Claiborne and Millers Ferry Locks and Dams Fish Passage Study

Appendix A - Engineering

May 2023

US Army Corps of Engineers

The Nature Conservancy

APPENDIX-A: Engineering

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A.1. Purpose

In accordance with Engineering Regulation (ER) 1110-2-1150, *Engineering and Design for Civil Projects,* this Appendix documents the engineering and design effort during project formulation by the U.S. Army Corps of Engineers (USACE), Mobile District (District). Engineering data and analyses in the feasibility phase shall be sufficient to develop the complete Project schedule and baseline cost estimate with reasonable contingency factors for each cost item or group of cost items. Engineering analysis shall integrate sound environmental engineering principles and procedures into all phases and feature of the Project.

The design will involve the submission of multiple design deliverables over the course of the Project including:

- District Quality Control (DQC) Review and Certification
- Value Engineering (VE) Studies
- Agency Technical Review (ATR) and Certification
- Calculations
- Quantity Take-Offs
- Cost Estimates

A.2. Study Background

The Mobile District is conducting the Claiborne and Millers Ferry Locks and Dams Fish Passage Feasibility Study to evaluate Federal interest in establishing fish passage around the two southernmost lock and dam structures on the Alabama River. Fish passage around Claiborne and Millers Ferry Locks and Dams would restore historic connectivity in the Alabama and Cahaba Rivers and would reconnect over 230 miles of critical riverine spawning habitat for migratory species to the Mobile River Delta and the Gulf of Mexico. Increased access to upriver habitat should result in an increase in the size and distribution of native migratory fish populations. The construction of the Claiborne and Millers Ferry Locks and Dams severed this critical spawning habitat connectivity for several species including those listed as threatened and endangered species such as the Gulf Sturgeon and Alabama Sturgeon, respectively.

A.3. Study Area

Claiborne and Millers Ferry Locks and Dams are part of the Alabama-Coosa-Tallapoosa (ACT) River system. The ACT is an interconnected river system and drainage basin that that extends from southeast Tennessee and the northwest corner of Georgia through Alabama and discharges at Mobile Bay in southwest Alabama. The system contains 5 U.S. Army Corps of Engineers (USACE) dams and 11 privately owned dams as shown on

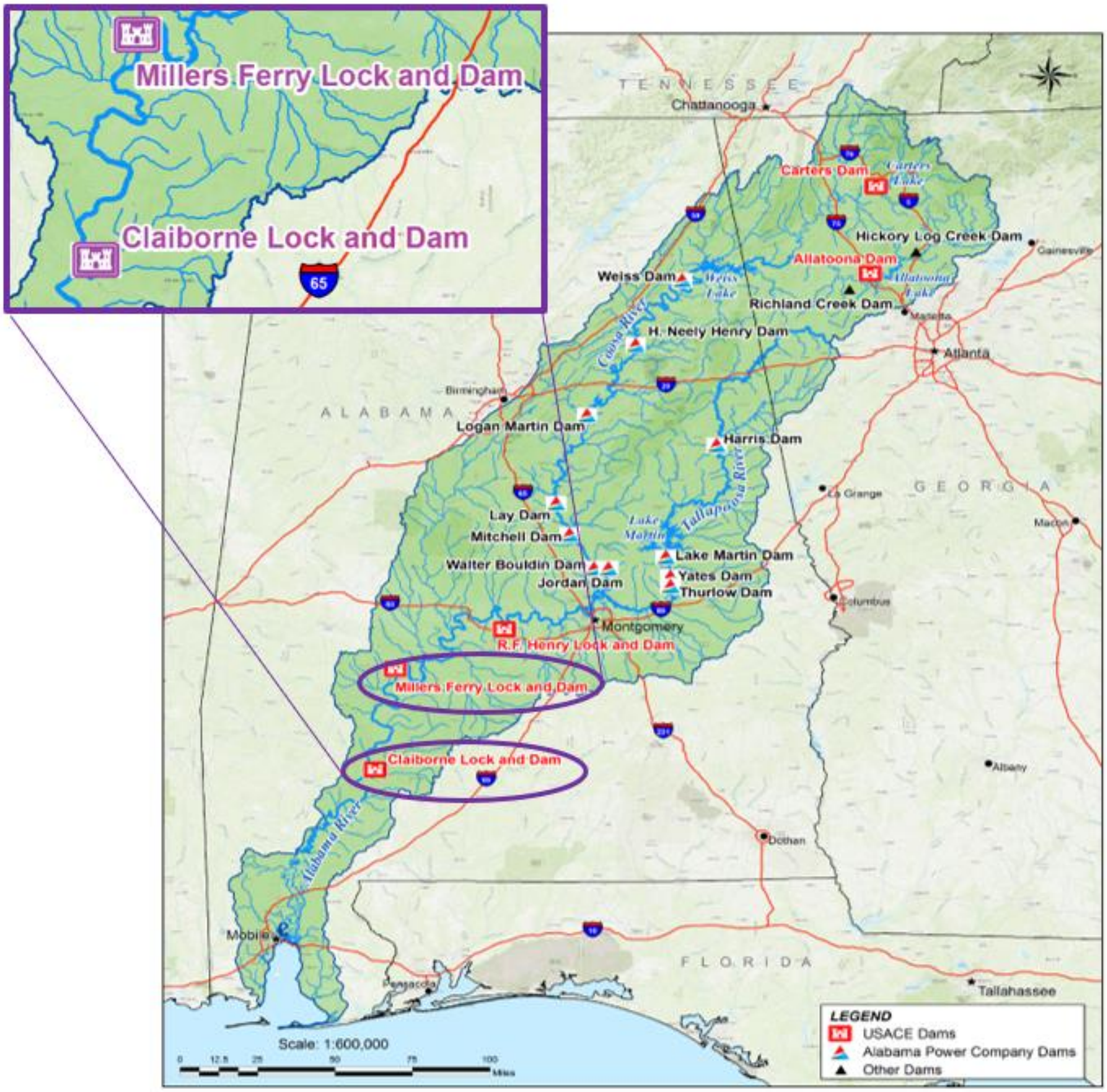

Figure A-1: The Alabama-Coosa-Tallapoosa (ACT) River system

A.3.1. Project Area

The project reach includes two existing USACE lock and dam projects, Claiborne Lock and Dam (Claiborne) and Millers Ferry Lock and Dam (Millers Ferry). The project area extends from the Alabama River below Claiborne to the Millers Ferry pool upstream of the dam and is approximately 165 river miles long.

A.3.1.1. Claiborne Lock and Dam

Claiborne is the southernmost lock and dam on the Alabama River and was constructed between 1966 and 1970. The project is primarily a navigation structure, but also reregulates the peaking power releases from the upstream Millers Ferry Project. Other project purposes include water quality, recreation, and fish and wildlife conservation and mitigation. There is no flood risk management storage for this project. Its features include a lock, fixed crest spillway, gated spillway and right and left dikes as depicted on Figure A-2.

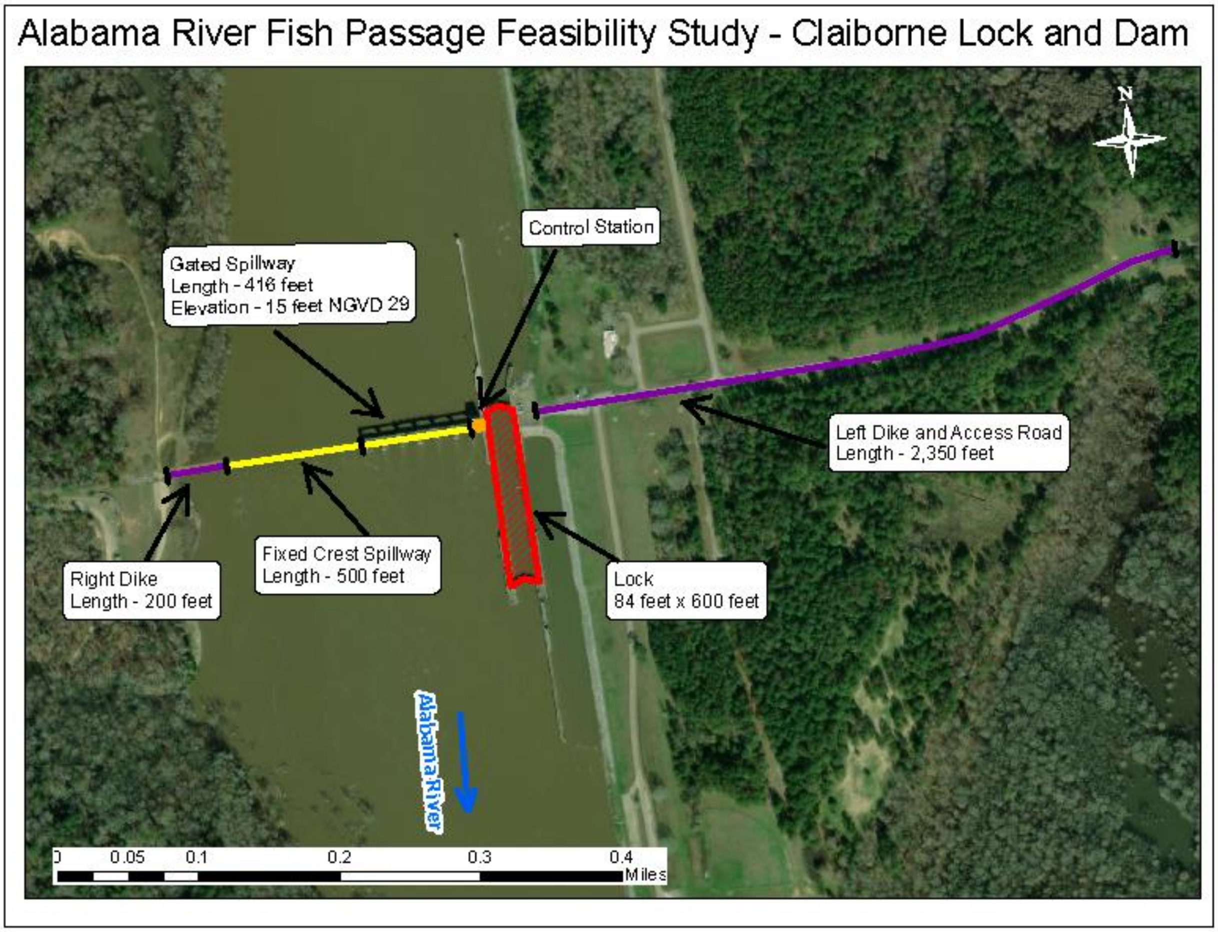

Figure A-2: Claiborne Lock and Dam

A.3.1.2. Millers Ferry Lock and Dam

Millers Ferry is upstream of Claiborne on the Alabama River and was constructed between 1964 and 1970. The project purposes include hydropower and navigation. Other project purposes include recreation, water quality, and fish and wildlife conservation and mitigation. There is no flood risk management storage for this project. Its features include a lock, powerhouse, gated spillway, and right and left dikes as depicted in Figure A-3.

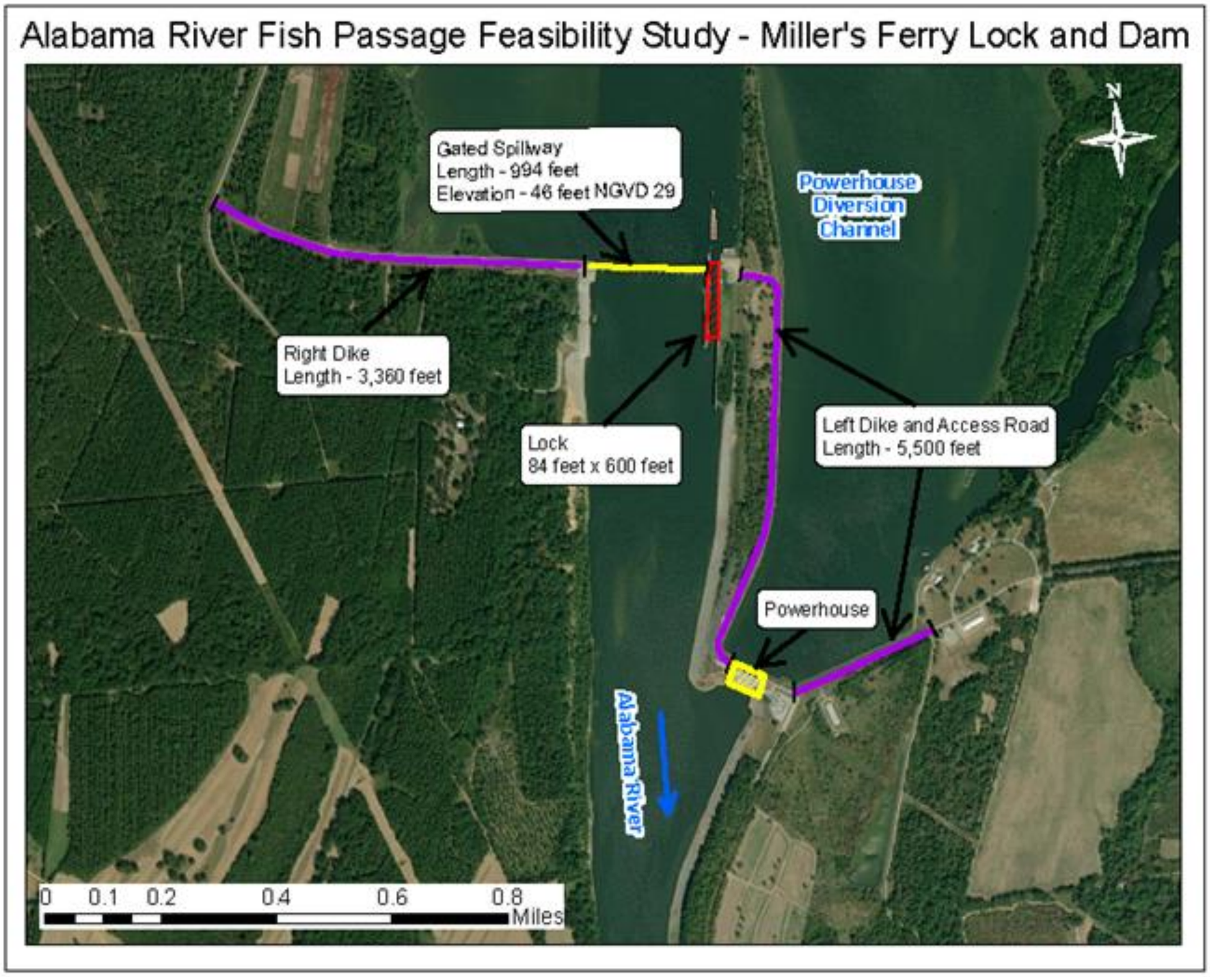

Figure A-3: Millers Ferry Lock and Dam

A.3.1.3. Pertinent Data

A.3.1.3.1. Claiborne Lock and Dam

GENERAL

Location – Clarke, Monroe, and Wilcox Counties, Alabama; Alabama River, river mile 72.5

Drainage area Millers Ferry to Claiborne – sq. mi.	836
Total drainage area above Claiborne Dam site – sq. mi	21,473
Maximum Static Head (feet)	30

RESERVOIR

Length at elevation 36.0 feet NGVD29 – miles	60.5
Area at pool elevation 36.0 feet NGVD29 – acres	6,290
Total volume at elevation 36.0 feet NGVD29 – acre-feet	102,480

GATED SPILLWAY

Total length, including end piers – feet	416
Elevation of crest – feet NGVD29	15.0
Number of gates	6
Type of gates	Tainter
Size of gates – feet	60x21
Elevation of top of gates in closed position – feet NGVD29	36.0

FIXED CREST SPILLWAY

Length – feet	500
Elevation of ogee crest – feet NGVD29	33.0
Type of stilling basin	Roller bucket

EARTH DIKES

Right Bank Dike	
Total length – feet	200
Total width – feet	25.0
Top elevation – feet NGVD29	40.0
Side slopes	1v to 3h
Left Bank Dike	
Total length including esplanade and ramp – feet	2,350
Total width – feet	32.0
Top elevation – feet NGVD29	60.0
Side slopes	1v to 4h

LOCK

Maximum lift – feet	30.0
Chamber width by length – feet	84 x 600

A.3.1.3.2. Millers Ferry Lock and Dam

GENERAL

Location – Dallas and Wilcox Counties, Alabama; Alabama River, river mile 133.0

Drainage area R.F. Henry to Millers Ferry – sq. mi.	4,404
Total drainage area above Claiborne Dam site – sq. mi	20,637

RESERVOIR

Maximum operating pool elevation – feet NGVD29	80.8
Length at elevation 80.8 feet NGVD29 – miles	105
Area at pool elevation 80.8 feet NGVD29 – acres	18,528

Total conservation volume between elevation 78.0 – 80.8 feet NGVD29 – acre-feet	102,480

GATED SPILLWAY

Total length, including end piers – feet	994
Number of piers, including end piers	18
Elevation of crest – feet NGVD29	46.0
Number of gates	17
Type of gates	Tainter
Size of gates – feet	50x35
Elevation of top of gates in closed position – feet NGVD29	81.0

EARTH OVERFLOW DIKES

Right Bank Dike (overtopped at approximately 240,000 cfs)	
Total length – feet	3,360
Total width – feet	85.0
Top elevation – feet NGVD29	25.0
Side slopes	1v to 2.5h
Left Bank Dike (overtopped at approximately 525,000 cfs	
Total length including lock mound – feet	5,500
Total width – feet	32.0
Top elevation – feet NGVD29	97.00
Side slopes	1v to 2.5h

LOCK

Maximum lift – feet	48.8
Chamber width by length – feet	84 x 600

POWER PLANT

Number of units	3
Generator rating, 3 units @ 30,000 each – kW	90,000
Maximum static head – feet	48.0

A.4. Engineering

A.4.1. Hydrology and Hydraulics

General design criteria are described in the following sections. Additional hydraulic design descriptions, analysis and considerations are provided in Appendix H, Hydrology and Hydraulics.

A.4.1.1. Hydraulic Design Assumptions

For both projects the following design assumptions were made:

- The maximum recommended slope for any fish passage channel bottom is 2% for many of the target species such as sturgeon. The PDT moved forward with 2% channel bottom slope as a design criteria maximum.
- A minimum channel depth of 5 feet is needed to accommodate larger fish species such as sturgeon or paddlefish.
- A minimum channel width for both bypass and rock weir needs to be greater than 50 feet due to size and behavior of larger fish species.
- The mean velocities for channel based on Manning's Equation was considered acceptable within the range between 3 ft/s to 8 ft/s. The PDT wanted to ensure there was water movement, but not enough to induce erosion. The PDT also was too strong for the target fish species.

A.4.2. Surveying, Mapping, and Other Geospatial Data Requirements

A.4.2.1. Project Datums

- Horizontal: NAD 1983 (2011) State Plane Alabama West (US Feet)
- Vertical: North American Vertical Datum 1988 (NAVD88)
- Get survey in NAVD, Geoid 18
- Convert to MSL 1912
- Units: U.S. Survey Feet

A.4.2.2. Digital Terrain Data

Digital terrain data were obtained for the study area from the USGS National Elevation Dataset (NED), USDA-NRCS Geospatial Data Gateway, and USACE Bathymetry Data. The quality information for these datasets were not listed within the metadata obtained.

The horizontal projection for the combined terrain file was NAD 1983 State Plane Alabama West FIPS 0102 (US Feet). RAS Mapper within the HEC-RAS software was utilized to merge the datasets together and hydraulicly correct areas within the 2D mesh of the model. RAS Mapper was also used to smooth where the bathymetry and terrain met.

A.4.2.3. Bathymetry Data

Bathymetry data were obtained from the USACE Mobile District Operations Division site office in Tuscaloosa, Alabama. The bathymetry stretches from 30 miles downstream of Claiborne Lock and Dam to the downstream side of Robert F. Henry Lock and Dam.

A.4.3. Geotechnical

The complete geotechnical report can be found in Appendix G, Geotechnical Considerations.

A.4.4. Environmental Benefits

The environmental benefits for fish passage which are included in all evaluated alternatives are inherent in the design. The structure allows for the upstream migration of a variety of fish species. The structure also allows for fish to return downstream once they have spawned in their historic spawning grounds further upriver and in the Cahaba River upstream of Millers Ferry Lock and Dam. Additional discussion regarding environmental considerations are outlined in the Main Report.

A.4.5. Civil Design

A.4.5.1. Site Selection

Numerous project sites and alignments were considered, including right bank and left bank configurations at both Millers Ferry and Claiborne project locations. Decision criteria for natural bypass channel site selection attempted to avoid the need for relocation or demolition of existing facilities, minimize cut and fill quantities, and identify historic natural tributary locations where fish may be most likely to congregate therefore increasing the potential likelihood of fish to encounter bypass entry points.

Descending left bank alignment alternatives at Millers Ferry were not considered suitable sites due to proximity to hydropower house infrastructure, which could result high fatality rates for fish that enter the turbines. Ultimately, the descending right bank alignment was selected for Millers Ferry Natural Bypass Channel.

Both descending right bank and left bank alignment alternatives were considered suitable sites for a natural bypass channel at Claiborne. While the left bank alignments did provide the opportunity to utilize an existing tributary, a descending right bank alignment was determined to be most preferred due to shorter bypass channel length requirements to achieve passage around the existing dam. A left bank alignment alternative would also require the construction of a new vehicular bridge to provide operations access to the project and therefore further increased project costs compared to the shorter right bank alignment alternative. Similar to Millers Ferry, a descending right bank alignment was selected for Claiborne Natural Bypass Channel.

A.4.5.2. Real Estate

Real estate requirements for construction of the Claiborne Millers Ferry Natural Bypass Channels will require the acquisition of private property and issuance of a USACE outgrant to the Non-Federal Sponsor. A detailed discussion of real estate requirements for this project are presented in the Appendix D – Real Estate.

A.4.5.3. Relocations

There are no known existing utility lines in conflict with the bypass channel site at Claiborne Lock and Dam. The Claiborne Lock and Dam existing parking and bathroom facility along the west side of Alabama river may need to be relocated. Existing electrical and communication lines cross the proposed alignment of the bypass channel at Millers Ferry Lock and Dam. The existing private properties and USACE facilities are assumed to use well water and septic tank utilities. The existing electrical lines, communication lines, and roads that cross the proposed alignment will need to be relocated. The relocation of existing site works and utilities will be further developed in the pre-construction, engineering, and design phase.

A.4.6. Structural Requirements

A.4.6.1. Structural Design Criteria

The structural components of the proposed fish passage project will consist of ancillary structural elements used to form a path for the fish passage to cross the earthen dam at both project sites, Millers Ferry and Claiborne. The structural elements of the fish passage will include new bridge crossings and culverts with sluice gates. To construct the new fish passage and the appurtenant structures the project will also require cofferdams to be constructed for dewatering of the working area. As the size and location of the passage is finalized the preliminary design of these elements will be performed.

A.4.6.2. Structural Design Loads

The design loads consist of lateral earth pressures, hydrostatic pressures, and live loads associate with vehicular traffic. The earth pressures include the weight of the retained soil, any surcharge loads, and any loads developed from potential earthquake ground motions. The design loads for the feasibility level design will consist of a combination of retained soil, surcharge, hydrostatic load, and earthquake load will be considered.

Three different lateral earth pressure conditions should be considered, including: active earth pressure, passive earth pressure, and at-rest earth pressure. Loads will be accordance with the following codes and design manuals.

Codes EM 1110-2-2100 Stability Analysis of Concrete Structures
EM 1110-2-6053 Earthquake Design and Evaluation of Concrete Hydraulic Structures
EM 1110-2-2107 Design of Hydraulic Steel Structures
EM 1110-2-2502 Flood Walls and Other Hydraulic Retaining Walls
International Building Code
American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications

Seismic loading for both projects should be investigated, however based on the PGA (Maximum of .073, Millers Ferry) numbers at each site the seismic loading will more than likely not be the controlling case.

A.4.6.3. Vehicular Bridge Design

The vehicle bridge crossing at the existing Millers Ferry dam surface will consist of a 3-span bridge, with a total bridge length of +/- 76ft. The superstructure for the bridge would be steel girders and beams supporting steel grating. Bridge girders shall be fixed at one end and free at the other to allow for expansion and contraction. The substructure would consist of pier walls and concrete abutments. It is anticipated the substructure will be pile supported. At this time, it is not clear whether a steel sheet pile cut-off wall will be required.

The bridge loading shall be designed to AASHTO HS20 loading allow for truck traffic used during maintenance of the spillway structures. Wind and seismic loading on the bridge shall be accordance with ASCE 7 and all applicable USACE design manuals. Vehicular bridge design will be further developed during the pre-construction, engineering, and design phase.

A.4.6.4. Concrete Structures to Support Bridge and Control Gates (Millers Ferry)

The concrete structures supporting the bridge will be constructed using a minimum of 4000 psi concrete reinforced with 60ksi steel. The structures will be designed with consideration for mass concrete pours and admixtures shall be used to minimize the heat generated.

The abutments and wing walls will be designed to withstand lateral loads in combination with vertical loads associated with the bridge structure. Lateral load should include earth pressures, seismic loads, and lateral hydrostatic pressure when gate is in the closed position. Concrete structures to support bridge and control gates will be further developed during the pre-construction, engineering, and design phase.

A.4.6.5. Sluice Gate Design

The sluice gates will be used to control the flow of water through the fish passage at Millers Ferry. The gates will be remotely operated from an offsite location with a local mechanical override operation in the event of an emergency or loss of power. It is anticipated that the gates will be constructed using steel fabricated gates constructed to withstand hydrostatic pressure and debris impact. Sluice gate design and operation will be further developed during the pre-construction, engineering, and design phase.

A.4.6.6. Technical Basis for Type and Configuration of Appurtenant Structures

The cofferdam will be considered an appurtenant structure. The cofferdams will be designed and installed to fulfill the construction of the fish passage. It is anticipated that these cofferdams will need to be constructed at several locations. As the location of the fish passage is finalized during the pre-construction, engineering, and design phase the exact configuration of the cofferdams will be further developed.

A.4.6.7. Stability Analysis and Criteria

Structural stability analyses, such as the type performed for concrete monoliths, are applicable to this project. The stability of the abutments, wing walls, and pier columns will be determined using the design guides listed in Section A.4.6.2.

A.4.6.8. Initial Seismic Analysis and Criteria

The seismic loading on walls is typically evaluated using pseudo-static analysis. A common method for seismic design of retaining structures is the pseudo-static method developed by Okabe (1926) and Mononobe (1929), known as the Mononobe-Okabe method.

Engineering Manual (EM) 1110-2-2504 (Design of Sheet Pile Walls) discusses earthquake forces in Section 4-6.e, where it indicates that earthquake forces should be considered “in zones of seismic activity.” This section indicates that earth pressures should be determined in accordance with procedures outlined in EM 1110-2-2502 (Retaining and Flood Walls). EM 1110-2-2502 presents the Mononobe-Okabe method as well.

The Mononobe-Okabe equations use a horizontal seismic coefficient (kh) and a vertical seismic coefficient (kv).

From the structural load data tool referenced in Unified Facility Criteria (UFC) 3-301-01, which is available on the Whole Building Design Guide, the PGA was determined to be 0.073 Millers Ferry and .058 Claiborne. Based on the low Peak Ground Acceleration (PGA) seismic is not considered a controlling force.

A.4.7. Electrical and Mechanical Requirements

It is anticipated there will be no electrical and mechanical requirements related to the Claiborne Natural Bypass Channel. The control gate structure at the Millers Ferry Natural Bypass Channel will require electrical and mechanical design considerations to operate gate closure structure. The electrical and mechanical requirements will be further developed in the pre-construction, engineering, and design phase.

A.4.8. Hazardous, Toxic, and Radioactive Waste

Hazardous, Toxic, and Radioactive Waste considerations are currently under development. At this time, there are no known environmental concerns related to the project and the need for a Phase 1 Environmental Site Assessment is not expected.

Refer to Appendix A-1, Hazardous, Toxic, and Radioactive Waste Documentation Report.

A.4.9. Construction Procedures and Water Control Plan

Detailed construction procedures will be developed during the pre-construction, engineering, and design phase. The Water Control plan for construction will also be developed in the pre-construction, engineering, and design phase.

A.4.10. Initial Reservoir Filling and Surveillance Plan

Not applicable to this Project.

A.4.11. Floodway / Floodplain Impacts for Areas Downstream of Corps Dams.

USACE completed Dam Break Studies and resulting inundation mapping for both Millers Ferry and Claiborne Lock and Dams (July 1983). Results from these studies are summarized below in Sections A.4.11.1 and A.4.11.2, respectively.

A dam breach will not result in out of bank flooding. The only consequences would be low water above the dam and a loss of navigation until the pool is restored.

A.4.11.1. Flood Emergency Plans for Areas Downstream of Millers Ferry Lock and Dam.

An inundation map was prepared to delineate conditions that may cause the greatest impact during severe dam failure. Sudden changes in river stages and turbulence caused by a major dam break at Millers Ferry Dam would be greatest if initially the river was in a low-flow condition. This is true because natural, rainfall-produced floods on the Alabama River may be larger than floods produced by a dam failure. In the more extreme flood events, a dam break may have no noticeable effect on river stages.

An examination of this map indicates that major out-of-banks flooding will not result from a failure at Millers Ferry Dam; however, emergency and contingency plans can be prepared using the information presented. Some of the more important factors that can be determined include:

a. Peak river elevations at locations along the river.

b. The rate of rise in river stages and the time available for warnings and to make preparations.

A.4.11.2. Flood Emergency Plans for Areas Downstream of Claiborne Lock and Dam.

An inundation map was prepared to delineate conditions that may cause the greatest impact during severe dam failure. Sudden changes in river stages and turbulence caused by a major dam break at Claiborne Dam would be greatest if initially the river was in a low-flow condition. This is true because natural, rainfall-produced floods on the Alabama River may be larger than floods produced by a dam failure. In the more extreme flood events, a dam break may have no noticeable effect on river stages.

An examination of this map indicates that major out-of-banks flooding will not result from a failure at Claiborne Dam; however, emergency and contingency plans can be prepared using the information presented. Some of the more important factors that can be determined include:

a. Peak river elevations at locations along the river.

b. The rate of rise in river stages and the time available for warnings and to make preparations.

A.4.12. Environmental Objectives and Requirements

Project Objectives, which are environmental objectives, are outlined in the Main Report.

A.4.13. Reservoir Clearing

Not applicable to this Project.

A.4.14. Operations and Maintenance

Reference the Main Report for operation and maintenance details.

A.4.15. Access Roads

Existing public roads and USACE roads will be used to access the site. Access roads damaged during construction will be replaced by the contractor to pre-construction condition at no extra expense to the government.

A.4.16. Corrosion Mitigation

Any required corrosion mitigation will be developed during the pre-construction, engineering, and design phase.

A.4.17. Project Security

Safety and security are important parameters which will be detailed during the pre-construction, engineering, and design phase. Some type of locked fence prohibiting unauthorized access to the project was considered. The possibility of people fishing in the bypass channel was a concern. Additionally, vandalism and safety issues were also considered. Coordination with the District’s Safety Office and Office of Counsel will be required in this area.

A.4.18. Cost Estimates.

Cost estimates are provided in Appendix C, Cost Estimate

A.4.19. Schedule for Design and Construction.

Refer to the Main Report for project schedules for design and construction.

A.4.20. Engineering Drawings

Refer to Appendix

A.4.21. Data Management

Data will be managed using the District's Bentley ProjectWise Explorer data management system.

A.4.22. Use of Metric System Measurements

This Project does not use the metric system of measurements. Not applicable to this Project.

A.5. Design Considerations

Design considerations are outlined under specific measures and in other engineering sections contained within the Main Report.

A.5.1. Dam Safety

Dam safety is a serious consideration for any modification to the dam or spillway. In accordance with USACE Engineering and Construction Bulletin 2022-7, Interim Approach for Risk-Informed Designs for Dam and Levee Projects, the PDT tasked the Risk Cadre from the USACE Jacksonville District to perform a semi-quantitative risk assessment (SQRA) investigating potential failure modes related to the Tentatively Selected Plan.

Refer to Appendix A - 2, Dam Safety Memo for additional information.

A.5.2. Navigation Impacts

A primary objective of this Study is to maintain a safe and efficient navigation system. The Rivers and Harbors Appropriation Act of 1899, Section 10 states that obstructions created in any navigable waterway are prohibited without Congressional authorization or a permit from the Chief of Engineers.

Navigation impacts are a concern for any bypass channel due to the change in velocity patterns near the lock induced by water converging with the navigable waterway. The location and orientation that was assumed to have the worst impact on navigation is a bypass channel extending downstream of the spillway, with the downstream end bending approximately 90 degrees so that the water velocity vectors coming down through the bypass channel is perpendicular the water velocity vectors coming through spillway gates.

A.5.3. Floodway / Floodplain Impacts

A preliminary analysis using HEC-RAS 2-Dimensional modeling showed little to no impact to the water surface elevations relating to storm events. Both projects are run-of-river navigation dams, which release all inflows and does store any additional water. The preliminary analysis is limited due to the complex flow conditions near both projects. In order to analyze the local affects in more detail, a more refined model will be needed.

A.5.4. Public Access and Security

Some type of locked fence prohibiting unauthorized access to the project was considered. Coordination with the District's Safety Office and Office of Counsel will be required in this area. Locals use the Claiborne dike and spillway extensively for recreational fishing and concern of such activities was expressed for the bypass channels along with the possibility of other activities such as net casting, swimming, and kayaking within the channels.

A.5.5. Construction Considerations

The project is likely to be implemented in two stages. Stage 1 would include design and construction of the cofferdam, gate structure, and bridges. Stage 2 would include the design and construction of the bypass channel. Monitoring and adaptive management would occur prior to construction (pre-construction monitoring) and after construction is complete (post-construction monitoring and adaptive management). Further construction considerations will be refined during the pre-construction, engineering, and design phase.

A.5.6. Storm Water Pollution / Erosion Control

The potential for storm water pollution during construction is primarily related to excavation activities. USACE standard best management practices such as silt fencings and erosion control measures should be employed during construction to minimize issues with storm water runoff and localized erosion. minimal for this project. Overall, the long-term storm water runoff characteristics of the site would not be expected to change as a result of the project.