Claiborne and Millers Ferry Locks and Dams Fish Passage Study

Appendix E: Socioeconomics

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US Army Corps of Engineers

The Nature Conservancy

E.1.INTRODUCTION

This socioeconomics appendix documents the analysis and evaluation of the National Ecosystem Restoration (NER) Plan and the Plan which maximizes net total benefits for the Fish Passage Ecosystem Restoration Study undertaken for Claiborne Lock and Dam and Millers Ferry Lock and Dam. The NER plan is the cost effective and efficient plan while the other identified plan is the plan that maximizes benefits across the four USACE Planning Accounts. Section I covers the study authority and purpose and provides the background information utilized to derive the Study Alternatives. Section II documents the Cost Effectiveness (CE) analysis and evaluation in addition to the Multi Criteria Decision Analysis (MCDA) and the results to identify the NER Plan and the Plan which maximizes net total benefits, respectively.

This appendix and the assessments herein are inclusive of the Hydropower Analysis Center (HAC) results. Further explanations and more details regarding the impact of the Final Array of Alternatives on hydropower for both the greater Alabama-Coosa-Tallapoosa (ACT) river system and the Millers Ferry Lock and Dam Powerhouse project are located within the report prepared by the Hydropower Analysis Center as Appendix F.

E.1.1. SECTION I: National Ecosystem Restoration

The Federal Interest of ecosystem restoration is established through numerous federal laws and executive orders to protect, restore, conserve, and manage ecological resources (ER 1105-2-100, Appendix E).

E.1.1.1. *Study Authority*

This Study is authorized by Section 216 of the Flood Control Act of 1970 [Public Law (PL) 91-611] as amended, which states: "The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due to significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest."

The condition created by these dams has impacted access to critical spawning habitat for multiple species. The project area contains 46 species of Federal or State concern, 12 of which are Federally protected.

E.1.1.2. *Purpose*

The purpose of the study is to evaluate Federal interest in establishing fish passage through restoring connectivity in the Alabama and Cahaba Rivers to address the impacts created by the dams. Individually, these rivers are nationally significant, but holistically they may be in the top 5 in the U.S. for biodiversity.

- The system is highly impaired from a loss in connectivity
- Passage would reconnect over 230 miles of the Alabama and Cahaba Rivers to the Mobile River Delta into the Gulf of Mexico providing connectivity for several species of fish, crawfish, mussels, turtles, etc. that are extremely important to this freshwater system.
- This system provides one of the last habitats to many affected species.
- Carbon sequestration occurs in the bottom hardwoods of the delta.
- The system is critical to the Native Americans indigenous to the region.
- This project is part of the development of a resilient, productive and variegated habitat in the region which will provide added resilience in a changing climate.

E.1.1.3. *Study Area*

Claiborne and Millers Ferry Locks and Dams are part of a larger system extending through Alabama, the northwest corner of Georgia, and into Tennessee, and are part of the Alabama-Coosa-Tallapoosa (ACT) River system. The system contains 5 USACE dams and 11 privately owned dams as depicted in Figure 1.

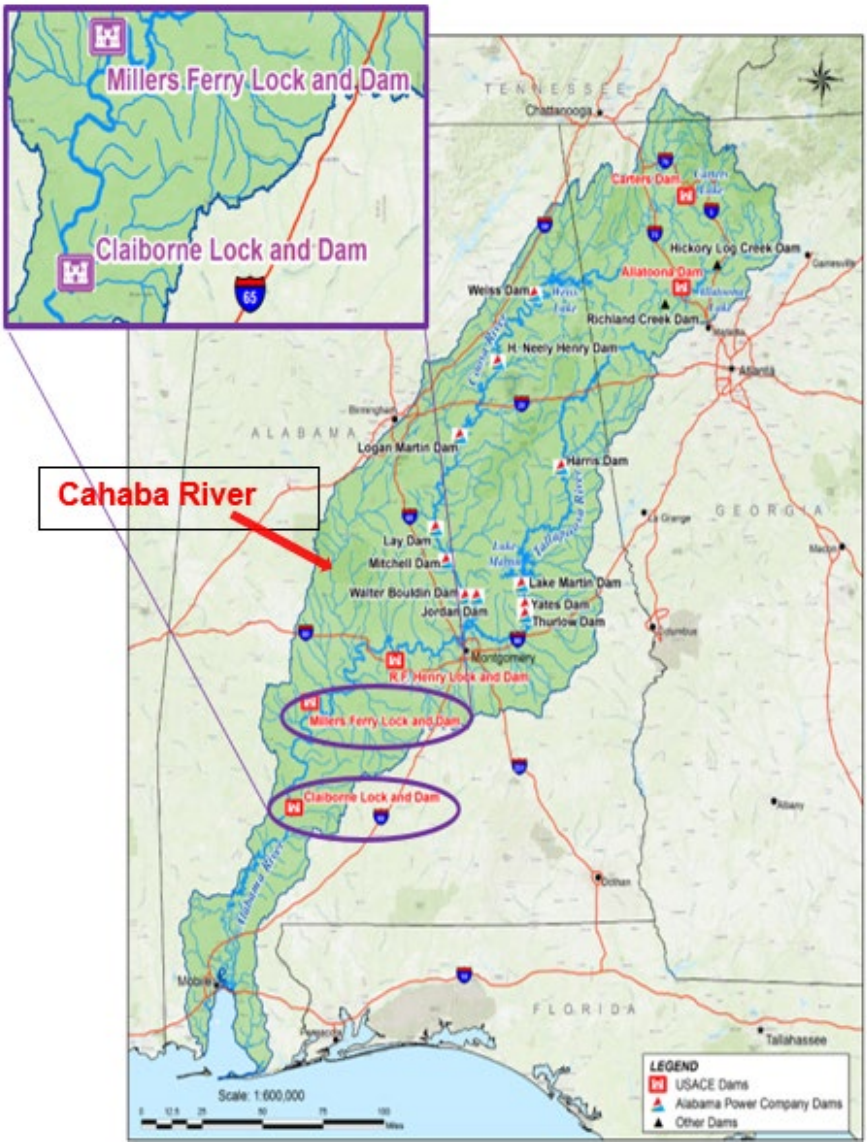


Figure 1: The Alabama-Coosa-Tallapoosa (ACT) River system

E.1.1.3.1.*Focus Area*

In line with the study's objectives, as described in the Main Report, the focus area includes over 230 miles of the Alabama and Cahaba Rivers to the Mobile River Delta into the Gulf of Mexico. Again, reestablishing this connection for migration, spawning, foraging and for thriving nurseries for native fish and mussel species will preserve and bolster the biological diversity within this ecosystem.

E.1.1.3.2.*Project Area*

Two lock and dam projects are located in the project area, Claiborne Lock and Dam (Claiborne) and Millers Ferry Lock and Dam (Millers Ferry). The project area extends from

river mile 72.5 on the Alabama River at the Claiborne lock and dam up to river mile 133 at the Millers Ferry 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 in Figure 2.

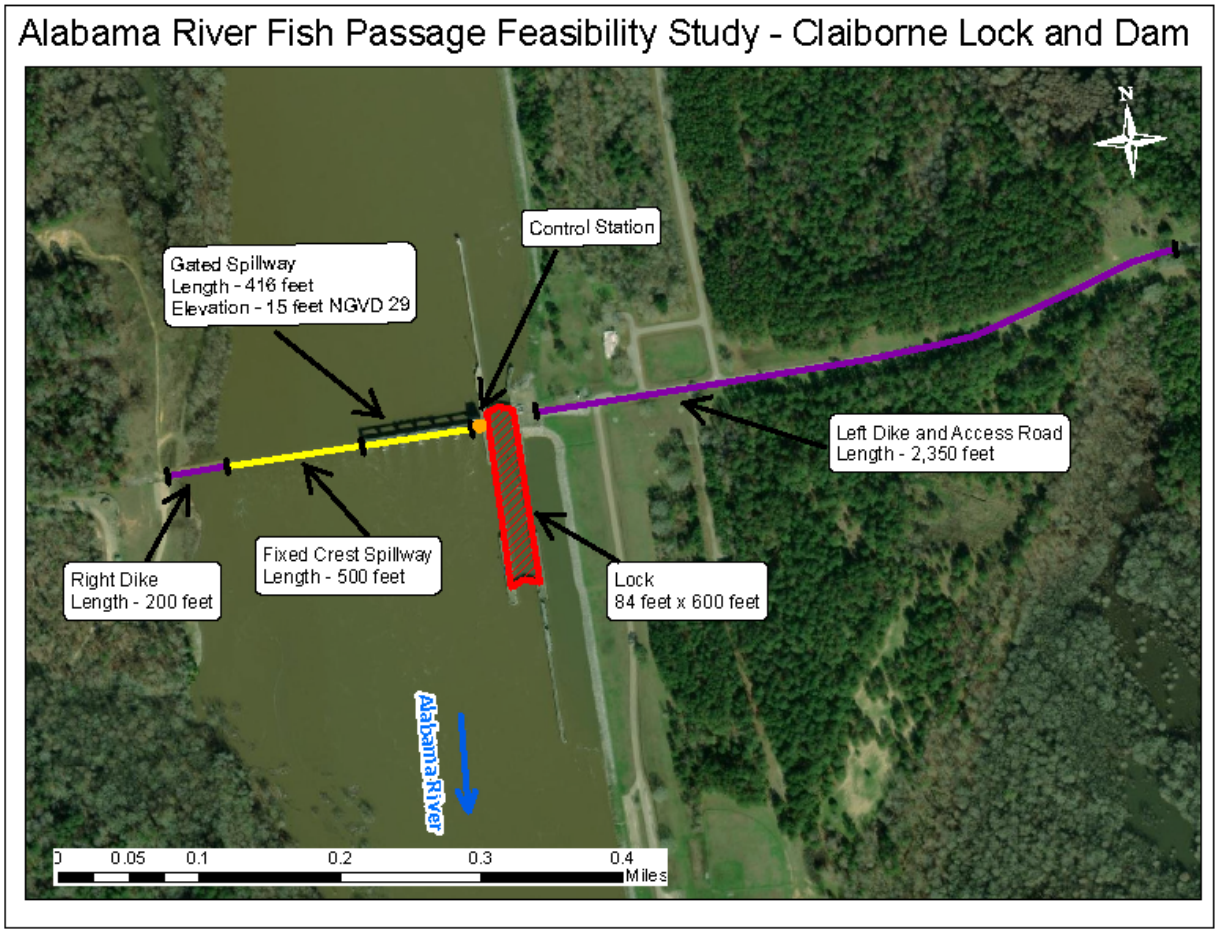


Figure 2: The Claiborne Lock and Dam

Millers Ferry is upstream of the Claiborne on the Alabama River and was constructed between 1964 and 1970. The project purposes here 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 3.

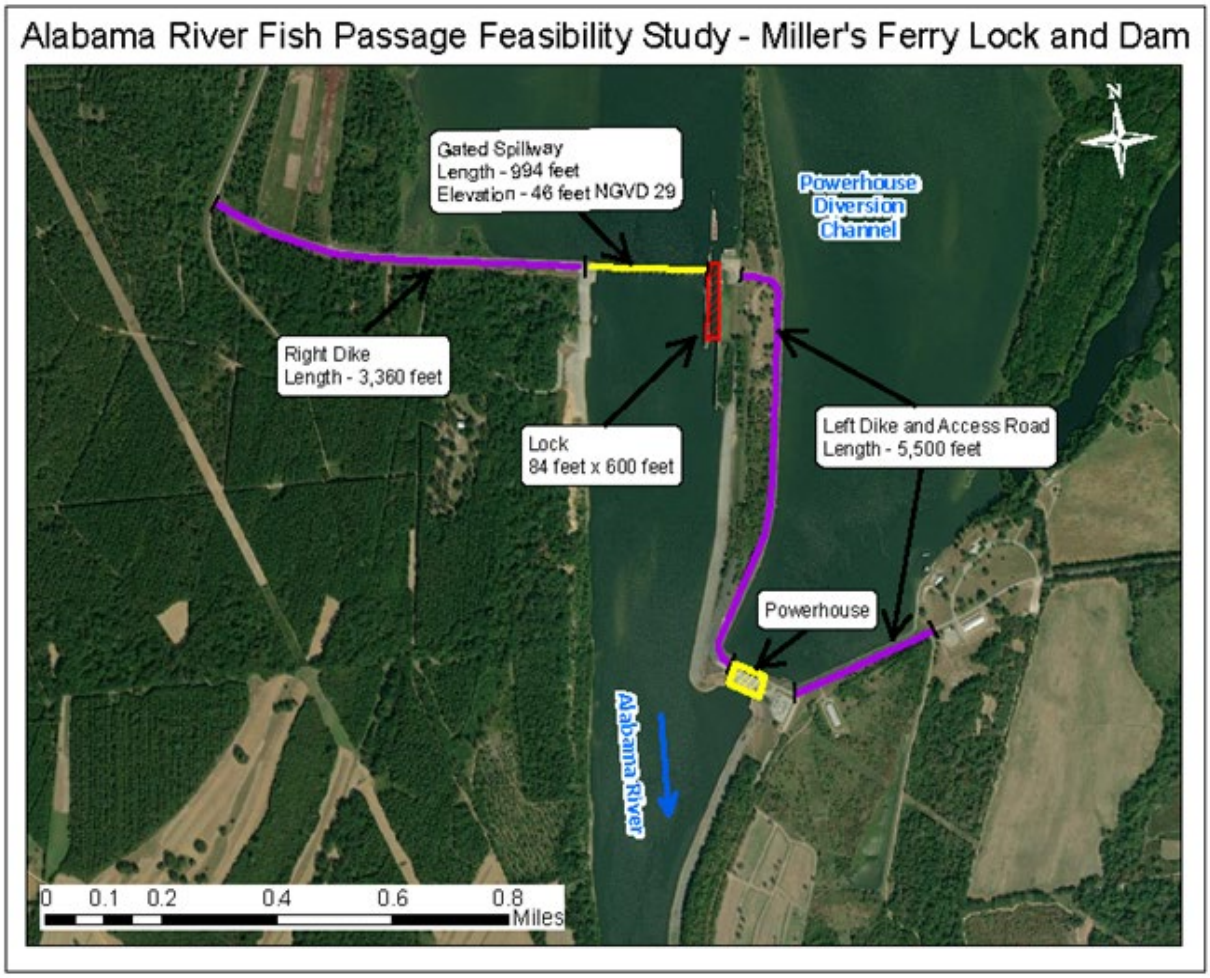


Figure 3: The Millers Ferry Lock and Dam

E.1.1.3.3.*Socioeconomic Data*

The Mobile-Tensaw Delta and Cahaba River are nationally recognized, significantly biodiverse ecosystems with a footprint that traverses seven counties (Mobile, Baldwin, Washington, Clarke, Monroe, Wilcox, and Dallas). Four of the seven counties (Clarke, Monroe, Wilcox, and Dallas) fall within Alabama's Black Belt National Heritage Area (House 2022) which is widely recognized as the birthplace of the Civil Rights and Voting Rights movements. Homing in on the two project sites, Millers Ferry Lock and Dam is located within Wilcox County and Claiborne Lock and Dam is located within Monroe County, both within the Black Belt National Heritage Area.

Alabama Population and Demographics: The U.S. Census Bureau estimates Alabama to have a total population of 5,074,296 as of July 1, 2022, from extrapolating from the 2020 Decennial Census, which reported the State population at 5,024,279 allowing U.S. Census Bureau to infer growth in the State's population of 1.0% with 51.4% identifying as

female. A strong majority of the State's population (98.1%) identify as one race alone, with 68.9% identifying as White, 26.8% identifying as Black or African American, 4.8% identifying as Hispanic or Latino, 1.6% identifying as Asian, 0.7% identifying as American Indian and Alaska Native, and 0.1% being Native Hawaiian and Other Pacific Islander. Within Alabama there are 1,902,983 households with an average of 2.57 persons per household.

Wilcox County Population and Demographics: The U.S. Census Bureau estimates Wilcox County to have a total population of 10,446 as of July 1, 2022, from extrapolating from the 2020 Census, which reported the County population at 10,600 allowing U.S. Census Bureau to infer a decrease in the County's population of 1.5% with 52.9% identifying as female. A strong majority of the County's population (98.6%) identifying as one race alone, with 70.1% identifying as Black or African American, 28.0% identifying as White, 1.5% identifying as Hispanic or Latino, 0.3% identifying as Asian, and 0.2% identifying as American Indian and Alaska Native.

Camden Census County Division (CCD), AL Demographics: According to the 2020 Decennial Census, the total population for the Camden CCD was 4,746 with the median household income reported at $38,384 and an employment rate of 37.5% compared with the employment rate of 54.1% for the State of AL. The median household income in the United States was $64,994 in 2020.

Monroe County Population and Demographics: The U.S. Census Bureau estimates Monroe County to have a total population of 19,648 as of July 1, 2021, from extrapolating from the 2020 Census, which reported the County population at 19,772 allowing U.S. Census Bureau to infer a decrease in the County's population of 0.6% with 52.1% identifying as female. A strong majority of the County's population (98.2%) identify as one race alone, with 55.0% identifying as White, 41.3% identifying as Black or African American, 1.7% identifying as Hispanic or Latino, 0.5% identifying as Asian, and 1.4% identifying as American Indian and Alaska Native.

Monroeville Census County Division (CCD), AL Demographics: According to the 2020 Decennial Census, the total population for the Monroeville CCD was 8,932 with the median household income reported at $31,641 and an employment rate of 45.7% compared with the employment rate of 54.1% for the State of AL. The median household income in the United States was $64,994 in 2020.

E.1.1.3.4.*Assumptions*

This section of the analysis presents the assumptions used in computing average annual equivalent costs for the alternatives considered at the two project sites.

- The cost effectiveness analysis employs the federal discount rate of 2.5% throughout.
- All dollar figures are stated in constant FY 2023 dollars.
- The cost effectiveness analysis incorporates hydropower benefits foregone, as calculated by the Hydropower Analysis Center, as an opportunity cost with respect to each alternative in the Final Array.
- The hydropower impacts of the alternatives within the Final Array will be limited to Millers Ferry since these estimates reflect the overall hydropower impacts to the ACT system dams.

E.1.1.3.5. *Risk and Uncertainty*

Risk and uncertainty are inherent in water resources planning and design. These factors arise due to errors in measurement and from the innate variability of complex physical, social, and economic situations. The measured or estimated values of key planning and design variables are rarely known with certainty and can take on a range of possible values. Risk analysis in ecosystem restoration projects is a technical task of balancing multiple risks including those of design, accounting for climate resiliency, cost contingencies, along with other factors and trading off uncertainty to provide for reasonably predictable project performance. Risk-based analysis is therefore a methodology that enables issues of risk and uncertainty to be included in project formulation.

E.1.1.3.5.1. Modeling Description

Conforming with the purpose of this study, the habitat model used to derive habitat units is described within the Main Report Section 4.2.

E.1.1.4. *Existing Condition*

The Mobile-Tensaw Delta and Cahaba River are nationally recognized, significantly diverse ecosystems. The lack of connectivity threatens the diversity of this area by preventing access to critical spawning habitat. Alabama ranks one of the highest among the continental U.S. for aquatic diversity in both total and endemic populations. Alabama is home to 93 native reptiles (*Reptiles* 2020) and 450 fish species which is “the most found in any other state or province in North America” (Mettee, 2016). Additionally, Encyclopedia of Alabama states “Alabama is home to the most diverse fauna of freshwater mussels in all of North America, with 180 species” (Garner, 2013). Boshung and Mayden (2004), documented 185 fish species historically occurring within the Alabama River drainage including 161 native species, 2 euryhaline species, 4 marine species, and 18 introduced species. Williams et al. (2008), document 51 mussel species historically occurring within the Alabama River drainage area.

- The aquatic ecosystem is considered impaired, impacting several species, including some designated as threatened or endangered.
- Several federally threatened and endangered freshwater mussels occur within the study area with a broad range of host fish.
- The Claiborne and Millers Ferry Lock and Dam structures have created a loss of connectively between the Gulf of Mexico, Mobile Bay, Mobile-Tensaw Delta and critical aquatic spawning habitat in the Alabama and Cahaba Rivers resulting in increased risk to multiple species of fish and mussels.

  There are declining populations for several fish species, including the Alabama Sturgeon (endangered) and Gulf Sturgeon (threatened) which are impacted by lack of access to spawning habitat. The structures act as sediment transport barriers, resulting in a sediment rich system upstream and sediment deprivation downstream. Lack of sediment balance negatively impacts multiple species of fish and mussels.

E.1.1.5. *Study Alternatives*

The identification of management measures, formulation of alternatives and the screening process leading to the Final Array of Alternatives can be gleaned from section 2.0 of the Main Report. The evaluation of the following alternative actions included within the Final Array are analyzed in this appendix:

- **Baseline or "no action" alternative (NAA):** Operations remain unchanged from current conditions
- **Alternative 3:** Rock weirs at both Millers Ferry and Claiborne
- **Alternative 5d:** Bypass channels at both Millers Ferry and Claiborne
- **Alternative 12b:** Rock weir at Claiborne, bypass channel at Millers Ferry
- **Alternative 13b:** Bypass channel at Claiborne, rock weir at Millers Ferry

Full descriptions of the alternatives can be found in the Main Study Report. As noted above, ResSim simulation output reflecting operations at all ACT system dams indicates that the proposed alternatives will only impact hydropower at Millers Ferry dam.

E.2. *SECTION II:* Evaluation of Final Array Alternative Plans

The Claiborne and Millers Ferry Locks and Dams Fish Passage Study Project Delivery Team (PDT) evaluated and compared the Final Array of Alternatives using cost effectiveness analysis in addition to multi-criteria decision analysis to determine the National Ecosystem Restoration (NER) Plan and Plan which maximizes benefits across the four planning accounts, also referred to as the Total Net Benefits Plan, respectively.

E.2.1. *NER Plan Identification from Cost Effectiveness Analysis*

In accordance with ER 1105-2-100 Appendix E, the selection of the NER Plan first requires identification of the plan that meets planning objectives, avoids planning constraints, and reasonably maximizes environmental benefits while also determining its cost effectiveness.

The cost effectiveness analysis results in one best buy action alternative, 5d, as depicted in the table below beyond the best buy no action alternative. That is, the natural bypass channel at both project sites has the highest ecological lift at 1,005,661 habitat units and the lowest average annual equivalent cost of $8,496,000. Thus, Alternative 5d is the best buy action alternative with an average cost per habitat unit of $8.45.

Table 1: Cost Effectiveness Analysis

Alternative	Avg Annual Habitat Units	Avg Annual Equivalent Cost	Avg Cost per HU	Best Buy?
Alt. 1: No Action	6,513	-	-	Yes
Alt. 3: Fixed Weir Rock Arch – Both Dams	872,331	$10,360,000	$11.88	No
Alt. 5d: Natural Bypass Channel-Both Dams (CL right bank, MF right bank)	1,005,661	$8,496,000	$8.45	Yes
Alt. 12b: CL – Fixed Wier Rock Arch and MF – Natural Bypass Channel (right bank)	978,402	$8,906,000	$9.10	No
Alt. 13b: CL – Natural Bypass Channel (right bank) and MF – Fixed Wier Rock Arch	899,590	$9,236,000	$10.27	No

The results shown above in Table 1 distinguishes Alt 5d as the Best Buy Action Alternative and thus the PDT's NER Plan. No other Alternative generates more habitat units nor provides greater connectivity to the Cahaba from Mobile Bay than does Alternative 5d. Moreover, this alternative is not only the most effective plan within the Final Array of Alternatives, it also is most efficient with the lowest average annual equivalent cost, inclusive of the opportunity cost of annual hydropower benefits foregone.

E.2.2. *Identification of Plan that Maximizes Net Total Benefits Across All Benefit Categories*

In accordance with the ASA(CW) Memorandum for the Commanding General, USACE, dated 5 January 2021, the PDT is instructed to identify the Plan that Maximizes Net Total Benefits Across All Benefit Categories – economic, social, and environmental. This section documents the evaluation conducted to deduce the plan which maximizes benefits across the Four Planning Accounts (Environmental Quality, National Economic Development, Regional Economic Development, and Other Social Effects).

To evaluate the performance of each of the four action alternatives within the final array against the no action alternative, the PDT identified the most relevant standards of measurements, or metrics to evaluate each of the Four Planning Accounts. While the ASA(CW) Memorandum for the Commanding General explicitly states, "…it is imperative that any benefits reflected in more than one category are only counted once," it is instructive to differentiate between *metrics* and their use to capture *benefit categories* within separate planning accounts.

For instance, to evaluate benefits for the environmental quality account, habitat units can often be the distinguishing metric of choice. Establishing habitat units as the best metric to evaluate the environmental quality account, however, does not bar the metric from use in evaluating a separate planning account in which the metric might measure another benefit category and thus be a co-benefit with respect to the single metric.

E.2.2.1. *Environmental Quality Account*

The FPCI is used to measure benefits to aquatic species within the study area. A total of 19 species were identified to represent the biodiversity within the study area and are referenced as the species cohort. The FPCI calculates the "passability" for each alternative by evaluating the potential for species cohort to locate the passageway based on fish behavior, the potential to use the passageway based on critical swimming speeds, and the duration of passageway availability. These factors determine the connectivity index value which is then multiplied by available habitat to determine habitat units per each alternative. Essentially, higher habitat units mean the species cohort is more able to find it, use it, and access it better than compared alternatives. Alternative 5d provides the highest habitat units compared to all other alternatives in the Final Array.

E.2.2.2. *National Economic Development Account*

The alternatives also have impacts on NED Benefits. Captured through the Hydropower Analysis Center's evaluation (and further detailed within Appendix F, Impacts to Hydropower), the metric of hydropower value was used in the MCDA to capture hydropower benefits foregone to compare the alternatives within the final array.

E.2.2.3. *Regional Economic Development Account*

When the economic activity lost in the study area can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the Regional Economic Development (RED) account. The input-output macroeconomic model RECONS was used to address the impacts of the construction spending.

E.2.2.3.1. *RECONS Methodology*

The input-output macroeconomic model RECONS was used to quantify each of the alternatives in the final array.

For this regional analysis, the RED effects of implementing the recommended alternative is estimated. The RECONS Standard Geographic Area for Wilcox County, AL was selected.

This RED analysis, using RECONS, employs input-output economic analysis, which measures the interdependence among industries and workers in an economy. This model uses a matrix representation of a region's economy to predict the effect and extent that changes from the implementation of a project, from within a specific USACE Business Line, will have on various industries within the geographic areas of the project. The greater the interdependence among industry sectors, the larger the multiplier effect on the economy. Changes to government spending drive the input-output model to project new levels of sales (output), value added (Gross Regional Product or GRP), employment, and income for each industry.

The specific input-output model used in this analysis is RECONS (Regional Economic System). This model was developed by the Institute for Water Resources (IWR), Michigan State University, and the Louis Burger Group. RECONS uses industry multipliers derived from the commercial input-output model IMPLAN® to estimate the effects that spending on USACE projects have on a regional economy. The model is linear and static, showing relationships and impacts at a certain fixed point in time. Spending impacts are composed of three different effects: direct, indirect, and induced.

Direct effects represent the impacts the new federal expenditures have on industries which directly support the new project. Labor and construction materials can be considered direct components to the project. Indirect effects represent changes to secondary industries that support the direct industries. Induced effects are changes in consumer spending patterns caused by the change in employment and income within the industries affected by the direct and induced effects. The additional income workers receive via a project and spend on clothing, groceries, dining out, and other items in the regional area are secondary or induced effects.

The inputs for the RECONS model are expenditures that are entered by work activity or industry sector, each with its own unique production function. The Environment Business

Line production function of “Construction of Fish Facilities at Dams” was selected to gauge the impacts of the construction. The baseline data used by RECONS to represent the regional economy of Wilcox Count, AL (to proximately represent the expenditure at Millers Ferry Lock and Dam within Wilcox County in addition to the expenditure at Claiborne Lock and Dam within Monroe County) are annual averages from the Bureau of the Census, the Bureau of Labor Statistics, and the Bureau of Economic Analysis for the year 2020. The model results are expressed in 2023 dollars.

E.2.2.3.2.*Assumptions*

Input-output analysis rests on the following assumptions. The production functions of industries have constant returns to scale, so if inputs are to increase, output will increase in the same proportion. Industries face no supply constraints; they have access to all the materials they can use. Industries have a fixed commodity input structure; they will not substitute any commodities or services used in the production of output in response to price changes. Industries produce their commodities in fixed proportions, so an industry will not increase production of a commodity without increasing production in every other commodity it produces. Furthermore, it is assumed that industries use the same technology to produce all its commodities. Finally, since the model is static, it is assumed that the economic conditions of 2020, the year of the socio-economic data in the RECONS model database, will prevail during the years of the construction process.

E.2.2.3.3.*Description of Metrics*

“Output” is the total sum of transactions that take place as a result of the construction project, including both value added and intermediate goods purchased in the economy. “Labor Income” includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. “Gross Regional Product (GRP)” is the value-added output of the study region. This metric captures all final goods and services produced in the study areas because of the project’s existence. It is different from output in the sense that one dollar of a final good or service may have multiple transactions associated with it. “Jobs” is the estimated worker-years of labor required in full time equivalent units to build the project.

E.2.2.3.4.*RECONS Results*

Regional economic development (RED) benefits were quantified for each of the alternatives in the final array using the RECONS model. This analysis assessed how construction spending associated with the alternatives would affect regional economic conditions. The RED analysis estimates the direct, indirect, and induced effects to local regions as measured through jobs, gross regional product, labor income, and sales. The results of the RED analysis for the Tentatively Selected Plan are shown for in Table 4 below.

Table 2. RED Effects of Alternative 5d: Natural Bypass Channel – Both Dams

Alt. 2 Structural Effects/Impact Areas	Local Area	State of Alabama
First Cost ($000)	$165,035	$165,035
Direct Impact		
Output ($000)	$152,142	$163,172
Jobs*	2,036	2,173
Labor Income ($000)	$92,341	$124,522
GRP or Value Added ($000)	$49,177	$61,010
Secondary Impact		
Output ($000)	$45,575	$184,821
Jobs*	287	1,039
Labor Income ($000)	$10,292	$54,689
GRP or Value Added ($000)	$23,060	$98,029
Total Impact (Direct and Secondary)		
Output ($000)	$197,718	$347,992
Jobs*	2,323	3,212
Labor Income ($000)	$102,633	$179,211
GRP or Value Added ($000)	$72,237	$159,039

*Jobs are presented in full-time equivalence (FTE) and are short term resulting from construction spending.

E.2.2.4. *Other Social Effects Account*

Building on the application of HUs used to measure ecological lift and accounted for within the EQ Account, HUs are also used to as the metric, serving as a proxy, to capture the benefits within the Other Social Effects Account attributable to biodiversity strength and its relationship with climate positive impacts on vulnerable communities.

Since the action alternatives in the final array would in effect increase biodiversity, minor indirect beneficial impacts to climate are anticipated in comparison to the FWOP conditions where biodiversity is anticipated to decrease (Dasgupta 2021 and Shin et al. 2022).

E.2.2.5. *Multi-Criteria Decision Analysis*

Applying USACE Planning Account specific criteria within IWR Planning Suite's Multi-Criteria Decision Analysis (MCDA) tool, scores were generated ranging from 0-1 using a percent of maximum normalization technique. All criteria (e.g., Habitat Units, Hydropower

Value, Full Time Equivalent (FTE) Jobs, Gross Regional Product (GRP)), used as inputs to the MCDA with respect to each Planning Account, desired higher values except for each alternative's Project First Cost criterion where a minimum value is desired. Regional Economic Development (RED) benefits such as FTE Jobs and GRP are a function of project first costs which is a direct input to the certified Regional Economic Model (RECONS).

Utilizing the normalized scores for each Planning Account to compute a Total Score, adding the four accounts' scores, avoids the weakness of utilizing a ranking method where the magnitude of differences between Alternatives within any of the Planning Accounts might distort identification of the Plan that maximizes benefits across the Four Planning Accounts.

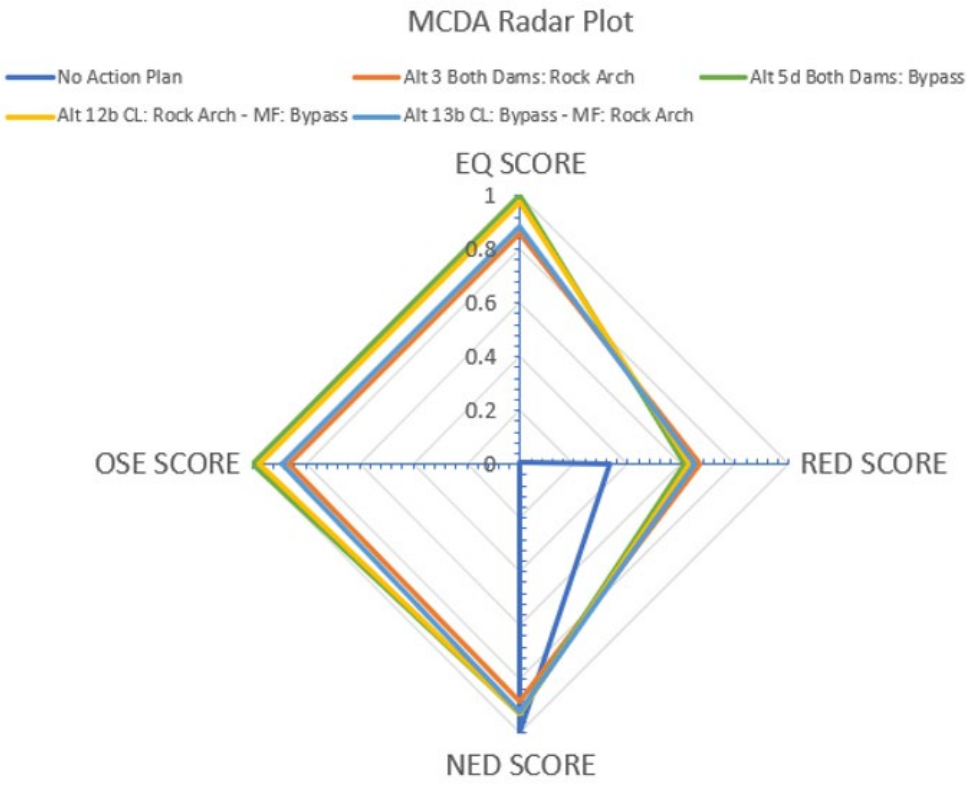
Table 3: The MCDA Scores

Alternative	EQ	RED	NED	OSE
Alt. 1: No Action	0.006	0.333	1	0.006
Alt. 3: Fixed Weir Rock Arch – Both Dams	0.867	0.666	0.883	0.867
Alt. 5d: Natural Bypass Channel-Both Dams (CL right bank, MF right bank)	1.000	0.608	0.930	1.000
Alt. 12b: CL – Fixed Wier Rock Arch and MF – Natural Bypass Channel (right bank)	0.973	0.628	0.930	0.973
Alt. 13b: CL – Natural Bypass Channel (right bank) and MF – Fixed Wier Rock Arch	0.895	0.646	0.921	0.895

As noted in Table 3 and referenced earlier within Section E.2.2.4, MCDA scores for the Environmental Quality Account and Other Social Effects (OSE) Account mirror one another attributable to each account's sole input criterion of Habitat Units. Again, the preservation or support of biodiversity and ecosystem resilience equate to climate positive impact benefits and mitigation of climate hazards (Dasgupta 2021 and Shin et al. 2022). Furthermore, climate hazards disproportionately impact the most vulnerable so using the proxy data of habitat units as the criterion for measuring OSE Benefits not only captures the alternative that most supports increasing resiliency in local economically disadvantaged communities, identified by the Council on Environmental Quality's Climate

and Economic Justice Screening Tool, but also captures the alternative that could improve resiliency in vulnerable communities worldwide. To this point and in conformity with climate justice, deriving OSE Account *co*-benefits from habitat units used as a proxy to measure climate positive benefits adheres to Executive Order 14008, Tackling the Climate Crisis at Home and Abroad.

Chart 1: MCDA Radar Plot



The Radar Plot above, also known as a spider plot, depicts the normalized scores, as displayed within Table 2, for each of the planning accounts on a scale of zero to one where one is most desired. Each alternative is displayed in a different color on the radar plot. The larger the scores are for each account, the farther away its alternative plot lines will be from the origin of the graph. Thus, applying the Riemann sum, or calculating the area under the curve, the plot above shows Alternative 5d in green with the most area. Since this radar plot only has four axis and each action alternative is graphed as a quadrilateral, we can also compute the area under the curves using the area of a triangle formula (Area = (1/2) X base X height) by breaking the quadrilaterals into triangles.

Table 4 below highlights Alternative 5d as the largest Total Score for both methods: summation of the four planning accounts normalized scores and from calculation of the area under the curves.

Table 4: MCDA Results

Alternative	Total Score (Summation)	Total Score (Area under the curve)
Alt. 1: No Action	1.345	0.171
Alt. 3: Fixed Weir Rock Arch – Both Dams	3.284	1.342
Alt. 5d: Natural Bypass Channel-Both Dams (CL right bank, MF right bank)	3.538	1.552
Alt. 12b: CL – Fixed Wier Rock Arch and MF – Natural Bypass Channel (right bank)	3.504	1.523
Alt. 13b: CL – Natural Bypass Channel (right bank) and MF – Fixed Wier Rock Arch	3.356	1.398

E.2.3. *Tentatively Selected Plan*

A formulation strategy is a systematic way of combining measures into alternative plans based on the planning objectives. No single formulation strategy will result in a diverse array of alternatives, so a variety of strategies is needed. Based on the planning criteria and objectives, the analysis herein determines that the NER Plan coincides with the Plan that maximizes benefits across the Four Planning Accounts and because Alternative 5d is the least cost plan, it therefore maximizes net total benefits across the Four Planning Accounts. In summary, the Tentatively Selected Plan is Alternative 5d, the Natural Bypass Channels along the right banks at both Claiborne and Millers Ferry Lock and Dams. (See the Main Report for unabridged detail of the chronological development and formulation of alternatives, from the beginning of this study.)

E.3. REFERENCES

ASA(CW). Memorandum for the Commanding General, U.S. Army Corps of Engineers, dated 5 January 2021, Subject: Policy Directive – Comprehensive Documentation of Benefits in Decision Document.

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