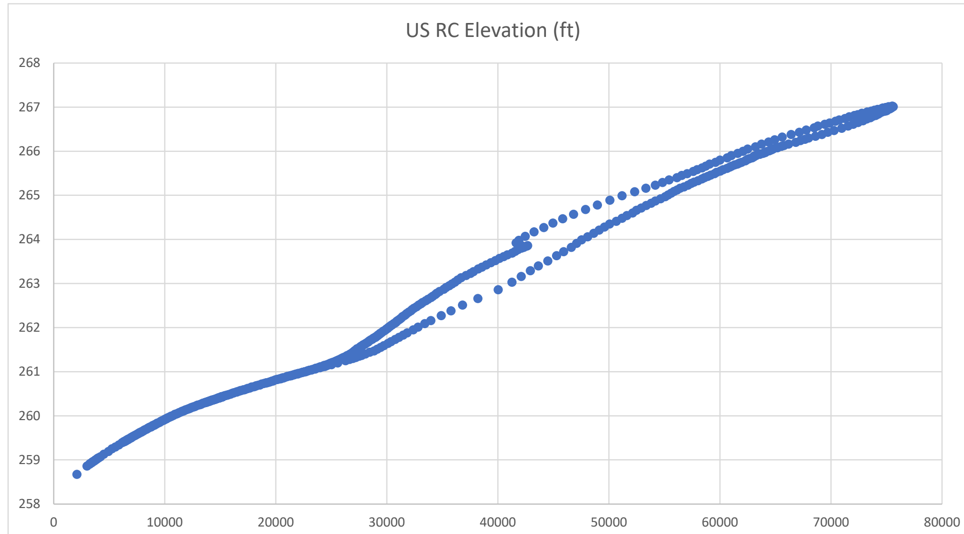
River	Reach	River Sta	Profile	Plan	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Pearl River	Upper	303.58	Max WS	2020-Feb	78106.33	246.61	280.81		280.88	0.000076	2.72	111108.7	13776.68	0.1
Pearl River	Upper	303.58	Max WS	500yearhigh	140452.8	246.61	286.42		286.49	0.000072	3.04	197184.3	16112.27	0.1
Pearl River	Upper	303.58	Max WS	1979-current calibration	131475.2	246.61	286.08		286.15	0.000068	2.92	191822.1	15966.54	0.09
Pearl River	Upper	303.58	Max WS	50Year_High	83349.78	246.61	281.53		281.6	0.000073	2.72	121372.3	14695.51	0.1
Pearl River	Upper	303.58	Max WS	25yearhigh	70160.57	246.61	280.27		280.34	0.000074	2.58	102826.8	13278.45	0.09
Pearl River	Upper	303.58	Max WS	10yearhigh	54790.53	246.61	278.68		278.73	0.000069	2.34	82020.94	11762.06	0.09
Pearl River	Upper	303.58	Max WS	5yearhigh	44388.16	246.61	277.62		277.67	0.000069	2.11	71464.38	10284.38	0.08
Pearl River	Upper	303.58	Max WS	200yearhigh	114978.8	246.61	284.33		284.4	0.000075	2.95	164257.8	15582.69	0.1
Pearl River	Upper	303.58	Max WS	Mannings100yr	98327.22	246.61	283.27		283.33	0.000074	2.71	147755.2	15511.11	0.09
Pearl River	Upper	303.58	Max WS	100Year_High-LeveeInflows	98240.44	246.61	282.99		283.06	0.000073	2.82	143358.9	15473.63	0.1
Pearl River	Upper	303.58	Max WS	100year-High-DamOperation	95469.11	246.61	282.74		282.8	0.000073	2.81	139494.8	15414.98	0.1
Pearl River	Upper	303.58	Max WS	1979-lowlosses	131466.9	246.61	286.08		286.14	0.000068	2.92	191731.5	15964.48	0.09
Pearl River	Upper	303.58	Max WS	100year-nolocal	93145.72	246.61	282.77		282.84	0.000069	2.73	140083.9	15423.68	0.09
Pearl River	Upper	303.58	Max WS	200yearDamOperation	108135.7	246.61	283.84		283.91	0.000074	2.89	156634	15547.49	0.1
Pearl River	Upper	303.58	Max WS	500yearhigh-DamReleases	134179.9	246.61	285.97		286.04	0.000072	3.01	190029.9	15923.94	0.1
Pearl River	Upper	303.58	Max WS	C-100	98320.29	246.76	281.3		281.41	0.000102	3.37	117709.7	14404.97	0.12
Pearl River	Upper	303.58	Max WS	C-500year	140585.2	246.76	284.47		284.58	0.000105	3.67	166109.3	15590.78	0.12
Pearl River	Upper	303.58	Max WS	C-200year	115039.8	246.76	282.61		282.72	0.000105	3.52	137330.1	15371.56	0.12
Pearl River	Upper	303.58	Max WS	C-1000year	162739.1	246.76	285.98		286.09	0.000103	3.75	189872.2	15943.5	0.12
Pearl River	Upper	303.58	Max WS	C-50year	83443.06	246.76	279.98		280.09	0.000101	3.26	98729.33	13175.7	0.12
Pearl River	Upper	303.58	Max WS	C-25year	70222.55	246.76	278.8		278.89	0.000096	3	83959.55	12156.56	0.11
Pearl River	Upper	303.58	Max WS	C-10year	54800.2	246.76	277.22		277.31	0.000099	2.73	67299.52	9962.06	0.1
Pearl River	Upper	303.58	Max WS	C-5year	44388.24	246.76	276.26		276.33	0.0001	2.42	58047.74	9578.15	0.09
Pearl River	Upper	294.43	Max WS	2020-Feb	73586.3	236.03	276.84		277.12	0.00012	4.74	27239.57	1831.93	0.15
Pearl River	Upper	294.43	Max WS	500yearhigh	119780.7	236.03	283		283.44	0.00015	6.05	41611.2	2532.06	0.18
Pearl River	Upper	294.43	Max WS	1979-current calibration	117099	236.03	282.8		283.23	0.000147	5.96	41092.93	2531.34	0.18
Pearl River	Upper	294.43	Max WS	50Year_High	79451.36	236.03	277.64		277.95	0.000125	4.95	28732.57	1927.65	0.16
Pearl River	Upper	294.43	Max WS	25yearhigh	67015.15	236.03	276.05		276.32	0.000122	4.54	22676.98	1653.07	0.15
Pearl River	Upper	294.43	Max WS	10yearhigh	52580.5	236.03	273.9		274.11	0.000116	3.92	20297.81	1364.93	0.13
Pearl River	Upper	294.43	Max WS	5yearhigh	42594	236.03	272.45		272.6	0.000119	3.4	18699.04	1344.02	0.12
Pearl River	Upper	294.43	Max WS	200yearhigh	105078.8	236.03	280.66		281.07	0.00015	5.77	35716.93	2475.01	0.18
Pearl River	Upper	294.43	Max WS	Mannings100yr	90970.72	236.03	279.72		280.13	0.000143	5.53	33448.86	2376.67	0.17
Pearl River	Upper	294.43	Max WS	100Year_High-LeveeInflows	92003.16	236.03	279.27		279.63	0.000136	5.36	32378.63	2355.32	0.17
Pearl River	Upper	294.43	Max WS	100year-High-DamOperation	90003.41	236.03	279		279.36	0.000135	5.3	31752.59	2351.9	0.17
Pearl River	Upper	294.43	Max WS	1979-lowlosses	118757.3	236.03	282.77		283.21	0.000151	6.05	41019.31	2531.23	0.18
Pearl River	Upper	294.43	Max WS	100year-nolocal	91030.56	236.03	279.1		279.46	0.000136	5.34	31988.58	2353.17	0.17
Pearl River	Upper	294.43	Max WS	200yearDamOperation	100286.9	236.03	280.17		280.56	0.000145	5.62	34520.6	2397.52	0.17
Pearl River	Upper	294.43	Max WS	500yearhigh-DamReleases	115256.3	236.03	282.66		283.08	0.000145	5.9	40749.74	2530.81	0.18

Pearl River	Upper	294.43	Max WS	C-100	92336.76	236.59	274.99		275.16	0.000075	3.69	29509.98	1385.96	0.12
Pearl River	Upper	294.43	Max WS	C-500year	133052	236.59	279.16		279.36	0.000092	4.47	43093.79	2325.82	0.14
Pearl River	Upper	294.43	Max WS	C-200year	106339	236.59	276.77		276.96	0.000081	3.99	31484.34	1688.51	0.13
Pearl River	Upper	294.43	Max WS	C-1000year	148712.5	236.59	281.37		281.58	0.000091	4.65	48406.73	2512.35	0.14
Pearl River	Upper	294.43	Max WS	C-50year	80725.27	236.59	273.52		273.66	0.000069	3.41	27886.64	1363.94	0.12
Pearl River	Upper	294.43	Max WS	C-25year	69087.27	236.59	272.19		272.31	0.000063	3.07	26423.63	1350.85	0.11
Pearl River	Upper	294.43	Max WS	C-10year	53983.89	236.59	270.14		270.22	0.000059	2.62	24169.74	1331.63	0.1
Pearl River	Upper	294.43	Max WS	C-5year	44612.45	236.59	268.29		268.36	0.000065	2.36	22159.56	1314.79	0.09
Pearl River	Upper	288.76	Max WS	2020-Feb	72950.45	237	270.14		270.45	0.000373	5.49	21478.31	1503.6	0.19
Pearl River	Upper	288.76	Max WS	500yearhigh	120125	237	275.27		275.7	0.00036	6.71	29454.05	1636.55	0.21
Pearl River	Upper	288.76	Max WS	1979-current calibration	121928	237	274.64		275.12	0.000405	7.02	28433.59	1594.67	0.22
Pearl River	Upper	288.76	Max WS	50Year_High	76611.95	237	271		271.3	0.000344	5.45	22776.96	1517.44	0.18
Pearl River	Upper	288.76	Max WS	25yearhigh	64814.9	237	269.89		270.14	0.000327	4.96	21106.82	1499.56	0.17
Pearl River	Upper	288.76	Max WS	10yearhigh	51595.6	237	268.25		268.48	0.000333	4.59	16928.97	1412.68	0.16
Pearl River	Upper	288.76	Max WS	5yearhigh	41166.74	237	266.6		266.79	0.000322	4.09	15070.1	1365.47	0.15
Pearl River	Upper	288.76	Max WS	200yearhigh	102628.2	237	273.62		274	0.000335	6.25	26814.26	1569.53	0.2
Pearl River	Upper	288.76	Max WS	Mannings100yr	86662.3	237	273.49		274.07	0.000499	7.08	26618.15	1565.97	0.23
Pearl River	Upper	288.76	Max WS	100Year_High-LeveeInflows	87763.16	237	272.16		272.49	0.00034	5.81	24549.74	1535.96	0.19
Pearl River	Upper	288.76	Max WS	100year-High-DamOperation	86086.17	237	271.99		272.32	0.000341	5.76	24298.66	1533.31	0.19
Pearl River	Upper	288.76	Max WS	1979-lowlosses	121806.5	237	274.56		275.04	0.000409	7.04	28305.93	1592.47	0.22
Pearl River	Upper	288.76	Max WS	100year-nolocal	90649.8	237	271.56		271.95	0.000392	6.23	23633.51	1526.4	0.21
Pearl River	Upper	288.76	Max WS	200yearDamOperation	99147.81	237	273.26		273.63	0.000332	6.16	26256.37	1559.28	0.2
Pearl River	Upper	288.76	Max WS	500yearhigh-DamReleases	117243	237	275.02		275.44	0.000356	6.64	29048.24	1634.69	0.21
Pearl River	Upper	288.76	Max WS	C-100	93714.34	237.04	271.48		271.64	0.000152	3.99	30992.73	1516.34	0.13
Pearl River	Upper	288.76	Max WS	C-500year	125884.7	237.04	274.49		274.71	0.000176	4.68	35642.85	1563.8	0.15
Pearl River	Upper	288.76	Max WS	C-200year	107125.4	237.04	272.89		273.07	0.000157	4.28	33160.1	1548.05	0.14
Pearl River	Upper	288.76	Max WS	C-1000year	143139.3	237.04	275.68		275.93	0.000197	5.08	37547.51	1621.93	0.16
Pearl River	Upper	288.76	Max WS	C-50year	82074.9	237.04	270.35		270.49	0.00015	3.69	29293.13	1494.28	0.12
Pearl River	Upper	288.76	Max WS	C-25year	69297.09	237.04	269.26		269.38	0.000148	3.41	25409.34	1473.81	0.12
Pearl River	Upper	288.76	Max WS	C-10year	53514	237.04	267.6		267.69	0.000126	2.86	23487.9	1444.16	0.1
Pearl River	Upper	288.76	Max WS	C-5year	43035.83	237.04	266.06		266.12	0.000116	2.51	21703.44	1392.77	0.09
Pearl River	Upper	267.01	Max WS	2020-Feb	72696.18	214.9	256.5	240.24	256.62	0.000201	4.17	98879.67	14490.38	0.14
Pearl River	Upper	267.01	Max WS	500yearhigh	142592.5	214.9	260.39	247.96	260.51	0.0002	5.05	156472.3	15125.71	0.16
Pearl River	Upper	267.01	Max WS	1979-current calibration	127933.5	214.9	259.55	247.37	259.68	0.000201	4.97	143897.4	15054.3	0.16
Pearl River	Upper	267.01	Max WS	50Year_High	88158.37	214.9	257.32	244.22	257.45	0.000201	4.5	110798.8	14626.35	0.15
Pearl River	Upper	267.01	Max WS	25yearhigh	72307.77	214.9	256.48	240.14	256.6	0.000201	4.16	98542.31	14483.89	0.14
Pearl River	Upper	267.01	Max WS	10yearhigh	54579.85	214.9	255.25	236.31	255.36	0.000201	3.79	80768.13	14300.65	0.13
Pearl River	Upper	267.01	Max WS	5yearhigh	43456.46	214.9	253.75	233.86	253.85	0.000197	3.43	59976.5	12925.12	0.12
Pearl River	Upper	267.01	Max WS	200yearhigh	120592.5	214.9	259.11	247.15	259.25	0.000201	4.92	137309	14983.5	0.16
Pearl River	Upper	267.01	Max WS	Mannings100yr	104639.9	214.9	258.13	246.01	258.26	0.0002	4.81	122638.7	14764.62	0.16
Pearl River	Upper	267.01	Max WS	100Year_High-LeveeInflows	104200.3	214.9	258.1	245.97	258.23	0.0002	4.8	122234.1	14761.66	0.16

Pearl River	Upper	267.01	Max WS	100year-High-DamOperation	102525.1	214.9	257.99	245.77	258.13	0.0002	4.79	120692.2	14750.39	0.16
Pearl River	Upper	267.01	Max WS	1979-lowlosses	127764.4	214.9	259.54	247.36	259.67	0.000201	4.97	143745.4	15053.58	0.16
Pearl River	Upper	267.01	Max WS	100year-nolocal	91294.3	214.9	257.46	244.64	257.59	0.000201	4.58	112872.1	14667.51	0.15
Pearl River	Upper	267.01	Max WS	200yearDamOperation	116180	214.9	258.85	247.06	258.98	0.0002	4.89	133301.9	14895.17	0.16
Pearl River	Upper	267.01	Max WS	500yearhigh-DamReleases	139220.2	214.9	260.2	247.88	260.33	0.0002	5.03	153701.1	15107.14	0.16
Pearl River	Upper	267.01	Max WS	C-100	108153.5	216.04	258.76	247.78	258.91	0.0002	5.88	134004.3	14870.13	0.17
Pearl River	Upper	267.01	Max WS	C-500year	145338.2	216.04	260.92	250.34	261.05	0.0002	6.1	166419.8	15072.89	0.17
Pearl River	Upper	267.01	Max WS	C-200year	123005.6	216.04	259.66	249.16	259.8	0.0002	5.98	147462.7	14965.26	0.17
Pearl River	Upper	267.01	Max WS	C-1000year	166461.8	216.04	262.05	252.41	262.18	0.0002	6.2	183510.9	15195.53	0.17
Pearl River	Upper	267.01	Max WS	C-50year	93547.27	216.04	257.97	246.27	258.12	0.0002	5.66	122317.7	14711.63	0.16
Pearl River	Upper	267.01	Max WS	C-25year	76491.7	216.04	257.13	244.77	257.26	0.000201	5.23	109931.8	14619.51	0.15
Pearl River	Upper	267.01	Max WS	C-10year	56098.89	216.04	255.76	238.25	255.89	0.000201	4.73	90225.55	14310	0.14
Pearl River	Upper	267.01	Max WS	C-5year	43853.45	216.04	254.27	235.14	254.39	0.000194	4.29	69171.59	13684.15	0.13

Alternative C Stage Flow Relationship at Proposed Dam, as developed by 2 Dimensional Model

Ordinate	US RC Flow (cfs)	US RC Elevation (ft)	DS RC Flow (cfs)	DS RC Elevation (ft)
1	0	242.33	0	242.07
2	0	242.33	0	242.07
3	0	242.33	0	242.07
4	0	248.79	0	242.07
5	0	249.72	0	242.07
6	0	250.68	0	242.07
7	0	251.68	0	242.07
8	0	252.69	0	242.07
9	0	253.72	0	242.07
10	0	254.77	0	242.07
11	0	255.82	0	242.07
12	0	256.88	0	242.07
13	0	257.94	0	242.07
14	2087.18	258.67	2087.18	243.02
15	3001.67	258.86	3001.67	244.16
16	3216.32	258.9	3216.32	245.03
17	3259.38	258.91	3259.38	245.45
18	3315.06	258.92	3315.06	245.7
19	3373.14	258.93	3373.14	245.9
20	3440.54	258.94	3440.54	246.08
21	3479.62	258.95	3479.62	246.23
22	3547.05	258.96	3547.05	246.37
23	3612.07	258.97	3612.07	246.51
24	3677.54	258.98	3677.54	246.64
25	3725.88	258.99	3725.88	246.74
26	3778.75	259	3778.75	246.84
27	3833.54	259.01	3833.54	246.94
28	3890.27	259.02	3890.27	247.04
29	3934.47	259.03	3934.47	247.12
30	3991.09	259.04	3991.09	247.2
31	4059.23	259.05	4059.23	247.28
32	4204.78	259.07	4204.78	247.41
33	4511.86	259.13	4511.86	247.64
34	4923.67	259.19	4923.67	247.99
35	5254.62	259.25	5254.62	248.34
36	5557.21	259.29	5557.21	248.65
37	5873.53	259.34	5873.53	248.98
38	6152.88	259.39	6152.88	249.29
39	6385.44	259.42	6385.44	249.58
40	6548.59	259.44	6548.59	249.83
41	6712.52	259.47	6712.52	250.03
42	6979.56	259.51	6979.56	250.27
43	7349.72	259.56	7349.72	250.56
44	7654.07	259.6	7654.07	250.84
45	7910.7	259.64	7910.7	251.11
46	8121.46	259.67	8121.46	251.34
47	8314.47	259.69	8314.47	251.55
48	8491.74	259.72	8491.74	251.75
49	8639.43	259.74	8639.43	251.92
50	8766.44	259.75	8766.44	252.08
51	8864.02	259.77	8864.02	252.21



52	8942.19	259.78	8942.19	252.34
53	8989.51	259.78	8989.51	252.45
54	9031.21	259.79	9031.21	252.54
55	9076.63	259.79	9076.63	252.63
56	9180.76	259.81	9180.76	252.72
57	9371.31	259.83	9371.31	252.84
58	9625.35	259.87	9625.35	252.99
59	9779.43	259.89	9779.43	253.13
60	9910	259.9	9910	253.26
61	10014.48	259.92	10014.48	253.37
62	10108.31	259.93	10108.31	253.47
63	10174.05	259.94	10174.05	253.57
64	10347.18	259.96	10347.18	253.68
65	10567.79	259.99	10567.79	253.8
66	10893.11	260.03	10893.11	253.98
67	11104.92	260.05	11104.92	254.13
68	11307.42	260.07	11307.42	254.28
69	11546.82	260.1	11546.82	254.44
70	11758.21	260.12	11758.21	254.59
71	11959.6	260.14	11959.6	254.74
72	12160.49	260.16	12160.49	254.88
73	12361.3	260.18	12361.3	255.02
74	12561.96	260.2	12561.96	255.16
75	12762.8	260.22	12762.8	255.3
76	12963.37	260.24	12963.37	255.43
77	13195.66	260.26	13195.66	255.56
78	13415.97	260.28	13415.97	255.7
79	13617.18	260.3	13617.18	255.83
80	13817.68	260.31	13817.68	255.95
81	13969.09	260.33	13969.09	256.07
82	14232.3	260.35	14232.3	256.2
83	14392.67	260.36	14392.67	256.33
84	14494.24	260.37	14494.24	256.43
85	14594.19	260.38	14594.19	256.52
86	14598.65	260.38	14598.65	256.58
87	14688.05	260.39	14688.05	256.65
88	14731.89	260.39	14731.89	256.71
89	14830.48	260.4	14830.48	256.77
90	14930.5	260.41	14930.5	256.84
91	14996.87	260.42	14996.87	256.9
92	15094.37	260.43	15094.37	256.95
93	15132.19	260.43	15132.19	257
94	15196.85	260.43	15196.85	257.05
95	15198.49	260.43	15198.49	257.08
96	15198.51	260.43	15198.51	257.11
97	15198.56	260.43	15198.56	257.13
98	15198.58	260.43	15198.58	257.15
99	15102.73	260.43	15102.73	257.15
100	15098.78	260.43	15098.78	257.16
101	15098.72	260.43	15098.72	257.17
102	15098.74	260.43	15098.74	257.18
103	15064.94	260.42	15064.94	257.19
104	15000.47	260.42	15000.47	257.18
105	14958.84	260.41	14958.84	257.18
106	14902.08	260.41	14902.08	257.17
107	14899.08	260.41	14899.08	257.17
108	14898.97	260.41	14898.97	257.17

109	14865.36	260.41	14865.36	257.17
110	14807.04	260.4	14807.04	257.16
111	14799.33	260.4	14799.33	257.15
112	14765.52	260.4	14765.52	257.15
113	14700.84	260.39	14700.84	257.13
114	14609.93	260.38	14609.93	257.11
115	14503.88	260.37	14503.88	257.08
116	14377.13	260.36	14377.13	257.05
117	14268.41	260.35	14268.41	257.01
118	14201.29	260.35	14201.29	256.98
119	14071.2	260.34	14071.2	256.94
120	14001.51	260.33	14001.51	256.9
121	13904.27	260.32	13904.27	256.86
122	13804.41	260.31	13804.41	256.82
123	13750.88	260.31	13750.88	256.79
124	13701.1	260.3	13701.1	256.76
125	13867.04	260.32	13867.04	256.77
126	14430.04	260.37	14430.04	256.85
127	15073.14	260.42	15073.14	257
128	15456.19	260.46	15456.19	257.13
129	15668.44	260.47	15668.44	257.24
130	15918.85	260.49	15918.85	257.34
131	16218.21	260.52	16218.21	257.46
132	16503.26	260.54	16503.26	257.56
133	16803.36	260.57	16803.36	257.68
134	17159.68	260.59	17159.68	257.8
135	17496.59	260.62	17496.59	257.92
136	17814.09	260.65	17814.09	258.04
137	18160.9	260.67	18160.9	258.16
138	18534.16	260.7	18534.16	258.28
139	19171.47	260.75	19171.47	258.44
140	19695.27	260.79	19695.27	258.61
141	20098.81	260.82	20098.81	258.75
142	20462.12	260.84	20462.12	258.89
143	20707.73	260.86	20707.73	258.99
144	21021.16	260.89	21021.16	259.1
145	21405.52	260.91	21405.52	259.21
146	21664.95	260.93	21664.95	259.31
147	22005.79	260.96	22005.79	259.41
148	22362.58	260.98	22362.58	259.51
149	22621.65	261	22621.65	259.6
150	22869.29	261.02	22869.29	259.68
151	23028.23	261.03	23028.23	259.75
152	23230.85	261.04	23230.85	259.82
153	23558.29	261.06	23558.29	259.89
154	23979.09	261.09	23979.09	259.99
155	24225.09	261.11	24225.09	260.06
156	24426.27	261.12	24426.27	260.13
157	24621.87	261.14	24621.87	260.19
158	25017.42	261.16	25017.42	260.27
159	25578.48	261.2	25578.48	260.36
160	26284.72	261.25	26284.72	260.49
161	26640.53	261.28	26640.53	260.58
162	26946.89	261.3	26946.89	260.66
163	27202.73	261.32	27202.73	260.73
164	27502.99	261.35	27502.99	260.8
165	27734.65	261.37	27734.65	260.86

166	28067.66	261.4	28067.66	260.92
167	28459.34	261.44	28459.34	260.99
168	28844.77	261.47	28844.77	261.06
169	29135.26	261.51	29135.26	261.12
170	29437.86	261.55	29437.86	261.18
171	29721.19	261.59	29721.19	261.24
172	30104.3	261.64	30104.3	261.31
173	30379.25	261.68	30379.25	261.37
174	30751.76	261.73	30751.76	261.43
175	31103.82	261.78	31103.82	261.5
176	31476.49	261.83	31476.49	261.56
177	31831.96	261.88	31831.96	261.63
178	32385.52	261.95	32385.52	261.71
179	32816.91	262.01	32816.91	261.78
180	33414.05	262.09	33414.05	261.87
181	33959.75	262.16	33959.75	261.96
182	34902.62	262.27	34902.62	262.07
183	35778.1	262.38	35778.1	262.19
184	36821.26	262.51	36821.26	262.32
185	38202.92	262.66	38202.92	262.48
186	40024.33	262.86	40024.33	262.69
187	41269.68	263.03	41269.68	262.87
188	42104.93	263.16	42104.93	263.01
189	42932.07	263.29	42932.07	263.14
190	43646.38	263.4	43646.38	263.26
191	44491.79	263.51	44491.79	263.38
192	45285.63	263.63	45285.63	263.5
193	45916.91	263.72	45916.91	263.6
194	46613.62	263.82	46613.62	263.7
195	47085.58	263.91	47085.58	263.79
196	47541.59	263.99	47541.59	263.87
197	48081.7	264.06	48081.7	263.95
198	48632.45	264.14	48632.45	264.03
199	49116.8	264.21	49116.8	264.1
200	49597.55	264.28	49597.55	264.17
201	50064.07	264.35	50064.07	264.24
202	50662.14	264.41	50662.14	264.31
203	51178.27	264.48	51178.27	264.37
204	51616.09	264.54	51616.09	264.44
205	52133.28	264.6	52133.28	264.5
206	52478.07	264.66	52478.07	264.55
207	52918.07	264.71	52918.07	264.61
208	53363.21	264.77	53363.21	264.67
209	53803.25	264.82	53803.25	264.72
210	54173.09	264.87	54173.09	264.77
211	54656.55	264.92	54656.55	264.82
212	55072.91	264.97	55072.91	264.87
213	55326.43	265.01	55326.43	264.91
214	55613.19	265.05	55613.19	264.95
215	55864.38	265.09	55864.38	264.99
216	56145.24	265.12	56145.24	265.02
217	56408.65	265.16	56408.65	265.06
218	56760	265.19	56760	265.1
219	57111.9	265.23	57111.9	265.13
220	57403.65	265.27	57403.65	265.17
221	57665.89	265.3	57665.89	265.2
222	58031.13	265.33	58031.13	265.23

223	58376.1	265.37	58376.1	265.27
224	58608.64	265.4	58608.64	265.3
225	58899.84	265.43	58899.84	265.33
226	59166.56	265.46	59166.56	265.36
227	59513.93	265.49	59513.93	265.39
228	59688.11	265.52	59688.11	265.42
229	60032.61	265.55	60032.61	265.45
230	60289.11	265.58	60289.11	265.48
231	60628.94	265.61	60628.94	265.51
232	60882.61	265.64	60882.61	265.54
233	61057.52	265.66	61057.52	265.56
234	61332.89	265.69	61332.89	265.59
235	61574.66	265.71	61574.66	265.61
236	61750.36	265.73	61750.36	265.64
237	61940.75	265.75	61940.75	265.66
238	62272.54	265.78	62272.54	265.68
239	62383.41	265.8	62383.41	265.7
240	62516.46	265.82	62516.46	265.72
241	62648.4	265.83	62648.4	265.74
242	62900.57	265.85	62900.57	265.76
243	63038.02	265.87	63038.02	265.77
244	63072.88	265.89	63072.88	265.79
245	63236.43	265.9	63236.43	265.8
246	63591.8	265.93	63591.8	265.83
247	63626.22	265.94	63626.22	265.84
248	63881.47	265.95	63881.47	265.86
249	64074.5	265.97	64074.5	265.87
250	64063.6	265.98	64063.6	265.89
251	64199.31	265.99	64199.31	265.9
252	64445.37	266.01	64445.37	265.92
253	64644.45	266.03	64644.45	265.93
254	64776.86	266.05	64776.86	265.95
255	64818.93	266.06	64818.93	265.96
256	65175.99	266.08	65175.99	265.98
257	65187.94	266.09	65187.94	265.99
258	65528.09	266.11	65528.09	266.02
259	65767.5	266.13	65767.5	266.04
260	66188.79	266.16	66188.79	266.07
261	66834.48	266.2	66834.48	266.1
262	67254.12	266.24	67254.12	266.14
263	67653.79	266.27	67653.79	266.17
264	67985.62	266.3	67985.62	266.2
265	68598.09	266.34	68598.09	266.24
266	69176.86	266.38	69176.86	266.28
267	69715	266.43	69715	266.33
268	70277.81	266.47	70277.81	266.37
269	70963.66	266.52	70963.66	266.42
270	71548.27	266.57	71548.27	266.47
271	71997.94	266.61	71997.94	266.51
272	72434.27	266.65	72434.27	266.55
273	72882.8	266.69	72882.8	266.59
274	73217.31	266.73	73217.31	266.63
275	73548.33	266.76	73548.33	266.66
276	73738.21	266.79	73738.21	266.69
277	74021.24	266.81	74021.24	266.71
278	74237.8	266.84	74237.8	266.74
279	74371.86	266.86	74371.86	266.76

280	74338.65	266.87	74338.65	266.77
281	74597.45	266.89	74597.45	266.79
282	74874.18	266.91	74874.18	266.81
283	75011.47	266.92	75011.47	266.82
284	74915.41	266.93	74915.41	266.83
285	75093.73	266.95	75093.73	266.85
286	75285.51	266.96	75285.51	266.86
287	75266	266.97	75266	266.87
288	75429.58	266.98	75429.58	266.88
289	75431.5	266.99	75431.5	266.89
290	75304.97	266.99	75304.97	266.89
291	75469.27	267	75469.27	266.9
292	75486.99	267	75486.99	266.91
293	75600.37	267.01	75600.37	266.91
294	75494.02	267.01	75494.02	266.91
295	75489.23	267.02	75489.23	266.92
296	75542.84	267.02	75542.84	266.92
297	75186.66	267.01	75186.66	266.91
298	74939.77	266.99	74939.77	266.9
299	74939.13	266.99	74939.13	266.89
300	74661.95	266.98	74661.95	266.88
301	74581.75	266.97	74581.75	266.87
302	74195.48	266.95	74195.48	266.85
303	73912.3	266.93	73912.3	266.84
304	73614.73	266.91	73614.73	266.82
305	73256.13	266.89	73256.13	266.8
306	72779.21	266.86	72779.21	266.77
307	72410.72	266.83	72410.72	266.74
308	72104.15	266.81	72104.15	266.71
309	71646.66	266.78	71646.66	266.68
310	71250.23	266.74	71250.23	266.65
311	70734.94	266.71	70734.94	266.62
312	70403.17	266.68	70403.17	266.59
313	69876.7	266.64	69876.7	266.55
314	69433.9	266.61	69433.9	266.52
315	68816.15	266.57	68816.15	266.48
316	68480.88	266.53	68480.88	266.44
317	67760.44	266.48	67760.44	266.39
318	67142.8	266.43	67142.8	266.34
319	66410.51	266.38	66410.51	266.29
320	65602.03	266.32	65602.03	266.23
321	64931.93	266.26	64931.93	266.17
322	64376.95	266.21	64376.95	266.12
323	63746.71	266.16	63746.71	266.07
324	63198.49	266.1	63198.49	266.02
325	62490.1	266.05	62490.1	265.96
326	62073.94	266	62073.94	265.91
327	61600.95	265.95	61600.95	265.86
328	61030.26	265.9	61030.26	265.81
329	60645.39	265.85	60645.39	265.77
330	59995.68	265.8	59995.68	265.71
331	59599.39	265.75	59599.39	265.67
332	59066.89	265.71	59066.89	265.62
333	58725.07	265.66	58725.07	265.57
334	58389.94	265.62	58389.94	265.54
335	57947.02	265.58	57947.02	265.49
336	57592.91	265.54	57592.91	265.45

337	57040.86	265.49	57040.86	265.41
338	56552.21	265.45	56552.21	265.36
339	56123.25	265.4	56123.25	265.31
340	55413.68	265.35	55413.68	265.26
341	54833.48	265.29	54833.48	265.2
342	54178.74	265.23	54178.74	265.14
343	53336.49	265.16	53336.49	265.08
344	52317.26	265.08	52317.26	264.99
345	51175.96	264.99	51175.96	264.9
346	50080.77	264.89	50080.77	264.8
347	48957.68	264.78	48957.68	264.7
348	47892.11	264.68	47892.11	264.6
349	46818.72	264.57	46818.72	264.49
350	45837.68	264.47	45837.68	264.39
351	44964	264.37	44964	264.29
352	44134.64	264.27	44134.64	264.19
353	43263.01	264.17	43263.01	264.09
354	42469.17	264.07	42469.17	263.99
355	41885.67	263.98	41885.67	263.9
356	41642.66	263.92	41642.66	263.83
357	41832.68	263.88	41832.68	263.79
358	41936.66	263.86	41936.66	263.77
359	42212.75	263.85	42212.75	263.76
360	42684.29	263.86	42684.29	263.77
361	42612.59	263.85	42612.59	263.76
362	42336.63	263.82	42336.63	263.73
363	42122.03	263.8	42122.03	263.7
364	41823.2	263.77	41823.2	263.67
365	41553.68	263.73	41553.68	263.64
366	41278.4	263.69	41278.4	263.6
367	40856.79	263.65	40856.79	263.56
368	40523.27	263.61	40523.27	263.51
369	40147.89	263.57	40147.89	263.47
370	39764.83	263.52	39764.83	263.43
371	39367.56	263.47	39367.56	263.38
372	38956.24	263.42	38956.24	263.33
373	38560.35	263.37	38560.35	263.28
374	38224.29	263.33	38224.29	263.23
375	37791.83	263.27	37791.83	263.18
376	37539	263.23	37539	263.13
377	37129.48	263.18	37129.48	263.08
378	36686.93	263.13	36686.93	263.03
379	36391.59	263.08	36391.59	262.98
380	36127.04	263.03	36127.04	262.93
381	35871.64	262.99	35871.64	262.89
382	35627.34	262.95	35627.34	262.85
383	35331.61	262.91	35331.61	262.8
384	35127.23	262.87	35127.23	262.76
385	34744.64	262.82	34744.64	262.72
386	34499.96	262.78	34499.96	262.67
387	34369.63	262.75	34369.63	262.64
388	34143.57	262.71	34143.57	262.6
389	33985.32	262.68	33985.32	262.57
390	33701.67	262.64	33701.67	262.52
391	33499.06	262.61	33499.06	262.49
392	33214.74	262.57	33214.74	262.45
393	33066.82	262.54	33066.82	262.41

394	32870.59	262.51	32870.59	262.38
395	32666.22	262.47	32666.22	262.34
396	32438.88	262.44	32438.88	262.3
397	32282.87	262.41	32282.87	262.27
398	32166.71	262.38	32166.71	262.24
399	31973.77	262.35	31973.77	262.21
400	31790.72	262.32	31790.72	262.18
401	31673.48	262.29	31673.48	262.15
402	31567.47	262.27	31567.47	262.13
403	31418.74	262.25	31418.74	262.1
404	31316.54	262.22	31316.54	262.08
405	31215.59	262.2	31215.59	262.05
406	31116.16	262.18	31116.16	262.03
407	30979.49	262.16	30979.49	262.01
408	30886.18	262.14	30886.18	261.99
409	30817.28	262.12	30817.28	261.97
410	30719.75	262.1	30719.75	261.95
411	30621.27	262.09	30621.27	261.93
412	30484.19	262.06	30484.19	261.9
413	30391.63	262.05	30391.63	261.88
414	30292.71	262.03	30292.71	261.86
415	30193.85	262.01	30193.85	261.84
416	30125.5	262	30125.5	261.83
417	30073.99	261.98	30073.99	261.81
418	29977.65	261.97	29977.65	261.79
419	29879.69	261.95	29879.69	261.77
420	29785.55	261.93	29785.55	261.75
421	29683.52	261.92	29683.52	261.74
422	29589.07	261.9	29589.07	261.72
423	29500	261.88	29500	261.7
424	29393.45	261.87	29393.45	261.68
425	29379.87	261.86	29379.87	261.67
426	29285.95	261.84	29285.95	261.65
427	29192.21	261.83	29192.21	261.63
428	29179.98	261.82	29179.98	261.62
429	29086.88	261.8	29086.88	261.61
430	28993.54	261.79	28993.54	261.59
431	28981.6	261.78	28981.6	261.58
432	28893.03	261.77	28893.03	261.57
433	28796.76	261.76	28796.76	261.55
434	28699.2	261.74	28699.2	261.53
435	28641.91	261.73	28641.91	261.52
436	28546.19	261.72	28546.19	261.5
437	28417.01	261.7	28417.01	261.48
438	28351.76	261.68	28351.76	261.46
439	28294.84	261.67	28294.84	261.45
440	28211.96	261.66	28211.96	261.44
441	28100.53	261.64	28100.53	261.42
442	28037.63	261.63	28037.63	261.4
443	27993.47	261.62	27993.47	261.39
444	27888.28	261.61	27888.28	261.37
445	27846.36	261.6	27846.36	261.36
446	27794.55	261.59	27794.55	261.34
447	27699.1	261.58	27699.1	261.33
448	27648.54	261.57	27648.54	261.32
449	27595.79	261.56	27595.79	261.3
450	27590.77	261.55	27590.77	261.29

451	27502.14	261.54	27502.14	261.28
452	27449.02	261.53	27449.02	261.27
453	27315.29	261.52	27315.29	261.25
454	27295.99	261.51	27295.99	261.24
455	27291.71	261.5	27291.71	261.23
456	27246.96	261.5	27246.96	261.22
457	27195.09	261.49	27195.09	261.21
458	27146.82	261.48	27146.82	261.2
459	27100.22	261.47	27100.22	261.19
460	27091.41	261.47	27091.41	261.18
461	27089.35	261.46	27089.35	261.17
462	27044.07	261.46	27044.07	261.16
463	26998.85	261.45	26998.85	261.16
464	27038.98	261.45	27038.98	261.16
465	27025.22	261.45	27025.22	261.15
466	26989.7	261.44	26989.7	261.14
467	26987.62	261.44	26987.62	261.14
468	26953.06	261.44	26953.06	261.13
469	26984.73	261.44	26984.73	261.13
470	26899.17	261.43	26899.17	261.12
471	26889.78	261.42	26889.78	261.11
472	26887.6	261.42	26887.6	261.11
473	26795.92	261.41	26795.92	261.1
474	26790	261.41	26790	261.09
475	26701.97	261.4	26701.97	261.08
476	26691.65	261.39	26691.65	261.08
477	26598.63	261.38	26598.63	261.06
478	26592.01	261.38	26592.01	261.06
479	26503.9	261.37	26503.9	261.04
480	26493.14	261.37	26493.14	261.04
481	26404.5	261.36	26404.5	261.02
482	26393.03	261.35	26393.03	261.02
483	26298.12	261.34	26298.12	261
484	26292.35	261.34	26292.35	261
485	26213.74	261.33	26213.74	260.98
486	26194.12	261.33	26194.12	260.98
487	26099.24	261.32	26099.24	260.96
488	26016.76	261.31	26016.76	260.95
489	25919.4	261.3	25919.4	260.93
490	25856.85	261.29	25856.85	260.92
491	25815.12	261.28	25815.12	260.91
492	25796.06	261.28	25796.06	260.9
493	25716.59	261.27	25716.59	260.89
494	25695.44	261.27	25695.44	260.88
495	25597.79	261.26	25597.79	260.86
496	25502.13	261.25	25502.13	260.84
497	25403.87	261.24	25403.87	260.83
498	25354.47	261.23	25354.47	260.81
499	25256.6	261.22	25256.6	260.8
500	25157.63	261.21	25157.63	260.78
501	25097.67	261.21	25097.67	260.76
502	25004.63	261.2	25004.63	260.74
503	24905.82	261.19	24905.82	260.73
504	24857.01	261.18	24857.01	260.71
505	24720.61	261.17	24720.61	260.69
506	24658.42	261.16	24658.42	260.67
507	24519.65	261.15	24519.65	260.65

508	24410.5	261.14	24410.5	260.63
509	24342.21	261.14	24342.21	260.61
510	24163.87	261.12	24163.87	260.58
511	24004.19	261.11	24004.19	260.55
512	23911.8	261.1	23911.8	260.53
513	23803.44	261.09	23803.44	260.5
514	23665.01	261.08	23665.01	260.48
515	23602	261.08	23602	260.46
516	23460.91	261.06	23460.91	260.43
517	23306.07	261.05	23306.07	260.4
518	23162.13	261.04	23162.13	260.37
519	23020.11	261.03	23020.11	260.34
520	22905.67	261.02	22905.67	260.31
521	22763.67	261.01	22763.67	260.28
522	22699.3	261	22699.3	260.26
523	22596.42	261	22596.42	260.23
524	22458.58	260.99	22458.58	260.2
525	22357.27	260.98	22357.27	260.17
526	22215.88	260.97	22215.88	260.14
527	22064	260.96	22064	260.11
528	21995.6	260.95	21995.6	260.08
529	21859.38	260.95	21859.38	260.05
530	21744.16	260.94	21744.16	260.02
531	21616.54	260.93	21616.54	259.99
532	21460.2	260.92	21460.2	259.95
533	21317.19	260.91	21317.19	259.92
534	21216.74	260.9	21216.74	259.88
535	21019.46	260.89	21019.46	259.84
536	20903.23	260.88	20903.23	259.81
537	20719.79	260.86	20719.79	259.76
538	20617.68	260.86	20617.68	259.73
539	20498.83	260.85	20498.83	259.69
540	20361.58	260.84	20361.58	259.65
541	20204.62	260.83	20204.62	259.61
542	20062.06	260.82	20062.06	259.57
543	19919.25	260.81	19919.25	259.53
544	19762.73	260.79	19762.73	259.49
545	19619.69	260.78	19619.69	259.44
546	19504.88	260.77	19504.88	259.4
547	19363.11	260.76	19363.11	259.36
548	19205.88	260.75	19205.88	259.31
549	19063.64	260.74	19063.64	259.27
550	18906.22	260.73	18906.22	259.22
551	18723.03	260.72	18723.03	259.17
552	18569.88	260.7	18569.88	259.12
553	18385.64	260.69	18385.64	259.06
554	18222.3	260.68	18222.3	259.01
555	18024.53	260.66	18024.53	258.95
556	17824.98	260.65	17824.98	258.89
557	17671.43	260.63	17671.43	258.83
558	17431.98	260.62	17431.98	258.77
559	17272.31	260.6	17272.31	258.71
560	17073.52	260.59	17073.52	258.64
561	16873.91	260.57	16873.91	258.57
562	16724.45	260.56	16724.45	258.51
563	16573.44	260.55	16573.44	258.45
564	16424.96	260.54	16424.96	258.38

565	16227.88	260.52	16227.88	258.32
566	16068.71	260.51	16068.71	258.25
567	15925.72	260.49	15925.72	258.19
568	15769.13	260.48	15769.13	258.12
569	15626.2	260.47	15626.2	258.06
570	15509.79	260.46	15509.79	258
571	15369.42	260.45	15369.42	257.94
572	15226.85	260.44	15226.85	257.87
573	15110.27	260.43	15110.27	257.81
574	14970.03	260.41	14970.03	257.75
575	14827.56	260.4	14827.56	257.69
576	14710.77	260.39	14710.77	257.63
577	14570.76	260.38	14570.76	257.57
578	14468.12	260.37	14468.12	257.51
579	14312.39	260.36	14312.39	257.44
580	14178.08	260.35	14178.08	257.38
581	14052.72	260.33	14052.72	257.31
582	13905.85	260.32	13905.85	257.24
583	13772.05	260.31	13772.05	257.17
584	13613.52	260.3	13613.52	257.1
585	13511.94	260.29	13511.94	257.03
586	13405.13	260.28	13405.13	256.97
587	13273.09	260.26	13273.09	256.91
588	13131.13	260.25	13131.13	256.84
589	12974.52	260.24	12974.52	256.76
590	12870.92	260.23	12870.92	256.69
591	12715.24	260.21	12715.24	256.62
592	12606.15	260.2	12606.15	256.54
593	12436.26	260.19	12436.26	256.47
594	12331.92	260.18	12331.92	256.39
595	12214.86	260.16	12214.86	256.32
596	12076.46	260.15	12076.46	256.24
597	11934.67	260.14	11934.67	256.16
598	11833.27	260.13	11833.27	256.09
599	11716.18	260.11	11716.18	256.01
600	11578.26	260.1	11578.26	255.93
601	11474.45	260.09	11474.45	255.86
602	11290.73	260.07	11290.73	255.77
603	11139.05	260.05	11139.05	255.68
604	11019.08	260.04	11019.08	255.59
605	10918.6	260.03	10918.6	255.51
606	10783.29	260.01	10783.29	255.42
607	10679.81	260	10679.81	255.34
608	10545.49	259.98	10545.49	255.25
609	10399.05	259.97	10399.05	255.16
610	10247.42	259.95	10247.42	255.06
611	10143.55	259.93	10143.55	254.97
612	10006.06	259.92	10006.06	254.88
613	9906.09	259.9	9906.09	254.79
614	9782.23	259.89	9782.23	254.7
615	9659.83	259.87	9659.83	254.6
616	9535.37	259.85	9535.37	254.51
617	9417.99	259.84	9417.99	254.41
618	9315.61	259.83	9315.61	254.31
619	9222.09	259.81	9222.09	254.23
620	9115.84	259.8	9115.84	254.13
621	8992.36	259.78	8992.36	254.03

622	8877.66	259.77	8877.66	253.94
623	8771.06	259.75	8771.06	253.84
624	8676.65	259.74	8676.65	253.74
625	8580.83	259.73	8580.83	253.65
626	8490.98	259.72	8490.98	253.55
627	8396.63	259.7	8396.63	253.46
628	8293.23	259.69	8293.23	253.37
629	8190.64	259.68	8190.64	253.27
630	8107.04	259.66	8107.04	253.17
631	8026.13	259.65	8026.13	253.08
632	7947.27	259.64	7947.27	252.99
633	7887.82	259.63	7887.82	252.91
634	7807.62	259.62	7807.62	252.82
635	7756.51	259.62	7756.51	252.74
636	7696.83	259.61	7696.83	252.66
637	7627.63	259.6	7627.63	252.59
638	7567.83	259.59	7567.83	252.51
639	7504.84	259.58	7504.84	252.43
640	7434.18	259.57	7434.18	252.35
641	7360.73	259.56	7360.73	252.28
642	7298.87	259.55	7298.87	252.2
643	7209.39	259.54	7209.39	252.12
644	7140.61	259.53	7140.61	252.03
645	7060.37	259.52	7060.37	251.95
646	7025.37	259.51	7025.37	251.88
647	6964.69	259.5	6964.69	251.81
648	6930.5	259.5	6930.5	251.74
649	6881.1	259.49	6881.1	251.67
650	6813.69	259.48	6813.69	251.61
651	6748.66	259.47	6748.66	251.53
652	6702.74	259.47	6702.74	251.46
653	6687.95	259.46	6687.95	251.41
654	6649.53	259.46	6649.53	251.35
655	6620.19	259.45	6620.19	251.3
656	6572.88	259.45	6572.88	251.25
657	6525.52	259.44	6525.52	251.19
658	6484.71	259.43	6484.71	251.14
659	6446.88	259.43	6446.88	251.08
660	6406.32	259.42	6406.32	251.03
661	6375.6	259.42	6375.6	250.98
662	6343.61	259.41	6343.61	250.93
663	6313.44	259.41	6313.44	250.89
664	6299.26	259.41	6299.26	250.85